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GRAPE PRODUCTION IN THE ASIA-PACIFIC REGION

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
REGIONAL OFFICE FOR ASIA AND THE PACIFIC
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Edited

by

Minas K. Papademetriou

Frank J. Dent

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
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This publication brings together edited manuscripts of papers presented at the Expert Consultation on "Viticulture (Grape Production) in Asia and the Pacific", held in Bangkok, Thailand, 2-4 May 2000. 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 August 2000 (RAP Publication:2000/13).

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TABLE OF CONTENTS

FOREWORD

It is acknowledged that grape is one of the most important fruit crops of the world and it contains many of the most valuable elements necessary for life. The crop has a wide adaptability, and grapes can be grown under temperate, sub-tropical and tropical climatic conditions and varied agro-ecological settings. Remarkable success has been achieved in grape production and productivity levels in certain countries of the Region, while in other countries the progress is very limited. Opportunities for the further development of the Region's grape industry appear to be very good, although problems to be addressed are many and serious. Realizing that the food, nutrition, medicinal and economic values of the crop could be of significant importance for the population of the Region, it is recognized that there is a need for enhancing the development of the grape industry.

Against the above backdrop, FAO organized a Regional Expert Consultation on Viticulture (Grape Production) in Asia and the Pacific at the FAO Regional Office for Asia and the Pacific, Bangkok, Thailand, from 2 to 4 May 2000. Experts from concerned countries participated in the workshop. They were able to identify critical issues needing attention. The report of the consultation was published as RAP publication No. 2000/13, in August 2000, highlighting the major recommendations. This publication collates further useful information in the form of proceedings.

Appreciation is expressed to the participants for their presentation of papers and contribution to the discussions. In particular, sincere thanks must be accorded to Messrs. M.K. Papademetriou and F.J. Dent for compiling and editing this valuable document. Also, the unfailing support of Mrs. Valai Visuthi, who provided assistance in formatting the manuscript, is greatly appreciated.

R.B. Singh
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. You may wish to know that this 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.

The grape is one of the finest fruits and the most strength-giving food. It contains many of the most valuable elements necessary for life. In addition, it is known to have commendable medicinal qualities/properties, and it has been used in naturotherapy for centuries.

Remarkable success has been achieved in grape production and yield levels in certain countries of the Region, while in others the progress is very limited. The opportunities for further development of the grape industry appear to be good. However, at the same time, the problems to be addressed are many and serious. There is a need and scope for enhancing the development of the grape industry for economic, food and nutrition purposes as well as other reasons.

Strengthening cooperation among countries, institutions and individual scientists in grape 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 grape production in Asia and the Pacific, discuss the problems faced as well as strategies required to overcome existing problems.
b) Elaborate on the potential and opportunities for grape development.
c) Discuss ways and means of strengthening collaboration on grape research and development.

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

Thank you for your attention.

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WELCOME ADDRESS

Ram B. Singh [*]

It is a great pleasure and privilege for me to welcome you to the Expert Consultation on Viticulture (Grape Production) in Asia and the Pacific. May I take this opportunity to extend to all of you warm greetings on behalf of the Director-General of FAO, from my colleagues in the Regional Office and myself. Special thanks are due to you all for gathering here to contribute to this Meeting.

Mr. Chairman! Permit me to congratulate you on your election. I am sure that under your leadership we shall have a productive meeting. I also congratulate Mr. David Oag on his election as Rapporteur of this Consultation.

Grape is one of the most important fruit crops of the world. It is also one of the most ancient crops known to people. Hyams (1954) traces its antiquity to 7000 BC and states that it was associated with people as a cultivated plant long before cereals. According to De Candolle (1886), the cultivation of grape in Egypt goes back to 4000 BC.

Grape cultivation is believed to have originated in Armenia near the Caspian Sea, from where it seems to have spread westward to Europe and Eastward to Iran and Afghanistan. The crop has a wide adaptability, and grapes are now grown in every continent, under temperate, sub-tropical and tropical climatic conditions and under varied agro-ecological settings, from mountains to plains to sea coasts. However, the ideal climate for grapes is in the Mediterranean region. In its natural habitat, the grape grows and produces during the hot and dry period, and undergoes dormancy during the cold period.

The long history of grape cultivation is linked with its multiple uses as food, source of nutrition, health and medicinal value and high economic significance. In Indian, Chinese and other societies, the role of grapes in health care and cure of diseases has been emphasized since ancient times. In this context, I would urge each one of you to read the book "The Grape Cure" by Johanne Brandt, popular for the last 73 years. As regards the economic dimensions, the Indian States of Maharashtra, Andhra Pradesh and Karnataka have found grapes as the most cash producing and job providing commodity. In Australia, grape wine export annually earns over 1,000 million dollars.

Countries with sizeable extent of grape cultivation in the region are China, Australia, India, Republic of Korea, Japan, Pakistan, New Zealand, Thailand, Vietnam and Myanmar. The total area under cultivation in these countries is estimated to be around 370,000 hectares, with a total production of about 5,000,000 metric tonnes and average yield of about 14 tonnes per hectare. There are wide variations in average national yields and from variety to variety, ranging from 5 to 50 tonnes per hectare. India, with the national average yield of 30 tonnes per hectare, is the world leader in the average yield.

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The worldwide distribution of grapes is coupled with the high genetic plasticity of this crop to enable its adaptation to temperate, sub-tropical and tropical regions. However, this diversity has not been effectively utilized. The countries must have their grape germplasm duly evaluated and share the information and desired stocks. Paradoxically, the genetic base of commercial grape varieties is rather narrow, causing vulnerability to diseases and pests, especially in the tropics and sub-tropics. Being amenable to propagation both through seed and vegetative means, there are wider options for its genetic maneuverings. In vitro propagation of grapes is highly commercialized in some of the countries and can be used for production of transgenics and other genetic transformants. With the above opportunities in mind, countries should give high priority to the development of promising new cultivars suitable for specific end uses and adapted to specific agro-ecological settings.

Grape production in the tropics and sub-tropics is exposed to complex biotic and abiotic stresses. Among diseases, anthracnose, downy mildew and powdery mildew are most serious. Important pests include mealy bugs, thrips and jassids. Both genetic and integrated pest management approaches should be promoted particularly to reduce the excessive use of pesticides. Often pesticide residues are obstructing grape promotion in many countries. Biological agents, such as the use of Australian lady bird beetle to manage mealy bugs, should receive high research and development priorities. In regard to abiotic stresses, drought, problem soils such as salinity, nutrient deficiencies, high temperature and untimely rains are major limiting factors. Selection and use of resistant/tolerant rootstocks will prove most promising.

Although the countries have developed useful production technologies such as pruning pattern and schedule for single or double fruiting, fertilization, water management etc, there is a need for greater understanding and manipulation of bud bursting, fruiting and ripening period and the overall reproduction phases. This will help in alleviating the adverse effects of rains, drought and market gluts and shortages. Physiological, biochemical and nutritional studies should be intensified to understand the intricacies.

Considering the various production regimes and end-uses of grape, it will be necessary to look at the grape industry in a matrix form. Each ‘box’ of the matrix should be analyzed critically and the problems and their solutions should be disentangled to provide greater location specific impact. The consultation is urged to undertake a SWOT (Strength, Weakness, Opportunity and Threat) analysis of the various regimes (boxes). Compilation of such information will be extremely helpful in identifying technologies and modes of their sharing among the partners and in deciding future priorities. The action points thus suggested will also give clear indication to FAO for internalizing the recommendations in its workplans.

Besides technologies, issues relating to policies, trade, marketing, pricing, and processing and product diversification should also be discussed. Development of the grape industry in the region thus calls for interplay of grape growers, industry and research systems in each grape producing country. Further, efficient inter-country cooperation mechanisms should be in place to share information, technologies and products to evolve a vibrant Asian grape industry.

I wish you success in your deliberations and a very pleasant stay in Bangkok.

Thank you.

GRAPE PRODUCTION IN AUSTRALIA

David Oag [*]

1. INTRODUCTION

The first grapevine planting material arrived in Australia with white settlement in 1788. Today grapes are grown commercially in all States and Territories. Grape growing (wine, raisin, and table) is the largest fruit industry in Australia with production in a wide range of environments from temperate to tropical. Wine grape production and wine making is the largest and most predominant of the three viticulture industries.

There has been considerable change in production in all three industries over the last 4 years, up to 1999. Wine grape production has almost doubled to 1,076,207 tonnes and dried grape production has fallen to 119,438 tonnes, largely in response to export markets plus increasing imports of dried grapes. Table grape production has increased by almost 60 percent to 69,891 tonnes fuelled by industry expansion in sub-tropical regions and increasing exports to Asia. A feature of recent industry expansion has been the increased planting of varieties specific to the end use (wine, dried, table). Nevertheless, the multipurpose varieties such as Sultana, Muscat Gordo Blanco and Waltham Cross continue to account for 40 percent of white grape production in Australia. Grape growers redirect their fruit from drying to processing for wine or production of table grapes as the fortunes of each industry waxes and wanes.

A comparison with other grape producing countries throughout the world shows that Australia was the 14th largest producer of grapes (tonnes) in 1997, when Australia was ranked 9th in the world for volume of wine produced. While 28 percent of production (170.6 ML) was exported, this amounted to only a very small percentage of world wine exports. Australia is a relatively small producer and exporter of table grapes and raisins by world standards.

The viticulture industries in Australia are well developed, innovative and utilize the latest production practices. Australia is ranked among the top 10 countries in terms of average grape yield (t/ha). There is a high degree of mechanization in the vineyard, particularly in the wine grape and raisin industries. A substantial research, development and extension effort continues to generate practices that improve production efficiency and grape quality.

2. CURRENT STATUS OF GRAPE PRODUCTION

Grapes are grown in all States of Australia but most of the production is in the temperate zone. The three largest States by production are South Australia (Riverland), Victoria (Sunraysia) and New South Wales (Riverina) (Table 1). Wine grapes are grown in all States, table grapes in all States except Tasmania and raisins in Victoria, New South

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Wales, South Australia and Western Australia. Important grape production districts are shown in Figure 1.

Over the last five years wine grape production has almost doubled, raisin production declined slightly and table grape production increased moderately (Table 2). Further substantial increases in wine grape production will occur during the next two to three years as non-bearing vines come into production and reach mature cropping levels. Most of the growth in the table grape industry has occurred in sub-tropical areas across northern Australia. Production volumes will increase over the next two years when these new vineyards come into bearing. New plantings of wine grapes are expected to slow down, while raisin grapes will remain static and table grapes show a slight increase.

Table 1. Production of Wine grapes, Raisins and Table grapes in Australia, 1998-99 (in tonnes).

	Wine making	Drying	Table grape	Total
New South Wales	270,236	19,137	14,128	303,501
Victoria	277,869	96,788	42,391	417,048
Queensland	1,264	-	5,586	6,850
South Australia	491,621	2,764	2,149	496,534
Western Australia	32,067	749	3,531	36,347
Tasmania	3,121	-	-	3,121
Australia	1,076,207	119,438	69,891	1,265,536

Source: Australian Bureau of Statistics, Catalogue No. 1329.0, 1999.

Table 2. Change in Grape Production (in tonnes), 1995 to 1999.

Year	Wine making	Drying	Table grape
1995	577,364	147,006	44,456
1999	1,076,207	119,438	69,891

Source: Australian Bureau of Statistics, Catalogue No. 1329.0, 1999.

A large number of varieties are grown in Australia. The area planted with each variety and tonnage utilized for wine making, drying or as table grapes is shown in Table 3. The major table grape varieties are Thompson Seedless, Red Globe, Flame Seedless and Menindee Seedless. Menindee Seedless is the predominant variety of plantings in northern Australia. Other table grape varieties grown include Cardinal, Emperor, Ribier (Alphonse Lavelle), Marroo Seedless, Calmeria, Ohanez, Purple Cornichon and Waltham Cross.

Table 3. Area under Grape Varieties and Production Extents (1998-99).

	Area of Vines (ha)			Grape Production (tonnes)			
Variety	**Bearing**	**Non-bearing**	**Total**	**Wine making**	**Drying**	**Table grape**	**Total**
Red Grapes:							
Barbera	111	105	216	669	-	-	669
Cabernet Franc	559	123	687	5 365	-	-	5 365
Cabernet Sauvignon	13 629	7 541	21 169	127 494	-	193	127 687
Currant	889	49	938	5 515	7 189	10	12 714
Grenache	2 025	231	2 255	24 196	53	33	24 281
Malbec	399	49	448	2 857	-	-	2 857
Mataro	683	183	866	9 217	-	69	9 286
Merlot	3 465	292	6 387	31 801	16	246	32 063
Muscat a Petit Grains Rouge/Rose	296	48	345	1 411	46	408	1 865
Petit Verdot	110	261	370	1 045	-	-	1 045
Pinot Noir	2 226	770	2 996	19 668	26	267	19 960
Ruby Cabernet	1 102	876	1 978	18 414	-	49	18 462
Sangiovese	311	129	440	403	-	-	403
Shiraz	16 944	8651	25 596	192 330	36	477	192 843
Tarrango	87	20	107	2 199	-	-	2 199
Other red grapes	2 528	601	3 129	7 228	658	20 179	28 065
Total Red Grapes	45 363	22 563	67 925	449 809	8 025	21 929	479 762
White Grapes*:*							
Chardonnay	15 298	1 558	16 855	210 770	-	299	211 069
Chenin Blanc	884	55	939	16 621	-	-	16 621
Colombard	1 382	266	1 648	34 781	-	-	34 781
Crouchen	83	5	87	1 136	-	-	1 136
Doradillo	306	8	314	6 597	-	1	6 598
Marsanne	137	63	201	1 878	-	-	1 878
Muscadelle	230	17	247	2 106	-	7	2 113
Muscat a Petit Grains Blanc	261	8	269	3 334	5	24	3 363
Muscat Gordo Blanco	2 924	81	3 005	58 017	2 575	112	60 703
Palomino	161	2	163	2 581	-	-	2 581
Pedro Ximenes	146	-	146	1 981	-	-	1 981
Riesling	3 190	157	3 347	30 144	-	-	30 144
Sauvignon Blanc	1 926	487	2 413	22 834	-	100	22 934
Semillon	5 307	737	6 044	80 191	-	-	80 191
Sultana	12 943	696	13 639	117 783	105 982	26 339	250 103
Taminga	44	-	44	862	-	-	862
Traminer	531	7	538	5 357	-	-	5 357
Trebbiano	689	1	690	10 482	-	-	10 482
Verdelho	708	267	975	7 290	-	-	7 290
Viognier	79	51	130	494	-	-	494
Waltham Cross	407	22	429	2 366	2 277	1 200	5 842
Other white grapes	2 303	564	2 867	8 794	575	19 881	29 251
Total White Grapes	49 938	5 052	54 990	626 398	111 414	47 962	785 774
TOTAL GRAPES	**95 301**	**27 614**	**122 915**	**1 076 207**	**119 438**	**69 891**	**1 265 536**

Source: Australian Bureau of Statistics, Catalogue No. 1329.0, 1999.

3. PRODUCTION OF PLANTING MATERIAL

Production, supply and maintenance of healthy planting material are well organized and wholly undertaken by industry. There are three tiers involved, namely, the national, state and individual nursery operator levels.

The Australian Vine Improvement Association (AVIA) is the national organization responsible for developing standards in vine health maintenance and product quality. Each state has a vine improvement organization (VIO) whose role is to produce healthy cuttings as specified by AVIA, for sale to nurseries. Privately owned nurseries propagate vines for sale to grapegrowers, preferably using cuttings from VIOs but also from commercial vineyards in times of short supply.

In recent years a substantial effort has been made at all levels of the industry to improve the health status of grapevine planting material in Australia. Virus indexing of government germplasm collections using more sensitive techniques is almost complete and indexing of the VIOs source area vineyards, from which cuttings are produced and sold to nurseries, is well advanced. These vines will now be indexed every 2 to 3 years.

AVIA and the state VIOs have jointly developed sanitation protocols for use by nurseries, in particular a hot water treatment (50^{o}C, 30mins) of cuttings for the control of crown gall and phytoplasmas. A quality assurance scheme has been developed by AVIA, which governs the health status and quality of planting material sold by participating nurseries.

The types of planting material available are dormant cuttings, vines on own roots and vines grafted to rootstocks. Most planting material is purchased from nurseries and planted as vines with roots. Some growers continue to plant callused cuttings directly into the vineyard but this practice is dying out. Bench grafting using machines built for the purpose is the most widely used technique by nurseries. A small number of nurseries continue to graft in field nurseries. One specialized nursery has recently started green micro-grafting which enables the production of bench grafted vines all year round.

Throughout the 1990's there was a large increase in the number of vines grafted to rootstocks. More than 20 rootstocks (Table 4) are used in the Australian viticulture industries, primarily for salt tolerance, increased productivity and nematode tolerance. Rapid expansion of the grape industries, mostly wine grape and table grape, has seen large increases in the number of vines produced each year but demand exceeded supply which led to shortages of propagating material. It was estimated that in some years, up to 60 percent of the propagating material used by nurseries came from commercial vineyards and hence had a doubtful health status and quality.

Table 4. Rootstock Cuttings Sold in Australia, 1998.

Variety	Number Cuttings
Ramsey	2,902,841
Schwarzmann	1,863,870
140 Ruggeri	908,332
1103 Paulsen	779,218
K51-40	543,471
99 Richter	536,900
5BB Kober	522,775
101-14	449,059
5BB Kober 5A	429,735
5C Teleki	326,219
SO4	296,466
K51-32	107,855
110 Richter	89,059
Dog Ridge	87,645
Teleki C	36,750
Freedom	29,164
Harmony	22,600
J17-48	18,150
420A	11,210
J17-69	2,200
Rupestris du lot	1,836
34 EM Foex	1,150
Riparia Gloire	400
St George 15-74-2165	215
ARG 1	100
1202 Couderc	100
5A Teleki	20
1616 Couderc	10
Total	**9,967350**

Source: Australian Vine Improvement Association.

4. ESTABLISHING VINEYARDS

Site Assessment

Long-term profitability and ease of management is greatly enhanced by detailed assessment of the proposed vineyard site. Firstly, the optimum district for producing the desired fruit (wine) quality or (table grape) harvest time is determined using long-term weather data. Once a vineyard site is chosen a detailed assessment of water and soil resources is undertaken.

The water survey will include assessment of on-farm water resources, access to off-farm water supplies and quality of the water. A water sample is then collected and analyzed.

Grapevines are not highly sensitive to salt but water supplies with a total salinity exceeding 2000 microSiemens per centimetre, sodium content greater than 20 milliequivalents per litre or chloride content greater than 4 meq/L should be avoided. On-farm water resources are surveyed to determine the quantity of water available from dams or underground sources through bores, as well as the catchment area so that recharge rates can be calculated. Much of Australia's viticulture is located in irrigable areas where water supply is reliable and well managed. Many of the new vineyard developments rely upon pumping water from rivers and streams, and this requires a licence issued by a statutory organization. The quantity and timing of rainfall in relation to the growing season, which varies considerably throughout Australia, is included in the assessment of water resources. The water survey is the major determining factor in the design of the vineyard irrigation systems.

Soil surveys are increasingly used in vineyard planning. They are the major determinant of vineyard layout and indicate what soil ameliorants and physical modifications are required before planting. A simple soil survey involves collecting soil samples for chemical analysis and nematode assay, whilst a detailed survey involves digging soil pits in a 100m grid across the vineyard site. Soil pits are used to determine variability across the site, presence of compaction or impermeable layers, and subsoil chemical status.

Soil Preparation

Soil preparation involves applications of lime or dolomite to adjust pH; superphosphate, as most Australian soils are low in phosphorous; and applications of magnesium, zinc and boron where these nutrients are locally deficient. Ripping along the vine row and sometimes of the entire site is used to break up compaction and impermeable layers and increase soil depth. Where nematodes are present tolerant rootstocks are chosen and ordered from commercial nurseries.

Planting

Immediately prior to planting the soil is cultivated. Planting is commonly carried out in late winter-early spring using dormant vines. Numerous mechanical devices are available to assist with planting of vines. The recent introduction of container grown vines has enabled the planting season to continue through to mid-summer (Dec/Jan), even in sub-tropical areas.

Vine Spacing

Vine spacing varies slightly with grape type (wine, raisin, table), age of vineyard and district. Rows are mostly 3.0-3.6m wide with vines 1.5-2.4m apart. Spacings are commonly at the higher end of the range in more recent vineyards because of larger trellis designs, plus rootstocks and improved management practices contributing to greater vine vigour. A few medium density (2.0m x 1.0-1.5m) wine grape vineyards have been planted but these spacings are not suited to the climate of most grape production districts in Australia.

The use of 'vine tubes' to promote faster growth and establishment of young vines has become widespread over the last 5 years. A variety of tubes are available, differing in design, colour, length and material. Vine tubes are rarely used and considered unnecessary in northern Australia, as vines establish quickly and carry their first crop 18 months after planting.

5. VINEYARD MANAGEMENT PRACTICES

The discussion in this section focuses on table grape production in northern Australia (Queensland, Northern Territory, Western Australia). Notable variations in management practices in the wine or raisin grape industries will be highlighted.

Trellis Systems

The most common trellis used for table grapes is a 6 or 8-wire large Y shaped trellis. The 6-wire Sloping T trellis is far less popular. Both trellis designs have two cordon wires and vines are trained to a quadrilateral. Moveable foliage wires are not used nor hand positioning of shoots. Both trellis designs provide good separation of fruit and foliage. The Y trellis is preferred as it provides unobstructed access from both sides for harvesting and pre-harvest hand manipulation of bunches. The application of plastic vine covers is a little easier with the Sloping T trellis.

Pruning

Most varieties grown are spur pruned even in the tropical areas (Mareeba). Thompson Seedless and Menindee Seedless require cane pruning and there has been a recent shift to cane pruning of Red Globe for greater fruit yield. All pruning of table grapes is done by hand. A large proportion of the wine grape area planted throughout Australia is machine pruned or not pruned at all.

Hydrogen cyanamide (Dormex ®) is applied after pruning to enhance percent bud burst, promote uniform bud burst and advance bud burst time in the early season districts. The interval between application and bud burst increases with latitude from 10 days (Mareeba) to 25 days (St George). Notwithstanding the use of hydrogen cyanamide bud burst is more protracted and the percent bud burst is less than in temperate areas. Our understanding of vine dormancy, interaction with the environment and the manipulation of bud burst needs to be improved if vineyard productivity in sub-tropical areas is to be increased.

Vine Nutrition

Inorganic fertilizers are predominantly used for maintaining vine nutrition. Annual dry matter analysis of petiole samples is commonly used for determining the nutrient requirements of grapevines. Some growers also use soil analyses but generally only every second or third year.

Most grape growers apply inorganic fertilizers through the irrigation system (fertigation) because it is easy, provides a high degree of flexibility and control, minimizes leaching losses in summer rainfall districts and ensures the nutrients are available when required by the plant. Broadcasting of fertilizer for incorporation by rain is uncommon and generally used only for particular fertilizer products.

Annual fertilizer application rates for table grapes in the sub-tropics range from 20 to 40 kg/ha N, 10 to 20 kg/ha P, and 60 to 100 kg/ha K. Dolomite or lime is regularly applied to adjust soil pH. Foliar fertilizers are increasingly being used for the application for micro-nutrients (Zn, B, Mg, Mn).

Only a small number of growers use organic fertilizers but the interest in organic fertilizers is increasing sharply. Organic fertilizers are invariably expensive per kilogram of nutrient, not easily accessible and often in short supply.

Vineyard Floor Management

Standard practice is a weed free strip along the vine row and a permanent plant cover between rows. This minimizes soil erosion and facilitates vehicle access after rain, when the timely application of fungicides for disease control is important. The inter-row plant cover is usually self sown, although in vineyards in temperate southern Australia there is a shift towards the planting of specialist species. The inter-row plant cover is regularly slashed and the under-vine strip maintained weed free with herbicides. Cultivation is generally not practiced.

Irrigation

Irrigation is essential for profitable table grape production. Drip irrigation is the standard technique used. Furrow irrigation or under-vine sprinklers are not used because of limited water supplies and both methods of irrigation are found only in irrigation districts in southern Australia.

Scheduling of irrigation is increasingly used over the traditional practice of regular application of a prescribed amount. Scheduling methods vary from rather inexpensive and simple (crop factors, evaporation and rainfall data, tensiometers, gypsum blocks) to highly technical and more expensive techniques (neutron probes, capacitance probes). Irrigation scheduling provides flexibility of management for growers, leads to efficient use of water, avoids leaching, and maximizes vine performance.

Pest Management

Low chemical input is a characteristic of Australian viticulture and over the last 10 years there has been a shift to greater use of biological control agents. The viticulture industries are moving from routine to strategic spray programmes and this is most advanced in the wine grape industry where higher fruit damage levels are acceptable.

The success of strategic spray programmes is the accurate prediction of pest outbreaks and disease infection periods. This requires monitoring in the vineyard for the presence and development stage of a pest and recording weather data. The 'AusVit' software package analyzes the weather data and vineyard observations to produce recommendations which assists grapegrowers to make spray management decisions.

The list of insects is very similar throughout the grape production regions of Australia. The one notable exception is the occurrence of Queensland Fruit Fly in northern Australia only, which is a major pest of table grapes in this region, and its absence in southern areas. A biological insecticide *Bacillus thuringiensis* is available for control of light brown apple moth (LBAM) and grapevine moth caterpillar. The predatory wasp *Trichogramma* is also effective against LBAM. The pest mites (blister, bunch, rust) are controlled organically by applications of wettable sulphur and several predatory mite species endemic in Australian vineyards. Growers maintain predatory mite populations by the careful selection of safe pesticides. Queensland fruit fly and cadydids (grasshoppers) are the

two significant pests of table grapes in northern Australia and require regular control to prevent serious damage.

Diseases are of far greater concern and impact on grape production throughout Australia. Downy mildew (*Plasmopara viticola*), Botrytis (*Botrytis cinerea*) and anthracnose (*Elsinoe ampelina*) are the most damaging diseases of table grapes in northern Australia. Under the high summer rainfall conditions common throughout northern Australia the damage to fruit and foliage can be extensive and severe.

The standard spray programme for table grape production involves regular applications of protectant fungicides with the timing determined by growth stage, weather forecasts and disease incidence the previous season. Copper oxychloride and mancozeb are the major fungicides used for downy mildew control. The eradicant fungicides metalaxyl, phosphorous acid, benalaxyl and oxadixyl are important for the post-infection control of downy mildew, particularly in Queensland where storms and two to three days continuous rainfall are common during the growing season.

The spray programme for Botrytis is very specific and consists of two sprays during flowering, one spray before bunch closure, and one to three sprays during pre-harvest. To avoid resistance developing, particular attention is paid to using a fungicide from a different chemical group at alternate applications. Resistance to benomyl and procymidone exists in some grape districts, particularly Western Australia where resistance is extensive throughout the table grape industry. The biological fungicide *Trichodex* is available but is less effective under high disease pressures.

Control of anthracnose is possible only with regular applications of the pre-infection dithiocarbomate fungicides or dithianon for woolly bud and whenever new growth is present during wet weather. Once an outbreak of anthracnose has occurred it can take three to five years of good control practices to clean the disease from the vineyard. Fungicides used for anthracnose will also control Phomopsis (*Phomopsis viticola*).

Powdery mildew (*Uncinula necator*) is less important in the wet and humid climate throughout Queensland, but is the major disease of table grapes at Ti Tree (Northern Territory). A programme of three or four sprays at seven to fourteen day intervals from bud burst is very effective in preventing powdery mildew. Wettable sulphur is commonly used early in the season, then as the daytime temperatures exceed 30^{o}C the demethylation inhibitor fungicides are used.

Table Grape Quality

Gibberellic acid is routinely used with Thompson Seedless and Flame Seedless to thin flowers in the inflorescence and increase berry size. Gibberellic acid is not applied to Menindee Seedless because it reduces fruitfulness, or Marroo Seedless because it leads to a large number of green, shot berries in the bunch at harvest.

Plastic rain covers to protect fruit from pre-harvest rain damage are a recent innovation within the table grape industry. The rain covers are spread over the canopy of the vine just after veraison (approximately four to six weeks before harvest). Their use has become widespread in the Sunraysia, is rare in Queensland and is standard practice at Ti Tree with Thompson Seedless.

Trunk or cane girdling is not used in northern Australia because the effectiveness of the technique in sub-tropical environments is not known and growers generally have no experience.

6. HARVESTING AND YIELDS

Table grapes are hand harvested, packed into cardboard cartons, cooled on farm and transported to market in refrigerated trucks. Most growers in northern Australia pack in the vineyard as it is cheaper, the fruit is destined for the domestic market, and is easy to manage as only one line of fruit is being packed. Shed packing is used where there is some damage requiring extra work to clean the fruit, and when the fruit is destined for an export market, multiple lines are packed simultaneously, and for varieties sensitive to handling (e.g. Thompson Seedless).

Polystyrene cartons are rarely used for table grapes since the major retail supermarket chains decided two years ago they would no longer accept produce in polystyrene, because of the waste disposal problems of this bulky material in the cities. This is despite the superior insulation properties and better protection of fruit during transport. Plastic bunch bags were introduced three years ago and their use has increased in response to demand by the retail supermarket chains. Sulphur dioxide pads are not used in northern Australia where fruit is consigned to the domestic market, but are included in cartons of table grapes exported from Sunraysia and Swan Valley.

Northern Australian table grape yields average 7 kg/vine (8.75 t/ha) and only 3 kg/vine (3.75 t/ha) for the major variety Menindee Seedless. In the Sunraysia the average yield is 12 kg/vine (18.5 t/ha) and can exceed 20 kg/vine (31.0 t/ha) for Red Globe.

Low bud fruitfulness due to the growing conditions in the sub-tropics is the major reason for relatively low yields across northern Australia. Low percentage bud burst and hence fewer shoots per vine is a major factor. The short duration of each growth stage (bud burst to harvest) leads to smaller bunches and berry size, which contributes to low yields and impacts on fruit quality.

Average yield of raisin grapes is 25 t/ha (fresh weight) and 6 t/ha of dried grapes to greater than 25 t/ha for wine grapes, largely due to the production system. A sizeable and increasing percentage of the wine grape crop is harvested mechanically. This provides cost savings and is beneficial for maintaining fruit quality. In the modern raisin grape vineyards canes are cut to allow drying of the fruit on the vine and subsequent machine harvesting. Considerable development of mechanical harvesting techniques for wine grapes and raisins has occurred in Australia.

7. MARKETING

Table grapes are sold by two methods in Australia. Firstly, the traditional practice of consigning fruit to a wholesale agent at the central market in each of the capital cities for sale on commission. More recently, an increasing amount of fruit is being sold directly to the retail supermarket chains under contract for an agreed price.

There are no table grape exports from districts across northern Australia as this production is early season and commands a high price on the domestic market. Table grape exports are predominantly from the Sunraysia and Swan Valley. In 1998-99 table grape exports reached a record high of 31,017 tonnes valued at $69.1 million. The major markets were Hong Kong and Singapore accounting for 40 percent and 25 percent, respectively, for a value of $44.3 million. The major varieties exported are Thompson Seedless, Red Globe, Flame Seedless and Menindee Seedless.

Table grape imports have been permitted only from New Zealand and are less than 5 tonnes each year. The Australian Quarantine and Inspection Service announced on 14 January 2000, that table grape imports from California would be permitted. Fruit is expected to arrive from July/August and continue through to December.

Export sales of Australian wine have grown dramatically from 21.3 million liters in 1986-87 to 215.5 million litres in 1998-99. The major markets are Europe, North America and New Zealand. Wine exports to countries throughout Asia have also increased significantly in recent years and this region has become the focus for further export growth.

8. INDUSTRY POTENTIAL

The table grape industry has grown significantly in recent years, mostly in northern Australia and the potential exists for continued expansion in this region. Water and land resources are available and support infrastructure is now well established. The potential exists to greatly increase domestic per capita consumption during the October to December period, which will in turn stimulate industry growth. Several large growers in Queensland have established links with exporters in preparation for export. Continued growth of table grape exports to Asia is likely to lead to industry growth in the Sunraysia and Swan Valley.

Expansion in the wine grape industry will slow but wine exports will continue to grow. Recent expansion of the wine grape industry has been into non-traditional production districts, including more sub-tropical parts of Queensland.

The raisin grape industry is likely to remain static under pressure from imports, loss of traditional export markets and as grape growers plant wine or table grapes in preference.

The major strengths of the Australian viticulture industries are the extensive research and development efforts and high level of skill amongst grape growers. The research and development effort has led to the current production practices and technologies in Australian viticulture to become some of the most advanced in the world. Grape growers are continually improving their skills and knowledge and adopting the technologies arising from research and development.

The geographic range of grape production districts spreads the risk of crop failure and reduces the likelihood of gaps in supply. The range of climates in which grapes are grown throughout Australia extends the supply time of fresh table grapes and enables a wide variety of wine products to be produced.

There is the potential for further advances in low chemical use production practices and the development of additional biological control methods. Scope exists for greater

adoption by grape growers of currently available integrated pest management practices and low chemical input viticulture. Significant improvements in vineyard efficiency and productivity will occur as a result of continued advances in irrigation management, vine improvement and vineyard mechanization.

9. CONTRAINTS ON GRAPE PRODUCTION

Increasing salinity and pressure on water resources in the major grape production districts of southern Australia is a major issue for the future viability and development of all grape industries. There are huge political and environmental implications surrounding both issues. The salinity problem will be expensive and take considerable time to correct and in the meantime could result in some water and land resources becoming unusable.

There are several constraints to development in the table grape industry. Firstly, the lack of new varieties which satisfy domestic and export market preferences and which are suited to local growing conditions, particularly those across northern Australia. Secondly, limited knowledge of vine physiology and performance under sub-tropical conditions is a major limitation to productivity. Specific issues include floral initiation and factors controlling bud fruitfulness, inflorescence and berry growth, vine nutrition, dormancy, the mechanism controlling bud burst, and managing vegetative growth. Major impediments to initiating and developing an export table grape trade from production districts in northern Australia are a lack of market intelligence, poor contacts in Australia and destination markets, and limited export experience amongst grape growers.

Grape growers in Australia are highly skilled, continually updating their viticulture knowledge and have a high propensity to adopting new technologies and practices. There is a comprehensive education programme providing training at all levels. Several universities train viticulturists and oenologists, the extensive network of TAFE colleges across Australia train vineyard workers in the practical skills, Government agriculture agencies provide education and training in new practices and technologies arising from research and development, and numerous secondary schools now teach viticulture. Learning also occurs in the many grape grower discussion groups organized within industry.

10. GOVERNMENT POLICIES AND RESEARCH AND DEVELOPMENT COMMITMENT

The Government is the major funding source for the substantial research effort within Australia on behalf of the viticulture industries. All three grape industries jointly fund research and development through levies paid by grape growers and processors (wine and raisin). The majority of the viticulture research is on wine grapes. Table grapes receive the least amount of research effort, almost all of which is undertaken in sub-tropical environments by the Queensland Department of Primary Industries, Northern Territory Department of Primary Industries, and Fisheries and Agriculture Western Australia.

Research and development is undertaken by numerous organizations throughout Australia. The major organizations at the national level are the Cooperative Research Centre for Viticulture, Commonwealth Scientific and Industrial Research Organization and Australian Wine Research Institute. The Agriculture Department in each state is another

major contributor to viticulture research and development, with the level of commitment varying depending on the size of the grape industries in the state. Several universities across Australia are also involved in grape research. The current research activities of each organization can be found in their annual report or web page.

Each grape industry has a research and development corporation, which formulates research priorities, collects the levy money and then allocates it to research projects. The priorities of the wine grape industry are:

a) Grapevine variety improvement,
b) Management of pests and pathogens,
c) Grape quality,
d) Resource and vineyard management,
e) Economic prediction and assessment,
f) Technology transfer.

Research priorities of the raisin industry are available in the annual report of the Dried Fruit Research and Development Corporation. The table grape industry is not organized at the national level, so priority issues are developed at the state or local level only. The important issues in Queensland are bud fruitfulness, vine nutrition, dormancy and bud burst management, environmentally suited new varieties, quality assurance management, and integrated pest management.

Federal and State governments have policies focusing on expanding exports of food products into Asia. This encompasses wine and table grapes. To achieve this objective, government funds have been committed to strategic projects addressing grape production and farm gate issues. The Federal government also provides funds through several agencies (e.g. Australian Council for International Agricultural Research) for collaborative research and development projects between organizations in Australia and throughout Asia, designed to assist industry development.

11. CONCLUSIONS

The grape industries in Australia are technically advanced with highly skilled operators and an extensive research, development and education programme. Sustained economic viability of the wine grape industry is dependent upon continued growth in wine exports. Asia is an emerging market for Australian vine exports and significant growth in sales in this market is important and will be a focus of export strategies. Enhanced trade links in countries throughout Asia could well benefit Australian wine and table grape exports to the region.

A greatly increased research and development effort in the sub-tropical environments of northern Australia is required, to improve vineyard productivity, achieve competitiveness with Californian imports and hence sustain the expansion of this growing sector of the Australian table grape industry. To enable more effective management practices to be developed, future research should focus on vine physiology and understanding the interaction between the plant and environment. Opportunities for collaboration in table grape research between Australia and countries in Asia should be explored and mutual benefits identified.

There are opportunities for countries in Asia to utilize the vast array of education programmes in viticulture and oenology, as well as access the extensive information resources available in Australia. Countries throughout Asia could access the technology and skills in wine making in Australia, to assist the development of their emerging wine industries.

Figure 1. Major Grape Growing Districts in Australia.

GRAPE PRODUCTION IN CHINA

Li Shao-Hua [*]

1. INTRODUCTION

Grapes (*Vitis vinifera* L.) have been grown in China for more than 2000 years. However, grape production was negligible until the founding of the People's Republic of China. The area under cultivation of grapes and their production were only about 3,200 hectares and 39,000 tonnes, respectively. The government paid great attention to improvement of the quality of life of the people after the founding of the People's Republic of China. Following rapid economic growth, fruit production, including grape production increased rapidly in the country, especially since the 1980's. The land area under grapes and their production in 1998 were respectively estimated to be 55.6 and 60.5 times greater than in 1949. This paper presents the current status of grape cultivation, the development of the wine industry, advances in cultural techniques, the potential for expansion, and some suggestions for the future development of grape production and the wine industry in China.

2. PRESENT STATUS OF GRAPE CULTIVATION IN CHINA

Following apple, citrus, pear and banana, grape production now ranks fifth in fruit production in the People's Republic of China. The area under vineyards was estimated to be 178,000 hectares in 1998. To examine the evolution of the area under cultivation of grapes after the founding of the People's Republic of China, two rapid development periods can be observed during the eighties and last few years of the last century. The land area under cultivation of grapes increased steadily from 31,600 to 146,000 hectares during the first rapid development period from 1980 to 1988, with an average increase of about 14,300 hectares per year. Then the grape extents decreased from 1989 to about 24,000 hectares in the following 3 years. Under the influence of the "red wine rush" in the Asian countries, grape growing again became the focus of people's attention in China from the early nineties. Thus, the area under cultivation of grapes continued to increase again from 1992 to 20,200 hectares by 1998 (about 15 percent more when compared with that of 1997). The area for the other four main fruit crops, however, decreased by 216,800 hectares for apple, 5,540 hectares for pear and 39,000 hectares for citrus.

The annual grape production has increased steadily for the last 20 years. It attained 2,358200 tonnes in 1998, 18.7 times more than in 1979. Most of this production was for table grapes and only about 10 percent for wine making and another 10 percent for raisins. The main areas of expansion are located in the north. The five leading provinces that contributed more than two thirds of the total grape production in the country in 1998 were Xingjiang, Hebei, Shangdong, Liaoning and Henan (Table 1).

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Table 1. Main Grape-Growing Regions and their Production, 1998

Province	Vineyard Area		Grape Production	
	1000 ha	% of the Country total	1000 tonnes	% of the Country total
Xingjiang	32.0	18.0	555.4	23.6
Hebei	31.5	17.7	404.4	17.1
Shangdong	20.9	11.7	269.0	11.4
Liaoning	14.2	8.0	275.6	11.7
Henan	11.3	6.3	153.0	6.5
Total in China	178.0	100	2358.2	100

Source of Data: China: Yearbook, Agriculture, 1999

Although the Chinese have a tradition of consuming alcoholic beverages, China has been very backward in wine industry development. At the time of the founding of the People's Republic of China, the estimated annual production of wine was about 85 tonnes per year. Although the wine industry has developed rapidly since that time (Table 2), wine production has contributed only a very small fraction towards the total alcoholic beverage production in the country.

Table 2. Development of Wine Production in China from 1949-1997 (the production before 1979 is estimated by converting all alcoholic beverages which are wine or part of which are originating from grape juice).

Year	1949-1950	1954-1955	1959-1960	1964-1965	1969-1970	1974-1975	1979-1980	1984-1985	1989-1990	1994-1995	1997
Average/ Year (1000 t)	0.085	0.72	4.12	9.50	12.0	21.8	26.7	119.1	269.2	235.4	195.0

Following a rapid growth in wine production, most of the provinces are now engaged in the industry. More than 400 wine companies and wineries were established in 26 provinces and municipalities operating directly under the Central Government at the end of 1997. The six leading provinces or municipalities which produced more than 10,000 tonnes of wine in 1997 were Shandong (65,500 t), Hebei (23,600 t), Tianjing (17,000 t), Beijing (16,400 t), Anhui (15,700 t) and Henan (14,600 t). The major areas for growing wine grapes, however, are essentially located in the North of China, such as in the Northeast, including Bohai Bay, Shacheng and Changli (Hebei), Qingxu (Shanxi), Yinchuan (Ningxia), Wuwei (Gansu), Tulufan Basin (Xinjiang), Shihezi (Xinjiang), as well as the ancient course of the Yellow River valley and Yunnan Maitraya.

Among hundreds of grape varieties grown in China, the following are the more important, from an economic point of view:

Table grapes: Niunai (Cow's Nipples), Kyoho, Muscat Hamburg, Thompson Seedless, Longyan (Dragon Eyes) Jingxiu, Zana, Rizamat, Fenghuang No 51, Red globe, Jingzhaojing, Jingyu, Italia and Fujiminori.

Wine Grapes: The main varieties for white wine are Chardonnay, Italian Riesling, Ugni blanc, Chenin blanc, Gewurztraminer, Sauvignon blanc, Semillon, White Riesling and Rkatsiteli. The main varieties for red wine are Cabernet Sauvignon, Cabernet franc, Merlot, French blue, Muscat Hamburg, Pinot noir, Syrah, Carignan and Saperavi.

3. PRODUCTION OF PLANTING MATERIAL

China is fortunate in not having any phylloxera pest problems. Most of the grape planting material used in the country is therefore propagated by cuttings. In some cold areas, however, vines are grafted on cold-resistant rootstocks, such as Beta (a probable hybrid between *Vitis riparia* and *V. labrusca*) and lines from *Vitis amurensis*.

4. ESTABLISHMENT OF ORCHARDS

Thorough preparation of the land is essential for successful establishment and good vine growth during the first two to three years because of poor organic matter status in the soil. The land is trenched to a width of 0.6 to 1 m and a depth of 0.8 to 1 m. The distance between the trenches depends on the distance between rows. The soil is mixed with organic matter or other fertilizer and filled back into the trenches before planting.

Young plants are set out in the vineyard in late autumn or early spring before growth begins. The planting season of vines depends upon the climate of the region. To reduce the risk of frost, vines have to be planted in early spring in most areas of north China where it is very cold in winter, while they may be planted in late autumn in the Valley of Yangtze River. The plant spacings used for grapes vary depending on the regions and the training systems. Table 3 presents the general information on the spacing and density used for establishing a new vineyard. Planting density varies from about 1,000 to 5,000 vines per hectare.

Table 3. General Suggestions for Plant Densities to be used for the Establishment of New Vineyards

Region	Trellis Form	Spacing between Rows (m)	Spacing in the Row (m)	Density Vines per ha
North China	Pergola	4.5-5.5	0.75-1.0	1818-2963
	Vertical Trellis	2.5-3.0	0.8-1.5	2222-5000
South China	Pergola	5.0-6.0	1.0-1.5	1111-2000
	Vertical Trellis	3.0	1.0-2.0	1666-3333

5. CARE AND MANAGEMENT OF VINEYARDS

Pergola and vertical trellis are the more popular forms of training used for grape growing in China. The popular training systems in the north are the multi-arm fan system with no trunk used for vertical trellis and the dragon system with a strong permanent cordon where grapevines usually need to be 'heeled' in winter. In south China or in the regions where grapevines need not be heeled in winter, the vertical trellis is frequently used. The multi-arm fan system with a strong trunk, the bilateral cordon system with two strong

horizontal cordons, the standard T bar system and the umbrella system are the most commonly used training systems.

Pruning is one of the important aspects of vine management to obtain consistently good yields and fruit quality each growing season. Dormant pruning is done in late autumn or winter before the growth begins. The one-year-old hardwood cuttings can be left as fruiting canes and are cut back to 5 to 9 buds, and sometimes to more than 10 buds if the "cane pruning" technique is used. For the hardwood cuttings to obtain renewal shoots, they have to be cut back to 2 to 4 buds. Summer pruning is done during early growing season by thinning and pinching.

Several fertilizer applications are usually carried per year in most vineyards. In general, three or four applications of chemical fertilizers are applied after bud break, at flowering, during rapid growth of young fruit, and during the maturation of grape berries. Nitrogenous and phosphorous fertilizer are usually supplied for the first two or three applications while only potash fertilizer is used during the maturation of berries. Moreover, a high quantity of manure (more than 30 t) is often applied after harvest or in late autumn. The last manure application is very important for obtaining a high grape quality because of the rather low content of organic matter in the soil.

China's continental climate produces hot, usually rainy summers, and very dry and cold winters. It is therefore necessary to supply supplementary irrigation for growing grapes in most regions. Two supplies of irrigation, one before the vines are heeled and the other one after bud break are obligatory to have a normal growth of the vines and to obtain a good yield. Irrigation is not recommended one to two months before harvest, especially for wine grapes. The climatic conditions are very variable in China. For example, it is very hot and humid in summer in the Yangtze valley, but very dry in the region of Xingjiang. Diseases are therefore, found to be different from one region to another. The main grape diseases in China are given in Table 4 according to their incidence in the various regions.

A few insects can endanger grape production in commercial vineyards. Main grape insects are the comstock mealy bug (*Pseudococcus comstocki* Kuwanna), scale (*Parthenolecanium cormi* Borchs), grape leafhopper (*Erythroneura apicalis* Nawa), grape horn worn (*Ampelophaga rubiginosa* Bremer et Grey), boston ivy tiger-moth (*Seudyra subflava* Moore), grape leaf beetle (*Oides decempunctata* Bilberg), grape erinose mite (*Colomerus vitis* Pagenstecher), grape bunch mite (*Brevipalpus lewis*i McGregor), grape clear wing moth (*Paranthrene regalis* Butler) and grape borer (*Xylotrechus pyrrhoderus* Bates).

Table 4. Main Grape Diseases Occurring on a Region-Wise Basis

Name	Causal Organism	Main Regions where the Disease Occurs
Anthracnose	*Elsinoe ampelina* (de Bary) Shear	In rainy, humid regions, especially in South China.
Downy Mildew	*Plasmopara viticola* (Berk. et Curt) Berl. et De Toni	In all regions of China
White Rot	*Coniothyrium diplogiella* (Sperg.) Sacc.	In all regions of China
Bitter Rot	*Glomerella cingulata* (Ston.) Spaul. et Schr.	In all regions of China
Powdery Mildew	*Uncinula necator* (Schw.) Bur.	In the regions of dry and hot summers, especially in North China
Grey Mold	*Botrytis cinerea* Persoon	In Hebei, Shandong, Sichun, Shanghai.
Dead Arm	*Cryptosporella viticola* (Reddick) Shear	In regions of the Northwest, Beijing, Tianjing, Hebei.
Brown Spot	*Pseudocercospora vitis* (Lev) Speg.	In all regions of China, especially in rainy year.
Axle Blotch	*Physalospora bacoae* Cavalra	In Hebei, Shandong, Henan, Liaoning, Jiangsu, Guangdong
Rust	*Phakopsora ampelopsidis* Diet. et syd	In Fujian, Guangdong, Guangxi, Sichun, Yunnan, Jiangsu.
Crown Gall	*Agrobacterium rumefaciens* (Smith et Towns) Conn.	Especially in Hebei, Beijing, Tiangjing, and the Northeast region.

6. HARVESTING AND YIELDS

Only several years ago, grape yields were very high in China, especially in the case of table grapes. Many growers obtained very high yields, as much as 40 to 60 t/ha, and sometimes up to 100 t/ha, but obviously at the expense of grape quality. Consequently, sugar content in the grapes was too low to be used for wine making and table grapes were non-marketable or sold at very low prices. In recent years, growers paid more attention to grape quality than to yield. The productivity is now severely controlled in most vineyards. The grapevines usually enter into bearing in the second or third year after planting and mature vines may produce 20 to 30 tonnes per hectare in irrigated vineyards in order to obtain a higher quality of grapes. The general information is given in Table 5 with respect to the date of harvest and the quality characteristics of wine grapes produced in North China (in Pindu, Shandong province).

Table 5. Harvest Date and General Quality of some Wine Grapes Produced in Pindu (Shandong Province)

Cultivar	Harvest Date Day/Month	Sugar (Brix)	Acids (%)	pH
Chardonnay	3/9	20	7.1	3.11
Italian Risling	3/9	18	7.2	3.09
Chenin Blanc	23/9	23	8.0	
Cabernet Franc	2/10	24	8.0	
Cabernet Sauvignon	2/10	23	8.2	
Merlot	2/10	24	7.4	3.20
Syrach	22/9	20	8.5	3.00
Gamay Noir	22/9	21	8.0	
Gewurztraminer	6/9	21	6.0	3.25
Sauvignon Blanc	4/9	21	8.2	3.08
Pinot Noir	22/8	16.5	7.7	3.15

Source: Zhusheng Dong, 1992

7. MARKETING

Most fruits produced in China are traded in the national marketing system. The volume of exported fruits is very small, averaging about 600,000 tonnes per year or 1.2 percent of total national production (Table 6). The situation with regard to grape marketing is the same as for other fruits. 650 tonnes of grapes and 1,100 tonnes of raisins were exported in 1997. This volume of grape exports ranks sixth in fruit exports of the People's Republic of China following apples, citrus, pears, bananas and peaches (nectarines included). However, the volume of grapes imported is much more significant if compared with that exported. Nearly 4800 tones of grapes were imported in 1997, some 7.4 times more than that exported. This import was essentially from USA and most of these grapes imported were the Red globe variety. With regard to raisins imported into China, the volume is less than that exported. Nearly 460 tonnes of raisins were imported in 1997, which amounted to about half of that exported.

Table 6. Fruit Exports and Imports in China (1997)

Fruit Crop	Export			Import		
	Volume (x1000t)	Value (x1000US$)	Price (US$/kg)	Volume (x1000t)	Value (x1000US$)	Price (US$/kg)
Apples	188.4	77441.7	0.411	11.5	3493.6	0.308
Citrus (oranges, Tangerines etc.)	223.1	7584.00	0.340	13.8	3926.7	0.285
Pears	120.0	52579.3	0.438	0.37	126.1	0.341
Bananas	14.7	5364.3	0.365	549.6	146410.4	0.266
Peaches and Nectarines	3.7	1115.2	0.301	0.016	5.7	0.356
Grapes	0.65	226.0	0.348	4.8	2221.9	0.463
Raisins	1.1	1496.0	1.36	0.46	386.9	0.841
Kiwifruits	0.016	33.0	2.062	0.88	554.3	0.630
Litchis	4.8	6216.3	1.295	1.8	699.9	0.389
Total	601.6	234018.9	0.389	640.4	175694.4	0.274

8. POTENTIAL FOR GRAPE PRODUCTION DEVELOPMENT

As described above, the establishment of vineyards in China is different from that of other countries in the world and most of the grape production is for table grapes. Although the wine industry has made rapid progress in recent years, the per capita production of wine remains small, as low as about 0.2 L per person. This production is far below the average wine consumption in the world (about 7 L per person) and does not satisfy the current consumption requirements of the Chinese people. This deficiency in production has resulted in the following situation in the country.

Firstly, many new wine companies and wineries have sprung up like mushrooms in recent years. There were about 240 wine companies and wineries by 1995, after a development phase spanning over a century in China, but an additional 200 wine companies and wineries were founded only during 1996 and 1997. The wine production capacity was almost doubled during these two years, mostly in Hebei, Shandong, Yunnan, Gansu, Ningxia, and Guangdong. Secondly, the area under cultivation of grapes increased rapidly all over the country, especially during the last two or three years. This rise in the cultivated area was essentially for wine grapes. Lastly, China experienced a sharp increase in wine imports, especially from European countries, with nearly 5,900 tonnes of wines being imported into China in 1996, which amounted to 7.7 times more than that of 1995. Import of wines continued to increase during the following years, exceeding 39,670 tonnes in 1997 and 49,840 tonnes in 1998.

The change in consumption habits of alcoholic beverages in modern China resulted in the above phenomenon. Chinese have a tradition of consuming alcoholic beverages, especially drinking of spirits distilled from sorghum and maize. This habit has been changing since the 1970's. Beer production in tonnage was more than 50 percent of the national alcoholic beverage production by the end of the 1980's. Since the early 1990's, consumption of wines has become a trend of the times. More and more people consumed wine instead of spirits and the demand for wine will continue to increase in the following years. China has, therefore, a high potential for grape development, especially for the wine industry. It is absolutely certain that the area under cultivation of grapes will continue to increase in the

coming years. The margin between wine production and demand is still very wide. Nearly nine millions tonnes of wine would be required per year to satisfy the current national requirements if the average consumption of wine reaches that of world per capita consumption.

9. CONSTRAINTS IN GRAPE PRODUCTION DEVELOPMENT

After continuous rapid development during the past twenty years, China has achieved great success in grape production. However, some problems arose at the same time as this rapid development of grape production in the country. Some of the salient problems have to be resolved if the country is to have a steady development of the grape industry in the future. Much more attention should therefore be paid to grape and wine quality rather than productivity, although the latter has been much improved during the last 10 years. Long-term planning for grape development in the whole country must be carried out in identifying new varieties, locating growing regions for new vineyards, and developing strategies for increasing production and processing into wine. Production of planting material has to be controlled by the Government for quality control purposes. Following the rapid increase of area under cultivation of grapes, it has been difficult to control the quality of plants by the Government. Moreover, many plants were imported mainly from European countries, such as 4.5 million cuttings from France in 1998. Monitoring the health of materials has therefore become a new problem for the grape industry in China. Both the grape production and wine industries need to be supported by the Government, research institutions and foreign companies with equipment, investments and advanced technologies.

10. GOVERNMENT POLICIES AND PLANS FOR RESEARCH AND DEVELOPMENT ON GRAPES

The Government of China has paid considerable attention to grape production and winery development since the founding of the Peoples Republic of China. Two national grape germplasm repositories were set up at Zhengzhou Fruit Research Institute of the China Academy of Agricultural Sciences (located at Zhengzhou, Henan province) and at the Institute of Fruit Research of Shanxi Academy of Agricultural Sciences (located at Taigu, Shanxi province). More than 1,300 varieties were collected in these two national grape germplasm repositories. Some varieties of grapes, mainly for table grapes, have been developed at the same time by Chinese researchers and breeders. Some of the popular Chinese varieties which have been cultivated or are being popularized are listed below:

Table Grapes: Zaomeigui, Zhengzhuo Zaohong, Fenghuang No 51, Jing Zaojing, Shangdong Zaohong, Jingxiu, Jingya, Zizhenxiang, Shengxiu, Jingyu, Fenghou;

Wine grapes: Beichun, Gongliang No 1, Shuangyou, Zuoshan No 1.

Moreover, many significant research findings have been made on identifying suitable agro-climatic zones for growing grapes (especially for wine grapes). Propagation of materials (including micro-propagation techniques), establishment of vineyards, training systems and pruning methods, fertilization and irrigation management, grape quality improvement, and table grape storage are some of the significant advances made in grape research.

The wine production in China is estimated to be over 300,000 tonnes by the year 2000. According to the wine consumption patterns in the last few years, the Government plans to achieve an annual increase of 50,000 tonnes in wine production in the coming 10 years. This means that China would produce 800,000 tonnes by 2010 and about 3,000 to 4,000 ha of wine grapes must be established each year in the future. In order to satisfy this increase of wine production in China, some emphasis would have to be made by the Government on controlling quality of planting material (by establishing "the Propagation Centre for Grape Materials"), planning a long-term programme for table grape and wine production in the whole country. The establishment of a wine grape industry and increasing the rate of the development of grape production by training farmers and controlling grape quality and wine quality are some of the important aspects of this strategy.

11. CONCLUSIONS

In the past 20 years, China has achieved great success in viticulture development. Grape production has increased sharply (in 1998 it was 22.7 times more than in 1978) and the quality of grapes has improved very much. China has still a great potential for developing viticulture and the wine industry. The area under cultivation of grapes and their production will continue to increase in the next few years. However, the emphasis on production development of wine grapes will be more rapid when compared to table grapes.

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GRAPE PRODUCTION IN INDIA

S.D. Shikhamany *

1. INTRODUCTION

Grape cultivation is one of the most remunerative farming enterprises in India. Famous Indian medicine scholars, Sasruta and Charaka in their medical treatises entitled '*Sasruta Samhita'* and *'Charaka Samhita',* respectively, written during 1356-1220 BC, mentioned the medicinal properties of grapes. Kautilya in his *'Arthashastra'* written in the fourth century BC mentioned the type of land suitable for grape cultivation. Native spp. resembling *Vitis lanata* and *Vitis palmata* grow wild in the northwestern Himalayan foothills. Indigenous varieties known as 'Rangspay', 'Shonltu White' and 'Shonltu Red' are grown in Himachal Pradesh even today.

Cultivated grapes are believed to have been introduced into the north of India by the Persian invaders in 1300 AD, from where they were introduced into the south (Daulatabad in Aurangabad district of Maharashtra) during the historic event of changing the capital from Delhi to Daulatabad by King Mohammed-bin-Tughlak. Ibn Batuta, a Moorish traveller who visited Daulatabad in 1430 AD, reported to have seen flourishing vineyards in south India. Grape was also introduced in the south into Salem and Madurai districts of Tamil Nadu by the Christian missionaries around 1832 AD, and into Hyderabad province by HEH, the Nizam of Hyderabad in the early part of the 20th century. From Delhi, Daulatabad, Madurai, Salem and Hyderabad, grape cultivation spread to different parts of the country.

2. PRESENT STATUS OF GRAPE CULTIVATION IN THE COUNTRY

Grape is grown under a variety of soil and climatic conditions in three distinct agro-climatic zones, namely, sub-tropical, hot tropical and mild tropical climatic regions in India.

Sub-tropical Region: This region covers the northwestern plains corresponding to 28° and 32° N latitude including Delhi; Meerut district of Uttar Pradesh; Hissar and Jind districts of Haryana; and Bhatinda, Ferozpur, Gurdaspur and Ludhiana districts of Punjab. Vines undergo dormancy and bud break starts in the first week of March while the rains arrive in the first week of June, and therefore, only 90-95 days are available from the initiation of growth to harvest. Consequently, 'Perlette' is the only early ripening variety grown in this region. Rain damage is a problem with Thompson Seedless in this region. Single pruning and a single harvest is the accepted practice here.

Hot Tropical Region: This region covers Nashik, Sangli, Solapur, Pune, Satara, Latur and Osmanabad districts of Maharashtra; Hyderabad, Ranga Reddy, Mahbubnagar, Anantapur and Medak districts of Andhra Pradesh; and Bijapur, Bagalkot, Belgaum, Gulberga districts of northern Karnataka lying between 15° and 20° N latitude. This is the major viticulture region accounting for 70 percent of the area under grapes in the country. Vines do not undergo dormancy and double pruning and a single harvest is the general

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practice in this region. Maximum and minimum temperature is 42°C and 8°C, respectively. The major problems in this region are soil and water salinity and drought. Berry growth is impaired and in certain locations pink blush sometimes develops on green berries due to temperatures that drop to a low of 8°C. Thompson Seedless and its clones (Tas-A-Ganesh, Sonaka), Anab-e-Shahi, Sharad Seedless and Flame Seedless are the varieties grown in this region.

Mild Tropical Region: An area covered by 10° and 15° N latitude including Bangalore and Kolar districts of Karnataka; Chittoor district of Andhra Pradesh and Coimbatore; and Madurai and Theni districts of Tamil Nadu fall in this region. Maximum temperatures in a year seldom exceed 36°C, while the minimum is about 12°C. Principal varieties are Bangalore Blue (Syn. Isabella), Anab-e-Shahi, Gulabi (Syn. Muscat Hamburg), and Bhokri. Thompson Seedless is grown only with limited success. Except for Thompson Seedless, two crops are harvested in a year.

Vinifera varieties susceptible to mildew suffer losses due to unprecedented rains during flowering and fruit set in both hot and mild tropical regions.

Area and production of different varieties of grapes in India is as follows:

Variety	Area (ha)	Production (t)
Anab-e-Shahi (white, seeded)	3,000	135,000
Bangalore Blue Syn. Isabella (black, seeded)	4,500	180,000
Bhokri (white, seeded)	500	15,000
Flame Seedless (red, seedless)	500	10,000
Gulabi Syn. Muscat Hamburg (purple, seeded)	1,000	30,000
Perlette (white, seedless)	1,500	60,000
Sharad Seedless - A mutant of Kishmish Chorni (black, seedless)	1,000	20,000
Thomson Seedless and its mutants (white, seedless)	22,000	550,000
Total	**34,000**	**1,000,000**

Approximately 85 percent of the total production, irrespective of the variety, is consumed fresh. About 120,000 tonnes of Thompson Seedless and its mutants, namely, Tas-A-Ganesh, Sonaka and Manik Chaman are dried for raisins. Some 20,000 tonnes of Bangalore Blue are crushed to make juice, and 10,000 tonnes of Bangalore Blue, Cabernet Sauvignon, Chenin Blanc, Chardonnay, Merlot, Pinot Noir and Uni Blanc are crushed to process into wine.

3. PRODUCTION OF PLANTING MATERIAL

Vines are raised on their own roots in India. Due to the non-prevalence of Phylloxera or nematodes, rootstocks are not employed, but in recent years, the 'Dogridge' rootstock is being employed to combat soil and water salinity problems.

Multiplication on Own Roots

Grapes are multiplied exclusively by the rooting of hardwood cuttings. No Government agency is involved in the multiplication and supply of rooted cuttings. Growers themselves obtain the hardwood cuttings from elite vineyards and raise their own nurseries. Well matured canes obtained in September/October are selected. Cuttings of 4 nodes each with a thickness of 8 to 10 mm are made from the selected canes. The fresh cuttings are soaked in running water for 24 hours to leach out the water-soluble rooting inhibitors. The basal parts of cuttings are then dipped in a 2,000 ppm strong IBA solution for five minutes before planting. It is also a practice to plant the cuttings *in situ* when three to four cuttings prepared and treated as above are planted at each spot in the main field. Soil drenching with chlorophyriphos 0.1 percent is a practice to safeguard the cuttings against termite damage.

Raising on Rootstocks

Hardwood cuttings of the 'Dogridge' rootstock are subjected to rooting, preferably in polybags of 15 x 25 cm. Rooted cuttings of this rootstock are planted in the main field during February-March. The desired scion variety is then grafted/budded on the rootstocks in the field by wedge grafting/chip budding. Wedge grafting is more common and the best time for the operation is September-October, while June-July is the suitable time for chip budding.

4. ESTABLISHMENT OF VINEYARDS

Land Preparation and Vine Establishment

The land is tilled and laid into plots of 120 m x 180 m separated by 3 m wide roads. Land within a plot is levelled perfectly to have a gradient of less than 1 percent in any direction to ensure uniform discharge of water through the emitters of drip irrigation systems.

Trenches of 75 cm width, 75 cm depth and 118 m length in a north-south direction with a gap of 3 m between trenches are opened with heavy machinery. They are closed with topsoil, up to a height of 45 cm after 15 days exposure to sun. The remaining gap is filled with a mixture of soil, cattle manure, single superphosphate, sulphate of potash and micro-nutrients. Usually, 50 kg of cattle manure, 2.5 kg of superphosphate, 0.5 kg of sulphate of potash and 50 g each of $ZnSO_4$ and $FeSO_4$ are added to the soil for every running meter length of the trench.

Planting Season

The best season for planting the rooted cuttings of cultivated varieties in the main field is September-October whereas for rootstocks it is February-March.

Spacing

Spacing generally varies with the varieties and soil fertility. For vigorous varieties it is 6 m x 3 m or 4 m x 3 m and 3 m x 3 m or 3 m x 2 m for less vigorous varieties.

5. CARE AND MANAGEMENT OF VINEYARDS

5.1 Training of Vines

Many training systems are in vogue in India, but the most popular are Bower, Telephone and Flat Roof Gable systems.

Bower System: Owing to the high productive potential, bower was a very popular system of training in the past. It is highly suited for vigorous varieties like Anab-e-Shahi, Bangalore Blue and Gulabi. But in varieties like Thompson Seedless and Tas-A-Ganesh where vine vigour and excessive foliage density affects the productivity adversely, this system is not popular.

Telephone System: T-trellis is used in this system of training. With three top wires and 'T' shaped supports, the trellis looks like a telephone pole and wires and hence the name.

This system is followed for moderately vigorous varieties like Thompson Seedless and other seedless cultivars in about 25-30 percent of the vineyard area in Maharashtra. Yields in this system are less than the bower. In very hot and dry places, sunburn of the berries and of the arms are experienced in summer.

Flat Roof Gable System: Combining the advantage of bower and the extended Y systems and eliminating their disadvantages, an inter-connected Y trellis forming a flat roof gable is being adopted. This system is particularly followed for vigorous vines (vines grafted on rootstocks). The bunches are protected from direct sunlight and well exposed to sprays of pesticides. The clusters hang within the reach of the worker of an average height. Owing to these advantages, this system is gaining popularity among the growers in Maharashtra, Andhra Pradesh and Karnataka.

5.2 Pruning of Vines

Three distinct pruning practices are in vogue in relation to cropping in the three grape growing regions of the country. In the sub-tropical region, vines are pruned only once in December and the crop is harvested once. Half of the canes are pruned to renewal spurs and the rest to fruiting canes (3-4 nodes for Perlette).

In hot tropical regions, vines are pruned twice but only one crop is harvested. All canes in a vine are pruned back to single node spurs in March-May to develop canes and the canes are forward pruned in October-November for fruiting. The number of nodes retained on a cane varies with the variety and cane thickness. There is no scope to prune earlier than October and later than November due to unfavourable weather conditions.

In the mild tropical region, vines are pruned twice and the crop is harvested twice. In varieties like Gulabi and Bangalore Blue, which are fairly resistant to rain damage and in

which fruit bud differentiation is not impaired by cloudy weather and rains, pruning is done at any time of the year. As a result, five crops are harvested every two years.

5.3 Application of Manure and Fertilizers

As vineyard soils are either sandy loams or heavy clays, the usage of organic manure has assumed high importance in India. A standard dose of 500:500:1000 kg of N, P_2O_5 and K_2O per hectare is followed in light sandy soils, while 660:880:660 kg are applied for heavy clay soils. The annual dose is fixed based on the petiole analysis carried out at 45 days after spur pruning. While 40 percent of the annual dose is given through organic sources, 60 percent is given as inorganic fertilizer. Calcium ammonium nitrate is usually not used. Sulphate of potash is the only source of potash used in place of muriate, particularly in heavy clay soils. Recently application of soluble fertilizers through drip irrigation is picking up. 40 percent of N, 50 percent of P_2O_5 and 33 percent of K_2O of the annual dose is given during the growth season and the rest in the fruiting season.

5.4 Weeding

Weeds between the rows of vines are removed mechanically by tractor drawn implements. Within the rows, weeds are manually hoed and removed. Sometimes the post-emergent weedicides, mainly glyphosate at about 2.0 kg/ha or paraquat at about 7.5 kg/ha is sprayed in fully grown vineyards.

5.5 Supplementary Irrigation

Since grapes are grown in areas where the evapotranspiration exceeds the precipitation, irrigation is essential. Less than 10 percent of the vineyard areas are surface irrigated, while the rest is irrigated by drip systems. Water requirement is calculated based on the pan evaporation using 0.8 as the crop factor. Water is applied at different rates at different stages of vine growth and berry development.

5.6 Pests and their Management

The important pests of grapes in India are, flea beetles, thrips, mealy bugs and leaf hoppers.

Flea beetles: The adult beetles scrape the sprouting buds and eat them up completely after each pruning. Damaged buds fail to sprout. Insecticides like carbaryl at 0.15 percent, quinolphos at 0.05 percent, dichlorvas at 0.1 percent or phosalone at 0.05 percent are sprayed from the fourth day until the emergence of leaves.

Thrips: Thrips attack the ovaries of flowers and newly set berries and suck sap from them. The affected berries develop a corky layer and become brown on maturity. Scab formation on the berry surface is also due to thrip damage to the ovaries/young berries. Such berries are not suitable for marketing. Thrips are effectively controlled by spraying phosphamidon at 0.05 percent, carbaryl at 0.125 percent, phosalone at 0.05 percent or malathion at 0.05 percent. Prophylactic sprays of insecticides against thrips are given once in five days from the initiation of bloom to berry set.

Mealy Bugs: Mealy bugs are the most serious and problematic pests of grapes in India. Nymphs and adults suck sap from the tender shoots resulting in crinkling and stunting of the new shoots. They excrete honey on leaves and berries and sooty mold develops on the honey. Mealy bug infected bunches are unfit for marketing. Yield losses can be up to 50 percent due to mealy bug damage. Mealy bugs are hard-to-kill insects and the package of practices for their control in India is as follows:

i) Avoid spraying broad-spectrum insecticides particularly synthetic pyrethroids.
ii) Spray only dichlorvas at 0.1 percent mixed with neem oil 0.2 percent or tridemorph at 0.1 percent.
iii) Release *cryptolaemus montrozieri* beetles at 8,000-10,000 per hectare when the berries start softening. It is better to release a mixed population of grubs and adults rather than only adults.

Leaf hoppers: This pest has assumed serious proportions in all grape growing regions of India in recent years. The adults and young nymphs of hoppers suck sap exclusively from the lower side of the leaves. Carbaryl at 0.15 percent, fenitrothion at 0.04 percent, phosalone at 0.05 percent or quinalphos at 0.05 percent are sprayed to control this pest. A mixture of quinalphos at 0.05 percent and phosalone at 0.05 percent is more effective on the nymphs while tridemorph at 0.1 percent only is effective on the adults.

5.7 Diseases and their Management

The important grape diseases are anthracnose, downy mildew, powdery mildew and bacterial leaf spot. In recent years, *Alternaria* is also becoming a serious pathogen.

Anthracnose is prevalent in all grape growing regions of the country. The disease is characterized by small light brown or greyish black lesions on tender shoots, young leaves, flowers and young berries. Bordeaux mixture at 0.8 percent, copper oxychloride at 0.25 percent or carbendazim at 0.1 percent are used to control this disease.

Downy mildew is the most devastating disease of grapes in the tropical region of the country. The disease mainly appears on the leaves, but also attacks the flower clusters and young fruits. The losses are very high when it attacks the clusters before fruit set. Entire clusters decay, dry and drop down. Properly neutralized Bordeaux mixture at 1 percent, copper oxychloride at 0.2 percent, Mancozeb at 0.2 percent, metalaxyl (Ridomil Mz at 0.2 percent) or Phosethyl-Al (aliettle at 0.2 percent) are used against this disease.

Powdery mildew is prevalent in all the grape growing regions. It is next in importance to downy mildew in its devastating severity. The disease is characterized by the presence of white powdery (ash like) coating in patches on both sides of the leaves, young shoots and immature berries. Powdery mildew is controlled easily by wettable Sulphur formulations. A wide range of fungicides, namely, Calaxin at 0.07 percent, Karathane EC at 0.04 percent, Myclobutanil (Systhane at 0.05 percent), Triademifon (Bayleton at 0.1 percent) and Penconazol (Topas at 0.025 percent) are used to control this disease.

Bacteria infects leaves, shoots and berries. The symptoms appear as minute water soaked spots on the lower surface of the leaves, especially along the main and lateral veins. Mostly these spots coalesce and form larger patches. Severely infected leaves give a blighted appearance. Streptocyclin at 500 ppm is used as a prophylactic spray, while

Bordeaux mixture at 0.8 percent or copper oxychloride at 0.15 percent is used to check its spread.

5.8 Physiological Disorders

Physiological disorders associated with high temperature and low atmospheric humidity in the hot tropical region are dead arm and trunk splitting. Salinity injury is common in Maharashtra and north Karnataka. Other physiological disorders are cane immaturity, water berries, cluster tip wilting, shot berries, uneven ripening and post-harvest berry drop. The eco-physiological disorders are '*coulure'*, blossom-end rot, pink berry syndrome, berry cracking and rotting.

5.9 Quality Improvement

Shoot and Cluster Thinning: Only one or two clusters are retained per cane depending upon the density of the latter. Irrespective of the number of clusters, only the apical two or three shoots are retained. In vines trained to the flat roof gable, individual shoot length is encouraged rather than the total canopy size for preventing sunburn of the berries.

Production of Loose Clusters: Pre-bloom GA sprays of 10 ppm and 15 ppm are given respectively on the 11^{th} to 14^{th} day after bud break for cluster elongation. Rachides of the clusters are trimmed to retain 8-10, depending on the number of leaves available per cluster. Clusters are dipped in GA solution of 30-40 ppm when 10-20 percent of the flowers open in each cluster for berry thinning.

Increasing Berry Size: Manual means are used to supplement chemical thinning to ensure adequate berry thinning and improve the quality of grapes. Approximately 90-120 berries are retained per cluster depending upon the number of leaves available to nourish it at 8-10 berries per every leaf depending on its size. Clusters are dipped in GA solution of 40-50 ppm concentration once at 3-4 mm size of the berries and again at 7-8 mm size. When berry diameter is to be increased to more than 16 mm, clusters are dipped in a mixture of 10 ppm BA + 25 ppm GA or 2 ppm CPPU + 25 ppm GA or 1 ppm brassinosteroid + 25 ppm GA instead of GA alone at these two stages.

In addition to the treatment with growth regulators, berry size and crispiness are increased by girdling. The width and depth of girdling are 1-1.5 mm. Girdling is done at 4-5 mm diameter of the berries.

Increasing the TSS Content: Berry thinning and cluster thinning to maintain adequate leaf/fruit ratio (5 cm^2), while girdling will ensure a TSS content of 20°B.

6. HARVESTING AND YIELDS

Approximately one million tonnes of grapes are harvested annually in India. Grape is harvested almost all the year round. If not all the varieties, one or more varieties are always available at any given time of the year. Period of harvest and yield of different varieties is given below.

Variety	Yield (t/ha)		Period of Harvest
	Average	Potential	
Anab-e-Shahi	45	90	February-May, July, November-December
Bangalore Blue	40	60	January-March, June-December
Bhokri	30	50	November-December, June-July
Gulabi	30	50	January-March, June-December
Perlette	40	50	June
Thompson Seedless and other seedless varieties	25	50	January-April

However, the major proportion of produce, mainly of Anab-e-Shahi, Thompson Seedless and its clones, is harvested during March-April from the hot tropical region, which contributes more than 70 percent of the total harvest.

The productivity of grapes in India is very high, particularly in the Hyderabad region. Yields as high as 100 t/ha in Anab-e-Shahi and 75 t/ha in Thompson Seedless were recorded in this region. However, quality of grapes is usually poor as a result of high yields.

7. MARKETING

More than 80 percent of the total production is consumed as table grapes in India, and more than 70 percent of the total production is harvested in March-April, but the cold storage facilities are inadequate. Therefore, market gluts and fall of prices of grapes in March-April are common. Approximately, 2.5 percent (22,000 t) of fresh grapes are exported to the Middle East and European countries. The rest of the produce is marketed within the country. Grapes are exported through three different agencies viz., Grower Exporters, Growers' Cooperatives and the Trader exporters. These agencies have established their own facilities for pre-cooling and cold storage in the vicinity of major production sites.

8. POTENTIAL FOR GRAPE PRODUCTION DEVELOPMENT

India has the distinction of achieving the highest productivity in grapes in the world, with an average yield of 30 t/ha.

a) Sustaining productivity and minimizing risks in grape cultivation is possible because of the availability of a variety of agro-climatic regions suitable for grape cultivation for table, raisin and wine grapes.
b) Technologies to achieve high productivity are currently available.
c) Scope for double cropping in certain regions and harvesting round the year in certain varieties is practically feasible.
d) Technologies to produce export quality grapes and quality raisins are available.

9. CONSTRAINTS IN GRAPE PRODUCTION DEVELOPMENT

Although grape cultivation is considered as highly remunerative, the area under grapes is confined to only 34,000 hectares due to the following constraints.

a) Heavy initial investment for establishing a vineyard.
b) High recurring costs in vineyard management.
c) Narrow variety base and lack of diversity in utilization of the germplasm available in grape growing countries.
d) High risk of losing the crop due to unprecedented changes in weather.
e) Soil and water salinity in Maharashtra and drought in the hot tropical areas.
f) Short period available for ripening in the north.
g) Very low proportion of export quality grapes.
h) Wine is not a popular drink at present.
i) Marketing problems in table grapes.

10. GOVERNMENT POLICIES AND PLANS FOR RESEARCH AND DEVELOPMENT OF GRAPES

The Government of India is supporting the grape industry of the country in the following ways:

a) Encourage and support the farmers for establishing the vineyards and installing drip irrigation systems by providing soft loans and subsidies.
b) Provide research support to sustain the productivity of grapes under adverse situations.
c) Promote and support the export of fresh grapes by training the growers and providing soft loans and subsidies for pre-cooling and cold storage facilities.

Research on grapes is carried out by the Indian Council for Agricultural Research (ICAR) Institutes and State Agricultural Universities at different centres under the All India Coordinated Research Project on Grapes. The National Research Centre for Grapes (ICAR) located at Pune, Maharashtra is the focal point for conducting and coordinating the research activities on grapes throughout the country.

11. CONCLUSIONS

Grape is cultivated over an area of 34,000 hectares with an annual production of 1,000,000 tonnes. Although, the returns per unit area of land are very high with grape cultivation, the area under grapes is not expanding fast owing to the high initial cost of establishing the vineyards and high recurring cost of production. The risk of losing a crop due to unprecedented changes in weather is also very high. Since the highest productivity in grapes has been achieved, efforts are needed to extend grape cultivation to newer areas. Soil and water salinity and drought are the impediments in this direction, for which suitable rootstocks are to be identified.

There is a need to diversify the uses of grapes. Currently more than 80 percent of the produce is used for table purposes. The major bulk of the produce is harvested in March-

April, but as cold storage facilities are currently inadequate there are frequent market gluts. Diversification of uses as wine/juice and export of table grapes can ease the marketing problems. Maintenance of quality of table grapes by crop regulation is the priority consideration to increase exports. For the survival of the grape industry in India, the produce should be quality and cost competitive. Future efforts are to be concentrated in this direction.

GRAPE PRODUCTION IN JAPAN

Kunihisa Morinaga *

1. INTRODUCTION

Several species of the genus *Vitis*, such as *Vitis coignetiae* Pulliat., *V. flexuosa* Thumb., and *V. amurensis* Rupr., are native to Japan. However, they have not been brought into cultivation or for breeding. The first grape culture in Japan dates back to the 12th century, when a wild grapevine bearing good fruit bunches was found in Yamanashi. The vine was apparently not native to the land, suggesting that its ancestor might have been imported from China in the 8th century. The progenies from the vine adapted to the environment of that district, and the cultivar 'Koshu' was thus released. In the 17th century, 'Koshu' grapes became famous for their excellent fruit quality. In the late 19th century, the Government actively imported numerous species including *V.vinifera, V.labrusca,* and *V.labruscana* from the USA and European countries. However, most *vinifera* grapes could not be cultivated successfully because of the spread of diseases. Only a few *vinifera* cultivars, such as 'Muscat of Alexandria,' could grow normally with the aid of glasshouses. The vines of both *V.labrusca* and *V.labruscana*, on the other hand, grew successfully. 'Catawba,' 'Campbell Early,' and 'Delaware' were planted in Yamanashi, Osaka, and Okayama prefectures in the early 20th century.

Grape growers tried to breed new good quality table grapes suitable for the humid conditions of Japan. Some cultivars, such as 'Kyoho,' 'Muscat Baily A,' 'Neo Muscat,' and 'Hiro Hamburg,' were identified from the crosses between *V.vinifera* and *V.labruscana* or between *vinifera* grapes in the middle 20th century. These cultivars, however, could not be cultivated successfully because of poor berry set and susceptibility to fungal attack in those days.

The cultivation of grapes grew rapidly from 1960 to 1980. Success in the production of seedless 'Delaware' grapes by GA treatment further accelerated the spread of this cultivar. The cultivar 'Kyoho,' famous for its large sized berries and excellent taste, was also planted throughout the country except in Hokkaido, the northernmost island. Another contribution in the development of grape growing was the application of plastic films, which greatly decreased the spread of diseases and increased both yield level and fruit quality. The practice of forcing culture by heating the vines in plastic houses also spread. Recently, propagation of virus-free vines has been developed using the technology of *in-vitro* cultures of heat-treated stem apices. Vine growth and fruit quality have also been significantly improved. This has resulted in the spread of virus-free vines in most newly established vineyards that are suitable for replanting. The main producing areas have been established in the north, central, and western districts of the country.

Viticulture in Japan started from adoption of the variety 'Koshu' (*Vitis vinifera* var. *orientalis*), which was discovered in Yamanashi in 1186. Thereafter, European and

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American grape cultivars were introduced in the 1800's. Most *V. vinifera* grapes from Europe could not grow well because of serious damage by Phylloxera and many other diseases. On the other hand, American cultivars derived from *V. labrusca* were suited to the Japanese environmental conditions. 'Delaware,' 'Campbell Early,' 'Niagara,' and 'Concord' became popular at the beginning of the 20th century. Thereafter, the popularity of 'Kyoho' increased rapidly in the 1970's.

It is important to develop new grape cultivars that are well suited to the Japanese environmental conditions and consumers' preferences. Grape-breeding programmes in Japan that originated in the 1920's aimed at these objectives. More than 200 grape cultivars have been developed so far. Thus, conventional techniques by cross-hybridization have contributed to the development of the grape industry. However, when using this approach, not only desirable but also unfavourable characteristics are inherited. Recent advances in biotechnology offer many strategies, such as gene transformation and molecular markers for breeding, and may help overcome the limitations of conventional techniques.

2. PRESENT STATUS OF GRAPE CULTIVATION IN JAPAN

Grape production has been undertaken in all four main islands in Japan from north to south. The major producing regions are Yamagata, Yamanashi, and Nagano prefectures in the northern and central parts, and Okayama and Fukuoka prefectures in the southern part of Japan (Figures 1 and 2). In 1997, the total grape production was 250,900 metric tonnes (Figure 3), and the vineyard area was 22,800 hectares. (Figure 4). Most vineyards in Japan produce table grapes. In 1997, table grapes made up 87.4 percent of the total production, while 11 percent and 1.4 percent went to the production of wine and juice, respectively.

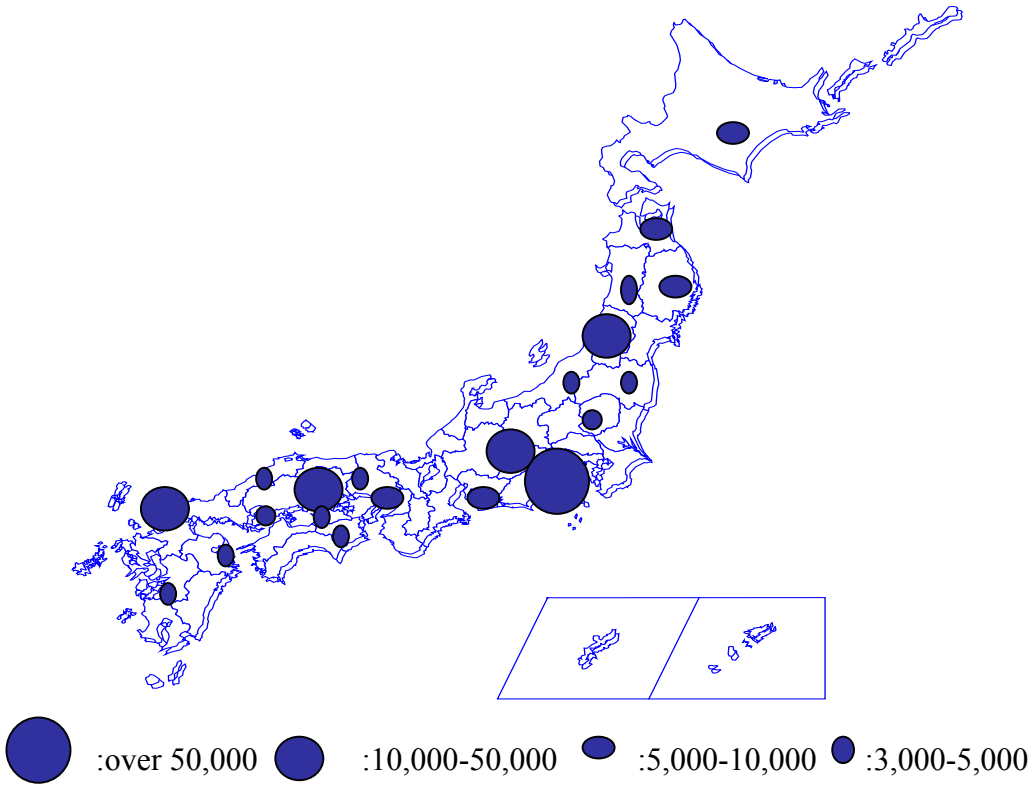

Figure 1. Major Areas of Grape Production in Japan (table grapes, metric tonnes, 1997)

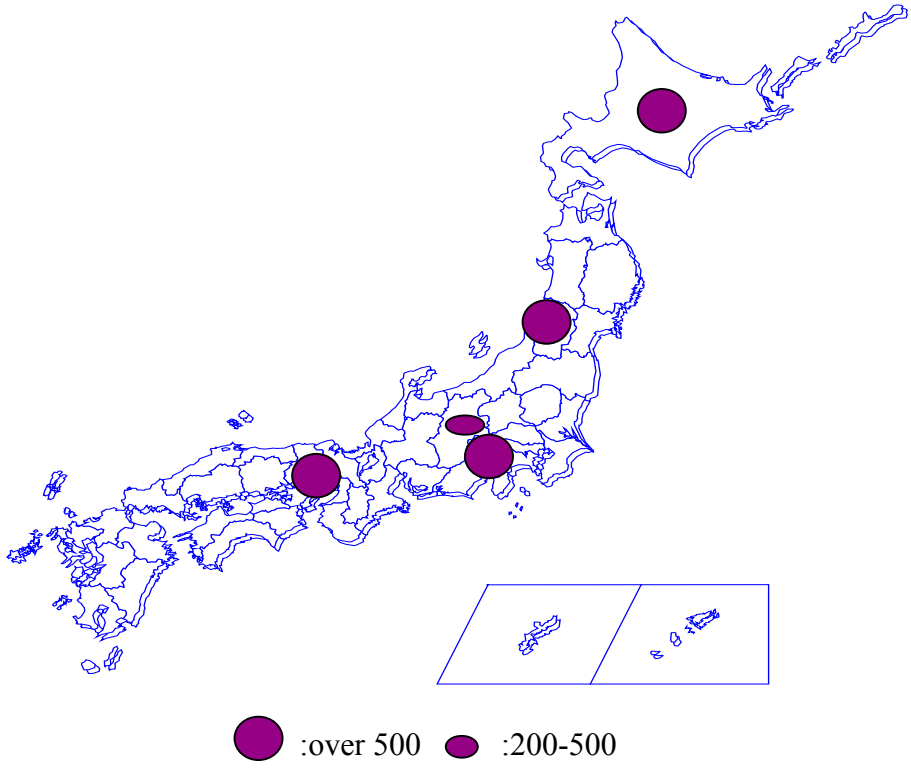

Figure 2. Major Areas of Grape Production for Processing (metric tonnes, 1997)

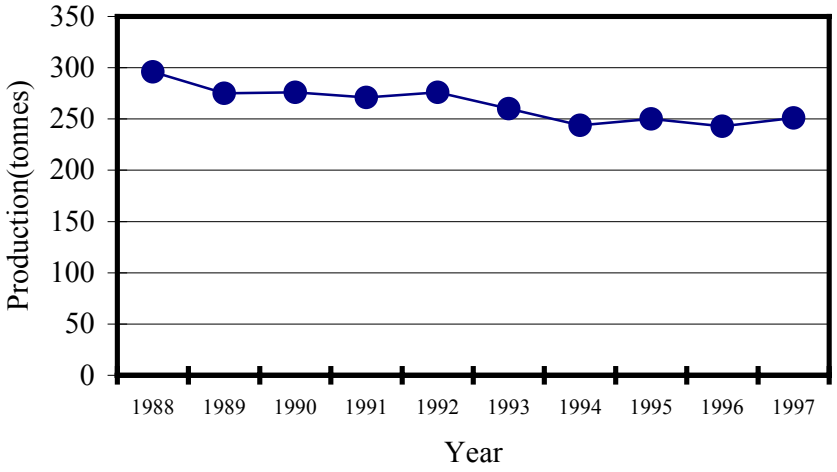

Figure 3. Total Production of Grapes

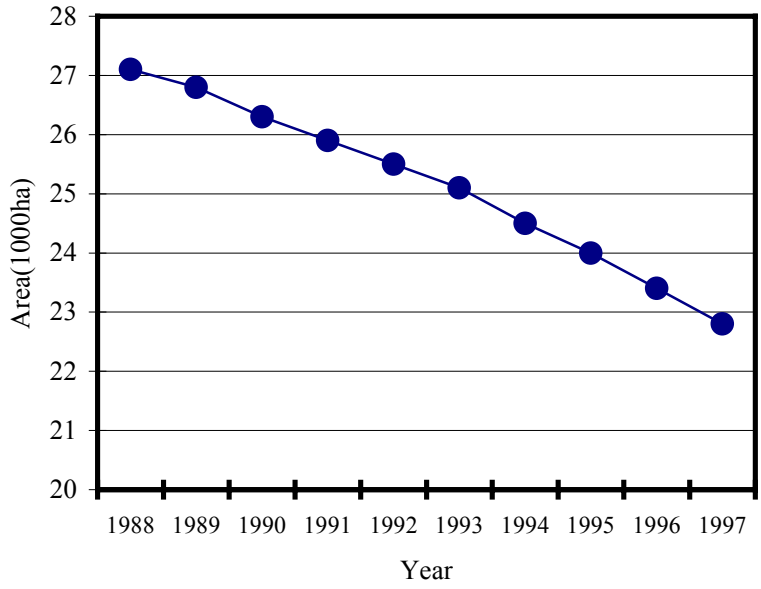

Figure 4. Total Area Under Cultivation

Table 1. Grape Production and the Proportion of Table Grapes and Grapes for Processing (1997)

Product	Production (tonnes)	Proportion of total production (%)
Table Grape	219,300	87.4
Wine	27,700	11.0
Juice	3,500	1.4
Canned Fruit	400	0.1
Total Production	250,900	100

'Kyoho,' a tetraploid, which is one of the main cultivars in Japan, produces large sized berries exceeding 15 g with strong sweetness (18-20 Brix) and good flavour. Another major cultivar is 'Delaware', which is one of the *labrusca* cultivars introduced from the USA in the late 19th century. This is the first cultivar in which the production of seedless berries by GA (gibberellic acid) treatment was successful. Main cultivars grown are shown in Tables 2 and 3.

Table 2. Main Cultivars Grown in Japan (table grapes, 1997)

Cultivars	Area (ha)	Proportion (%)
Kyoho	6,531	33.0
Delaware	4,878	25.0
Campbell Early	1,500	7.6
Pione	1,400	7.5
Muscat Baily A	864	4.4
Niagara	492	2.5
Kosyu	470	2.4
New Baily A	382	1.9

Table 3. Main Cultivars Grown in Japan (for Wine and Juice, 1997)

Cultivars	Area (ha)	Proportion (%)
Yamabudo (*V. coignetiae*)	124.2	19.8
Muller Thurgau	102.7	16.4
Chardonnay	96.3	15.3
Merlot	88.6	14.1
Cabernet Sauvignon	69.9	11.1
Seibel	69.7	11.1

Some new cultivars for table grapes such as 'Aki queen,' 'Honey Seedless,' 'Honey Black,' 'North Red,' and 'Sunny Rouge,' have been bred at the National Institute of Fruit Tree Science. Table grape cultivars bred in Japan are briefly described in Table 4.

Table 4. Description of Table Grape Cultivars Bred in Japan

Cultivar (Polyploidy)	Parentage	Fruit Description
Aki Queen (4x)	Kyoho x Kyoho	End Aug., very large, bright red, excellent quality
Fujiminori (4x)	Ikawa 682 x Pione	End Aug., very large, dark purple-red, good quality
Honey Seedless (3x)	Kyoho x Concord Seedless	Mid-Aug., medium berry (GA), greenish yellow, seedless
Kaiji (2x)	Flame Tokay x Neo Muscat	Early Oct., large, bright red, excellent quality
King Dela (3x)	Red Pearl x Muscat of Alexandria	Early Aug, small (GA), red-brown, seedless, good quality
Koshu (2x)	Unknown	Early Oct., medium , red-purple, medium quality
Kyoho (4x)	Ishihara Wase x Centennial	End Aug., very large, violet-black, excellent quality
Mirei (3x)	Red Queen x Koshu Sanjaku	Mid-Aug., medium (GA), yellow-green, good quality
Muscat Bailey A (2x)	Bailey x Muscat Hamburg	Mid-Sept., very large, bluish black, medium quality
Neo Muscat (2x)	Muscat of Alex. x Koshu Sanjaku	Early Sept., large, greenish yellow, muscat flavour
North Red (2x)	Seneca x Campbell Early	Mid-Aug., medium, red-brown, sweet, foxy
Pione (4x)	Kyoto x Cannon Hall Muscat	Early Sept., very large, violet-black, excellent quality
Rosario Bianco (2x)	Rosaki x Muscat of Alexandria	Mid-Sept., very large, greenish yellow, excellent quality
Sekirei (2x)	Early sport of Kaiji	Mid-Sept., large, bright red, excellent quality
Suihou (4x)	Pione x Centennial	Early Sept., very large, green-yellow, excellent quality
Summer Black (3x)	Kyoto x Thompson Seedless	Early Aug., large (GA), purple-black, seedless, good quality

3. PRODUCTION OF PLANTING MATERIAL

Private nurseries produce most of the planting material such as rootstocks from cuttings, and then scions of commercial cultivars are grafted. Saddle grafting has produced over 90 percent of grape planting materials. Another popular grafting method is cleft grafting.

In the early 1920's, '3309,' '3306,' and '101-14' rootstocks were introduced to Japan. After that, the '420A' and 'Teleki' strains were also introduced. Growers have chosen 'Teleki 8B,' '5BB,' and '5C' because of their excellent characteristics, including high berry quality, early ripening, and wide soil adaptability. These are the reasons why they are still the major rootstock varieties in Japan.

4. ESTABLISHMENT OF VINEYARDS

Land Preparation

The land selected for vineyards should have a gradient of less than 5 degrees, underground watertable below 1 m, long hours of solar radiation, average annual rainfall of 1,000 mm, and, in particular, a low amount of rainfall during the harvest season. Long drainage pipes with small holes should be buried to drain underground water and provide aeration in the soil. In sloping land, prevention of surface soil erosion is very important, and, therefore, it is necessary to cover the surface with a species of grass such as Italian ryegrass.

Planting Season

There are two planting seasons, in spring and in autumn. Spring planting is done at the beginning of March, before commencement of active growth. Autumn planting, carried out between the beginning of October and the end of November, is superior to spring planting for better growth of vines.

Spacing

It is important to enlarge the canopy after planting using a horizontal trellis method of support for training the vines. The canopy enlargement depends on the kinds of cultivars, pruning methods, soil fertility, planting material quality (virus-free), cultivation style (such as root-restriction cultivation), and rootstocks. The standard planting density for 'Delaware' used to be between 80 and 240/ha, but proper spacing has recently been examined under different conditions.

5. CARE AND MANAGEMENT OF VINEYARDS

5.1 Training and Pruning of Plants

Most vineyards are furnished with a horizontal trellis (Fig. 5). The horizontal trellis is very popular since most of the grape-growing areas are hit by typhoons almost every year. A horizontal trellis is more effective in minimizing wind damage. The rainy season through June and early July coincides with the period of berry enlargement or ripening in open cultures. The shortage of sunshine hours and the humid conditions tend to retard berry development and promote fungal diseases. Leaves on a horizontal trellis can utilize the sunshine more efficiently and minimize the spread of diseases. Shoot growth also tends to be too vigorous to ensure good berry set and berry growth during the warm and wet rainy season. Enlargement of the canopy to control shoot growth can be easily performed in this training system. Grapevine management, such as cluster trimming, GA treatment, and berry thinning, which are indispensable in order to produce high quality grape bunches, is easily conducted under a horizontal trellis. Recently, a flexible horizontal trellis that allows adjustment of the trellis angle to the stature of the grower has been developed to save labour hours and enhance management efficiency under protected culture (Fig. 6).

There are two principal pruning methods, namely, short cane pruning (severe spur-pruning) and long cane pruning. The objectives of short cane pruning are to leave only 2 to 3 buds on one lateral shoot and maintain straight primary shoots. This pruning method has

been mainly used in the western part of Japan. This kind of heavy pruning is easy for farmers to carry out without using a special technique. On the other hand, one year old canes that elongated in the previous year are pruned leaving several buds in the long cane pruning method. This pruning system has been used in the eastern areas of Japan.

Figure 5. The Horizontal Trellis System

Figure 6. A Flexible Horizontal Trellis with Root-Restricted Culture Under a Protected Culture

5.2 Application of manure and fertilizers

Standard amounts of manure and fertilizers used in the Yamanashi area are shown in Table 5. The amount of fertilizer depends on the soil type, the age of plants and the cultivar. Young vines, virus-free vines, and tetraploid cultivars should receive less nitrogen to

suppress excess growth because they exhibit very vigorous cane growth. Most fertilizer is supplied as basal fertilizer between October and the beginning of November.

Table 5. Standard Amounts of Fertilizers Used in Some Major Cultivars (Yamanashi, 1989)

Cultivars	Yield (t/ha)	Amount of Fertilizer (kg/ha)				Amount of Manure (t/ha)
		N	P_2O_5	K_2O	CaO, MgO	
Delaware	15	150-170	170-180	150	800	15
Kyoho, etc. (tetraploidy)	12-14	60	150	120	1000-1500	15
Neo Muscat Kaiji	18-22	160-200	150-170	150-160	1500	20
Muscat Bailey A Kosyu	22-24	130-210	190-260	130-150	1000-2000	15

5.3 Weeding

There are three different kinds of surface soil management. One is sod culture, particularly in sloping land, because grass prevents surface soil erosion during the rainy season. Grass supplies organic matter into the soil, and grass roots also improve the physical conditions in the soil. However, grapevines and grass sometimes compete aggressively for water and nutrients under conditions of drought stress in shallow soils.

Another management method is known as clean culture, mainly used in flat vineyards. Herbicides such as ‘glyphosate (isopropylamine)’ and ‘diquat paraquat’ are sprayed in spring and summer. However, the soil surface surrounding the main cane is covered with straw to prevent vines from drought stress and nutrient competition and which also supply organic matter.

5.4 Irrigation

Grapevines require the most amount of water during two periods of growth, usually before germination and during berry enlargement. On the contrary, water is restricted to improve berry quality during the maturation period. The number of irrigations depends on the soil type and the growth stage of the crop. About 30 mm of water per irrigation is sufficient during the summer season for a vineyard on clayey soil. Vineyards on clayey soils are watered at longer intervals than those on sandy soils. Soil moisture should be recorded with a pF meter and kept between pF2.3 and 2.5. Use of sprinklers is the most common irrigation system in Japan. In addition to irrigation, it is possible to use the sprinklers to spray some chemicals on a flat canopy developed on a horizontal trellis. Drip-irrigation and misting nozzles are also used under protected culture.

5.5 Pests and Diseases

a) Pests

The main pests of grapes in Japan include yellow tea thrips, grape borer, grape clearwing moth, grape phylloxera, grape leafhopper, swift moth, mealy bugs and mites. Thrips and borers are notorious pests in Japan. In warmer areas, the occurrence of yellow tea thrips is 7 to 8 times per growing season, but it is 5 to 6 times in cooler areas of Japan. Thrips over-winter under grape bark, dropped leaves, or in soil. Timely sprays are given before blooming, after flower dropping, and during the maximum occurrence period, from mid-July to early-September. Synthesized pyrethroid can be sprayed to effectively control this pest.

b) Diseases

Vitis vinifera is subject to numerous diseases. Some of them cause serious problems in all grape-growing areas, while some others are of local importance. Among fungal diseases of leaves and fruit, powdery mildew, downy mildew, anthracnose, grey mold, and ripe rot are prevalent. Crown goal is an important bacterial disease. Leafroll is caused by viruses GLRaV-1 and GLRaV-3 which have been detected with ELISA. It is reported that both of them propagate and spread through grafting. In addition, GLRaV-3 is transmitted through comstock mealy bug (*Pseudococcus comstcki*), and GLRaV-1 has shown evidence of sap transmission. In Japan, several cultivars show latent infection by corky bark, a kind of rugose wood complex. Although damage is not serious, grapevine berry inner necrosis caused by GINV (grapevine berry inner necrosis virus) was found in Ibaragi Prefecture in 1984. This virus shows graft and sap transmission. Yellow speckles caused by viroids have not been detected in Japan so far. Many cultivars show lateral infection with Fleck that is thought to cause Aji-nashika (low-sugar berry) disease.

5.6 Physiological Disorders

a) Shatter (floret dropping)

This disorder is a phenomenon characterized by florets dropping after blooming. Lack of proper fertilization, bad nutrient conditions, and physiological stress (water deficit or high temperature) cause florets to drop. Several cultivars, such as ‘Kyoho,’ ‘Pione,’ and ‘Muscat of Alexandria,’ are susceptible to this type of disorder.

b) Sunscald

Sunscald has been mainly observed on ‘Muscat of Alexandria’ under glasshouse conditions from the late first stage to the late second stage of berry growth. There are different kinds of disorders on the berry surface, including blotch, berry shrink, and sunburn. These disorders are commonly caused by denaturation of the vascular bundle. The sunscald phenomenon might be related to ‘water berry’ or ‘stem necrosis,’ which are also caused by a disorder of the vascular bundle. Therefore, the mechanism of this disorder needs to be clarified as soon as possible.

c) Berry Cracking

Cracking during maturation depends on cultivars and cultivation conditions. 'Delaware,' 'Olympia,' and 'Red queen' crack easily. Berry cracking is observed in diluvial soil more frequently than in alluvial or volcanic ash soils. Research on grape skin indicates that cracking is due to inferior texture of the skin, the long oval shape of the berry with a pericarp that can be easily distorted, and a thinner cell wall of the sub-epidermal cell layer. It is important to avoid wet soil conditions after long periods of water deficit during the growth stage to protect berries from cracking.

In addition to these disorders of the berry, low berry colouration is a problem caused by high temperature during the maturation stage, heavy fruit load, bad nutrient conditions, virus infections, or low light intensity, among others.

d) Less Growth due to Cold Damage

This is a kind of cane growth disorder. Less sprouting and slow growth of canes are observed in the spring, particularly in cold areas, due to cold damage in association with water deficit. It is therefore necessary to improve freezing resistance of both cultivars and rootstocks. New cultivars with high freezing tolerance bred by the National Institute of Fruit Tree Science (NIFTS), such as 'North Red' and 'North Black,' have been introduced in northern areas of Japan.

5.7 Grape Quality Improvement and New Cultivation Systems

a) Inducing Seedless Grapes by GA Treatment

Consumers prefer seedless grapes because they are easy to eat. Success in producing seedless 'Delaware' grapes with GA application remarkably increased the consumption of this kind of grape. Fruit clusters are dipped with 100 ppm of GA solution 2 weeks before blooming and again after blooming. The pre-bloom treatment makes the berries seedless, while the post-bloom application stimulates berry enlargement. These treatments cost about 300,000 yen (US$ 2,800) for the chemicals and require 300 to 400 hours of labour per hectare. Seedless 'Muscat Bailey A' grapes have also been successfully produced by the same treatment. For 'Kyoho' and 'Pione,' a modified treatment with lower concentration of GA and a later application time has been developed.

b) Prolonged Period of Fruit Supply by Protected Cultivation and New Storage Systems

Fruit harvesting under an open culture begins in late July or early August for early cultivars, followed by mid-season cultivars in late August and October, and ending in late December for late cultivars. Harvest time is markedly advanced in heated houses and grapes marketed earlier are sold at a higher price. Application of heating can begin as early as late November or December. In such cases, fruit is harvested from April to May. In vines heated in late January or February, fruit is harvested from May to July or August.

Cold storage of grape bunches can delay the time of shipping. 'Kyoho' bunches can have their marketable period extended by 30-50 days when wrapped with plastic films and stored at 0^{o} C and 80 percent relative humidity. New storage methods with minus ion and

ozone that were developed by NIFTS can tremendously extend the storage period by over 70 days.

Although heated cultivation and new storage systems can extend fruit supply from early April to December, it is difficult to supply grapes during the spring season from late January to March. For this reason, the suppression culture, which requires the use of UV-less plastic films, and the double-cropping culture have been examined.

c) Double-cropping

Research on the double-cropping of 'Muscat of Alexandria' under protected cultures began in the 1960's in Japan. Grape growers have been interested in double-cropping to enhance yield and income. The first cropping is in late June or early July, and the second one is in December or January, when high prices are expected. In this cultivation, specific techniques such as temperature control, breaking of dormancy, pruning, long-day treatment by fluorescent lamps, and enhanced CO_2 application are very important. Some growers in Okayama and Shimane prefectures have adopted the double-cropping system.

d) Root-restricted Culture and Soil-less Culture

In addition to developing the protected cultivation techniques, root-restricted culture and box culture have been examined (see Fig. 6). These culture systems promote good control of vine vigour, stable production, and fruit quality improvement.

In a soil-less culture, a hydro-culture or artificial solid materials such as a rock wool system are used to produce grapes. This culture has been tested to control grape production automatically.

5.8 Use of Plant-Growth Regulators in the Vineyard

The use of plant-growth regulators in vineyards to control growth and fruit quality has been studied for many years. Several plant regulators have been known to improve grape production in Japan. Gibberellic acid (GA) has been used since the 1950's to grow seedless grapes and increase berry size. The effect of GA on the promotion of berry maturation and bunch elongation has been observed. Forchlorfenuron (1-(2-chloro-4-pyridyl)-3-phenylurea) liquid has also been used to increase berry size and prevent floret dropping (shatter). Streptomycin is also effective for seedless grape growth and promotion of berry maturation. To prevent florets from dropping, BA (6-N-benzylamino purine) has been used. Calcium carbonate has been employed to reduce the damage by water-soluble copper powder. Forchlorfenuron and BA, ethephon (2-chloroethylphosphnic acid), and mepiquatchloride (1,4-dimetyl piperidinium chloride) are effective to prevent florets from dropping. C-MH (maleic hydrazide choline) has also been used to suppress excess vegetative growth of the cane.

6. HARVESTING AND YIELDS

One of the indicators of the harvest season for table grapes in 'Kyoho' is a sugar:acid ratio of 30 to 40 in late August. Fruit quality, including bunch appearance and skin colour, is quite important for shipping in Japan. Using the standard colour chart, skin colour can be

determined. Yields depend on cultivars and culture type. An open culture of 'Kyoho' has an average yield of 12 to 15 metric tonnes per hectare. The average sugar content (Brix) is 17-18, and the content of tartaric acid is 0.8-0.9. 'Delaware,' 'Campbell early,' 'Muscat Bailey A,' and 'Neo Muscat' yield 15 to 18, 24, 23, and 20 to 24 t/ha of table grapes, respectively. Proper yields per hectare are decided by average cane length and the number of new cane per/m^2 based on the material production theory through photosynthetic capacity. Heavy fruit load causes low sugar content and a colouration that is not acceptable for table grapes. Moreover, grapes with berry skin disorders do not sell or must be sold at a low price. Proper yields promise high fruit quality and income.

7. MARKETING

In 1997, total grape production was 250,900 metric tonnes, 87.4, 11.0, 1.4, and 0.2 being the percentages for the production of table grapes, wine, juice, and canned fruit, respectively. Only 14 tonnes of table grapes were exported, while 7,649 tonnes were imported in 1997. The grapes marketed earlier were sold at a higher price.

8. POTENTIAL FOR GRAPE-PRODUCTION DEVELOPMENT

Grape production in Japan has not changed dramatically during the past 20 years. However, wine consumption is gradually increasing these days because of its functional components, such as polyphenol, which are thought to be effective in suppressing human senescence. Therefore, high quality wine grape production might develop more in the future. Table grapes must always be of higher quality because higher quality fruit can be sold at a higher price. Stable production of high quality table grapes brings more income to farmers. The potential exists for the development of exports to overseas countries, since only 12 metric tonnes of grapes were exported in 1997.

9. CONSTRAINTS IN GRAPE PRODUCTION DEVELOPMENT

Although wine consumption has increased in recent years, the total consumption of not only grapes but also all kinds of fruit has been continuously on the decline in the last two decades. Grape farmers who have small grape farms cannot increase their vineyard area or their production to improve their income further. This consumption decrease is one of the biggest constraints in Japan. A second problem is that, as they age, most farmers suffer the consequences of the long, hard, and intensive labour required for berry thinning and bunch trimming, among other tasks that are necessary to produce high quality grapes. The requirement of intensive labour is the reason why there are few young successors. Therefore, new techniques to achieve low-cost production and save labour are required to solve those problems.

10. GOVERNMENT POLICIES AND PLANS FOR GRAPE RESEARCH AND DEVELOPMENT

Breeding Objectives

The major breeding objectives are to select excellent cultivars adapted to Japanese climatic conditions. Seedlessness, large berry size, good appearance, and high quality are the principal considerations for table grapes. The use of triploid or tetraploid cultivars is advantageous. For wine grapes, to improve the wine quality of old Japanese cultivars, back crossing of *V. vinifera* grape to these cultivars is being carried out as the demand for wine increases. The selections are propagated and distributed to several research stations with different climatic and soil conditions for multi-location testing. Productivity, fruit quality and wine quality are tested to select promising cultivars for both table and wine grapes.

Disease resistance is another important objective. Most grape cultivars are susceptible to many diseases. Inoculation techniques have been evaluated in downy mildew, anthracnose, ripe rot, and grey mold in Japan.

Biotechnology

The development of biotechnology is very important to improve grape cultivars. Grapes are heterozygous plants, and genetic analysis for important agronomic traits has not made appreciable progress. Haploid plants are of considerable value for genetic analysis and crop improvement. Protoplast fusion and somatic hybridization enable the achievement of wide hybridization and partial gene transfer. Although cross-hybridization is generally used for plant breeding, it results in plants inheriting both favourable and unfavourable characters at the same time. On the other hand, only the target gene can be transferred to the plant by means of genetic engineering. Gene-delivery systems such as the *Agrobacterium*-mediated system, electroporation, and DNA-coated microprojectiles can be used for this purpose. The analysis of DNA, such as RAPD, RFLP, and AFLP, is an important technique for the classification, identification, and development of molecular markers and the isolation of useful genes in grape breeding.

Physiological Aspects

A stable annual production of high quality fruit under different cultivation systems is the most important goal for both table and wine grapes. It is important to research stable berry set, control maturation, and skin colour based on plant hormone movement, water relations, photo-assimilate translocation, and gene analysis in grapevines.

Low-cost Production and New Technology for Labour Saving Culture

To achieve high quality table grapes, berry thinning and cluster trimming are the most labour-demanding management tasks. It is necessary to reduce the amount of labour and improve the efficiency of labour productivity to produce grapes at a lower cost. However, it is quite difficult to do berry thinning and cluster trimming automatically or mechanically, so breeders have been trying to breed a new cultivar that does not require berry thinning or cluster trimming.

Environmental Concerns

Fewer chemicals and less nutrients should be supplied to orchards to preserve the environment. A biological protection system using natural enemies, for example, will be researched to prevent grapevines from diseases and pests. The amount of nitrogen fertilizer used should also be examined and reviewed again from the point of view of environment preservation and plant nutrition effect.

11. CONCLUSIONS

To develop the grape industry, grape farmers try to produce a stable yield of high quality fruit. Research scientists such as plant physiologists, grape breeders, molecular biologists, and pest and disease researchers, working at both National and Prefectural Institutes of grapes in Japan, must solve the grape production problems mentioned above. In addition to that, more cooperation among research scientists, grape farmers, the fruit-produce cooperative societies, and fruit-market workers is important for the improvement of grape production strategies.

GRAPE PRODUCTION IN THE REPUBLIC OF KOREA

Gi-Cheol Song [*]

1. INTRODUCTION

Some wild species of grapes like *Vitis amurensis* and *Vitis coignetiae* found in the Republic of Korea are not commercially important species. Several cultivars grown until now were introduced through China from Europe, and found their way to Asia during the Koryo Dynasty around the 14th century. Modern viticulture began around 1906 when an experimental station was established to test imported cultivars. The wine industry began in 1910 in Kyongbuk Province. Some cultivars for wine were imported from USA, Europe, and Japan. These have been grown throughout the country since 1960.

The income from grape growing in the Republic of Korea is much higher when compared with that from other fruits. But over-production due to the rapid increase in grape growing areas and the high amount of imported grapes has brought about economic difficulties to local farmers. Presently, grape consumption is increasing because of the high national income and the superior quality of grapes. Grape production will boom as a promising industry if the quality of berries could be improved and the operating cost reduced.

2. PRESENT STATUS OF GRAPE CULTIVATION

Grape Cultivation Areas and Yields

From 1994 to 1998, the area planted to grapes expanded at an average annual rate of 11.5 percent. Correspondingly, production grew at an average rate of 18.3 percent (Table 1). The increasing trend of the area and the volume of production can be attributed to many factors, such as increasing consumption as a health food, ease of cultivation compared with other fruit crops.

Table 1. Area and Production of Grapes in the Republic of Korea, 1994-1998

Year	Area (ha)	Production (tonnes)
1994	19,773	211,930
1995	26,030	316,443
1996	27,196	357,274
1997	28,290	393,195
1998	29,871	397,784

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The area under cultivation of mature vines grew from 1995 to 1999. On the other hand, the area devoted to young vine cultivation decreased somewhat. Generally however, the trend in grape production, yield and consumption is currently increasing (Table 2).

Table 2. Area, Production, Yield, and Consumption of Grapes in the Republic of Korea, 1995-1999

Year	Area		Production (1000t)	Yield (t/ha)	Consumption (kg/person)
	Mature Vine Cultivation (1000 ha)	Young Vine Cultivation (1000 ha)			
1995	14.3	11.7	316.4	12.2	7.1
1996	15.7	10.9	357.3	13.1	7.8
1997	20.5	7.1	393.2	13.9	8.6
1998	22.8	6.2	397.8	13.5	8.9
1999	23.9	6.6	470.0	15.4	10.0

Kyongbuk province has the largest area planted to grapes (46 percent) followed by Chungbuk (15 percent), Chungnam (11 percent) and Kyonggi (10 percent). Cheju has the smallest area (8 ha) planted to grapes (Table 3).

Table 3. Area and Production of Grapes by Province in the Republic of Korea

Province	Area (ha)	Production (t)
Seoul	-	-
Pusan	-	-
Taegu	993	7,805
Inchon	184	2,031
Kwangju	225	3,159
Taejon	588	7,891
Ulsan	8	46
Kyonggi	3,086	50,549
Kangwon	140	1,599
Chungbuk	4,507	51,200
Chungnam	3,265	41,335
Chonbuk	1,432	18,530
Chonnam	582	7,112
Kyongbuk	13,703	193,897
Kyongnam	1,150	12,512
Cheju	8	118
Total	**29.871**	**397,784**

Grape Cultivars Growing in the Country

The distribution of grape cultivars is dependent on the prevailing climate in The Republic of Korea. European cultivars cannot be grown without ‘heeling’ under the soil in

winter in the northern areas. Many American cultivars and their hybrids with European cultivars can however, be grown using this method. The 'Campbell Early' cultivar occupies 66.4 percent of the total area cultivated to grapes. The 'Kyoho' variety occupies 14.5 percent, and 'Sheridan' 11.8 percent. These three occupy 93.5 percent of the total area planted to grapes (Table 4). Various varieties of good quality are currently needed to compete against imported grapes.

Table 4. Number and Percentage of Area Planted to Grape Cultivars

Cultivar	Area	
	1992 ha (%)	1997 ha (%)
Early		
Campbell Early	7,837.7 (69.8%)	15,419.3 (66.4%)
Seneca	–	219 (0.1)
Alden	–	8.0 (0.003)
Others	58.1 (0.5)	64.0 (0.3)
Mid		
Kyoho	1,178.4 (10.5)	3,359.0 (14.5)
Black Olympia	72.8 (0.6)	128.5 (0.6)
Seibel 9110	913.9 (8.1)	94.5 (0.4)
Delaware	63.1 (0.6)	79.4 (0.3)
Neo Muscat	92.0 (0.8)	64.3 (0.3)
Fujiminori	–	13.0 (0.06)
Pioneer	–	7.0 (0.03)
Others	214.3 (1.9)	247.5 (1.1)
Late		
Sheridan	–	2,741.8 (11.8)
M.B.A.	7.9 (0.07)	492.4 (2.1)
Tano Red	186.2 (1.6)	396.9 (1.7)
Muscat of Alexandria	–	34.2 (0.2)
Others	299.2 (2.7)	68.2 (0.3)
Unclassified	**356.0 (3.2)**	**0.2 (0.01)**
Total	**11,219.6 (100)**	**23,239.9 (100)**

Only a very small quantity of grapes is used for processing in the Republic of Korea. In 1998 18,279 tonnes of grapes were used for juice, liquor, vinegar, drinks and other products (Table 5).

Table 5. Volume of Grapes Used for Processing, 1998

Products	Volume (t)
Canning	2,590
Juice making	6,422
Jam	1,038
Liquor	1,800
Vinegar	391
Fruit Drinks	4,922
Others	803
Total	**18,279**

3. PRODUCTION OF PLANTING MATERIAL

Until recently many farmers grew grapevines without using rootstocks. There has been little infestation by grape phylloxera owing to the hot and rainy weather in summer and cold conditions in winter. It is reported that the grape phylloxera was present in some regions in 1912-1913. In 1998, phylloxera emerged in Cheonan and Anseong areas where mostly the 'Kyoho' cultivar is grown, but its spread has been nearly brought under control at present. To protect the grape from phylloxera and increase yield and colouration of berries, many farmers in The Republic of Korea began to use grafted grapevines. In some important regions like Cheonan, Anseong, Naju, Youngdong, and Kimchoen, farmers try to mass produce grafted nursery plants using rootstocks such as 5BB, SO4, 3309, 3306, 5C, and 8B etc. In addition there are some Agricultural Extension Services which plan to produce virus-free plants to supply their farmers.

4. ESTABLISHMENT OF VINEYARDS

Land Preparation

Precipitation in the Republic of Korea is more than 1,000mm a year, with almost half of it falling during June and July. This makes drainage installation important for vineyards. Considering the resistant level of grape cultivars against winter coldness, farmers are recommended to plant European cultivars in the areas where the minimum temperature is above -15°C and for American cultivars, above -20 to -25°C. Grapevines should be heeled to overcome these critically low temperatures during winter. The cultivars growing in the Republic of Korea have a large range of soil adaptability; hence planting vines on plains and slopes is possible. Generally, farmers prefer to plant grapevines in sandy loam soils. They make agricultural roads between vineyards for power tillers to operate and grow rye cereals or clovers as cover crops to avoid soil erosion.

Planting Season

Grape growers plant vines from November after leaf fall to the end of March when their roots start to revive. Generally, they prefer to plant grapevines in spring to avoid winter injury. Planting nursery stock is recommended before the end of March.

Spacing

Vine spacing is different according to varieties, rootstocks, soil fertility and other management techniques. To establish the Wakeman's system for 'Campbell Early' grapes, it is recommended to have spacings of 3.6m x 2.7m (1,000vines/ha) on fertile soils and 2.7m x 2.7m (1,370vines/ha) on poorer soils. In the Republic of Korea, every other plant is removed when the distance between rows is less than 1.8 - 2.4m.

In the shelf system for 'Kyoho' grapes, plants usually have a spacing of 1.8m x 3.6m at the beginning and then 3.6m x 3.6m in 4^{th} - 5^{th} year, the spacing of 5 - 6m in the row is acceptable.

5. CARE AND MANAGEMENT OF VINEYARDS

Training and Pruning of Vines

The shelf system, which has short and long canes according to the diameters of canes, is used for the 'Kyoho' grape variety. The umbrella system is also used, but this form is difficult to control when vines are fully grown. This should be changed into a simple and an effective form, which is appropriate for plastic culture. It is advisable to get 1cm-thick bearing mother canes for 'Kyoho' grapes. Each shoot of 'Campbell Early' grapes has an average of 1.5 clusters. Two buds are needed from each bearing spur branch and a shoot is chosen out of the lower part from the two buds.

Application of Manure and Fertilizers

Farmers apply fertilizers separately. Basal fertilizers are applied after leaf fall in November up to pre-sprouting stage in March. Grape growers apply slow releasing manure and a little more fertilizers to provide nutrient element requirements. They supply all of the phosphorous and lime at the same time. More fertilizers are sometimes applied from the end of May to the beginning of June. In this case, 20-30 percent of nitrogen and 40 percent of potassium should be applied at the berry enlargement stage. Sometimes farmers supply a small amount of fertilizers after harvest for recovery of vine vigor. Urea application on leaves to supplement nitrogen is also useful. After manure and fertilizers have been evenly applied on the surface of the soil, a tiller is used to plow and turn the soil.

Weeding

Too much rain during the vine growing season makes grasses grow well. Many farmers use herbicides 3-4 times a year to control weeds. Some farmers are also increasingly using cover crops like rye cereals and clovers to control soil erosion and weeds.

Supplementary Irrigation

The Republic of Korea has sufficient rainfall (1,000~1,300mm per year), but 40-50 percent of this precipitation occurs during July and August. Sometimes, irrigation is required from the beginning of May to the end of June. Precipitation from September to October is not enough; hence supplementary irrigation is necessary.

Pests and their Management

The common pests in the Republic of Korea are grape tiger longhorn, grape clearwing moth, grape leafhopper and yellow tea thrips. In 1998, grape phylloxera infected areas were found in some regions, but the infected areas are no longer increasing at present. Generally, farmers use insecticides about 10 times a year. However, some farmers apply these chemicals less than 3-4 times a year by using plastic houses.

Diseases and their Management

The common diseases in the Republic of Korea are bitter rot, leaf spot, downy mildew, powdery mildew, gray mold and anthracnose. In 1998 and 1999, bitter rot, downy mildew and anthracnose were a little severe due to heavy rains lasting until harvesting time.

Physiological Disorders

Poor sprouting and bud necrosis at the early growth stage, berry shattering, and cluster stem dehydration are conditions observed in relation to cluster formation. Sometimes, excess and deficiency of nitrogen, potassium, magnesium and boron are common. Many disorders occur under abnormal weather conditions. There is sunburn on berries and leaves, berry cracking and water berries. Very severe berry cracking and water berries occurred in 1998 and 1999. The search for solutions to these disorders is being undertaken through several research studies.

Other Factors such as Grape Quality Improvement

Plastic culture is the best method to improve berry quality, and so it has been popularized. Many growth regulators like GA, KT-30, and ethephon are being used to induce seedless grapes, berry enlargement, hastening and delaying harvest, cluster elongation, and improvement of berry setting. Sometimes improper application creates problems. Many farmers use products made commercially, and also produce their own formulations themselves even if their efficacies are not proven.

6. HARVESTING AND YIELDS

Grape yield is increasing annually due to the increase of grape cultivation area and advanced grape growing skills. Grape production in 1994 was 211,930 tonnes and reached 397,784 tonnes in 1998. In 1999, the production of grapes was estimated at around 470,000 tonnes because of increased growing area of mature grapevines. Growing grapes is much easier than other fruits; therefore farmers can easily get a good income. Berry shattering occurs every year especially in ‘Kyoho’ grapes, but this does not seriously affect grape production. In spite of bad weather conditions, farmers keep having good income because of excellent berry quality under plastic houses and their growing skills. The consumption of grapes has also been increasing steadily.

7. MARKETING

Grapes are sold through Agricultural Cooperative Associations, Producers’ Cooperatives, by the roadside, and at department stores. The Republic of Korea exports ‘Delaware’ grapes to the South East Asian markets and sometimes to Japan, but also imports wines, juice and table grapes. Table grapes like ‘Red globe’, ‘Thompson seedless’, and ‘Flame seedless’ are imported from Chile and USA, and since the change of the import policy in 1996, imports are increasing (Table 6). It is assumed that much more table grapes will be imported after the conclusion of the Free Trade Agreement in Agriculture between the Republic of Korea and Chile. At the same time the local price of grapes has declined since 1994 due to over-production.

Table 6. Import and Export of Grapes in the Republic of Korea, 1996-1999

	1996 (tonnes)	1997 (tonnes)	1998 (tonnes)	1999 * (tonnes)
Import	2,403	8,896	1,112	6,200
Export	1	0.02	75.5	155.4

* Estimated

8. POTENTIAL FOR GRAPE PRODUCTION DEVELOPMENT

The Government of the Republic of Korea recommends that farmers do not plant grapevines anymore. But some farmers continue to grow vines because they do not have other alternative crops. Farmers try to produce good quality grapes and they are making grape juice and wines for themselves. In some regions, farmers grow a hybrid cultivar between a wild Asian variety and an American cultivar to produce a popular wine and juice. But its quality is variable according to the different methods used by farmers to produce wine.

9. CONSTRAINTS IN GRAPE PRODUCTION DEVELOPMENT

Growers are supposed to apply chemicals about 10 times a year, but this frequency is reduced to less than 3 - 4 times by using plastic houses. Recently, the grape crop has had several physiological disorders like berry shattering, berry cracking and water berries under abnormal weather conditions. It is necessary to process surplus grapes and export more fresh grapes. This may lighten the farmers' burden caused by excessive production. Grape growing farmers should produce grapes of good quality under plastic houses and install irrigation systems. They also need some technical help like soil testing and continuous education of growers on new techniques.

10. GOVERNMENT POLICIES AND PLANS FOR RESEARCH AND DEVELOPMENT ON GRAPE PRODUCTION

The Government discourages farmers from growing grapes and no financial help is provided. Despite this situation, many researchers are still conducting studies on the pests, diseases and physiological disorders of grapes. Some courses are organized by Government organizations to train farmers on these aspects.

11. CONCLUSIONS

Table grape cultivation areas in the Republic of Korea have greatly increased recently. It is necessary to solve the problem of over-production. In spite of different growing skills according to regions and individual farmers, well developed growing techniques help other farmers. The wine industry is not well developed and is carried out on a very small scale at present. Specifically, high quality wine making is difficult due to the weather conditions. To solve excessive grape production, the country should process and export grapes. However, the level of knowledge and skills in grape processing is still limited.

Continuous dispatch of specialists for training in other countries with advanced skills is necessary. Financial support is also needed for research and development projects on high quality grape production and processing.

GRAPE PRODUCTION IN MYANMAR

Hla San [*]

1. INTRODUCTION

Grapes were planted in Myanmar on an experimental scale in 1959 at Sebauk State Farm, Kyaukpadaung Township, and Myingyan district, in the dry zone of Central Myanmar. As it was shown that cultivation of this crop was feasible in this climatic zone, grape was extended to Kyaukpadaung, Meikhtila, Nyaung Oo, Yamethin, Pyawbwe and Pakokku townships.

These townships are very dry areas of Central Myanmar. The climatic conditions of grape growing areas of Myanmar are probably different from that of other grape growing countries. Therefore, cultivation practices for grapes in Myanmar may not be the same as in other countries. Furthermore, there was only scanty research information available concerning grape cultivation in the 1950's. Consequently, the practices of cultivation were developed through experience by technicians of Sebauk grape farm.

Grapes naturally flower in April-May at the beginning of the rainy season and consequently there is flower drop and less fruit due to the rain, also the fruits that set in the rainy season have lower sweetness. Thus pruning systems were developed to make fruits set in the dry period, which is between February and March.

2. PRESENT STATUS OF GRAPE CULTIVATION

In Myanmar, grapes are grown mainly for the fresh fruit market. Grapes are grown not only in state farms but also in private farms. The cultivated area of grapes is shown in Tables 1 and 2.

Table 1. Grape Area under State Farms (Myanmar Agriculture Service)

MAS Farm	Area (ha)	Variety (ha)		
		Bokhari	Muscat	Pizzutello
Sebauk	17.25	16.25	0.75	0.25
Nyaung Oo	8.44	7.00	0.30	0.14
Meikhtila	6.99	3.00	2.00	1.99
Total	**32.68**	**26.25**	**3.05**	**2.38**

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Table 2. Grape Area in Private Farms

State & Div. Township	Cultivated Area (ha)	Variety (ha)					
		Bokhari	Muscat	Pizzutello	Kuato	Cardinal	Alexandria
Mandalay							
Meikhtila	107.65	85.80	11.33	10.52	-	-	-
Yamethin	373.13	267.10	57.47	48.56	-	-	-
Pyawbwe	206.80	153.79	29.94	23.07	-	-	-
Tatkone	0.40	-	-	0.40	-	-	-
Shan							
Tachileik	40.49	-	-	-	40.49	-	-
Taunggyi	15.61	13.36	-	-	-	1.25	1.00
Magway							
Pakokku	1.21	1.21	-	-	-	-	-
Rakhine	2.02	2.02	-	-	-	-	-
Total	**747.31**	**523.28**	**98.74**	**82.55**	**40.49**	**1.25**	**1.00**

3. PRODUCTION OF PLANTING MATERIAL

In Myanmar, use of cuttings is the only method for propagation of grapes. However, budding and grafting techniques were tested very recently in state farms but promising results have not been observed yet and experimentation of these techniques is still continuing.

Propagation of Grapes by Cuttings

Six to twelve month old hardwood cuttings are produced from established vines. The cuttings are taken in mid-October from healthy mature vines. The pencil-width mature canes 20-30 cm long are cut with three or four buds in each. The cane is cut at 2.5 cm away from the nodes, and the lower cut is slanting for easy planting.

The cuttings are taken from the canes already pruned and removed from the vines. The cuttings are dipped in sulfenatte suspension (1:300) for about 5 minutes and put in boxes. In the box, the cuttings are covered with a soaked gunny sack to maintain moisture and the boxes are then transported to the nursery sites.

Propagation at Nursery Site

The beds are prepared at least one month ahead of the cuttings being taken. Beds of 1 meter wide, 30 cm deep and 7 meters long are demarcated. The path between the beds is about 45 cm. The soil of the beds is loosened and left for 5 days for sun drying. About 2 baskets of farmyard manure (40 kg) is mixed with the soil in each nursery bed. Then the beds are watered for a few days. If the soil is hard and of high clay content, sand is added to loosen the soil for better aeration.

On the bed, planting points of 7.5 cm x 7.5 cm apart are prepared and slanted planting holes 15 cm deep are made by using a stick with a diameter of about 5 cm.

The cuttings are planted in the holes and the soil around each cutting is pressed down by foot. The nursery beds are watered once a day in the evening and hand weeding is done as necessary. If the weather is too hot and sunny, partial shade is given for the nursery beds. One month after planting the cuttings in the bed, the new shoots come out and they are transplanted into polybags.

The soil to fill up the polybags is prepared by mixing topsoil, sand and organic matter in a ratio of 10:5:1 ratio by volume. The prepared soil is filled in ploy-bags of 18 x 30 cm size and the soil is filled up to half of the bag.

The cuttings are dug up taking care not to damage the roots, and the roots are then washed out. The cutting is planted in the bag and soil is filled and pressed down gently. Polybag cuttings are put under shade and watered twice a day and placed under close supervision for controlling pests and diseases as necessary.

4. ESTABLISHMENT OF VINEYARDS

Land Preparation

Normal land clearing is done by under brushing, cutting, burning, stacking, re-burning and stumping. When the land is cleared, ploughing with tractors is done, and then harrowing and leveling of the field is carried out.

When land clearing is finished, planting points are marked by pegging. The spacing depends on the variety and training system adopted. There are three training systems, Arbor, Kniffin and Y- type or Cordon.

Spacing

Spacing depends upon soil fertility, variety and training system. Normal spacing used in Myanmar is shown according to the training system.

Training Systems	*Row spacing x plant spacing*
Kniffin	3.03 m x 1.8 m
Arbor (or) Bower	3.03 m x 3.03 m
Y-type (or) Cordon	3.6 m x 2.4 m

Hole Making

Holes of 0.3 m x 0.3 m x 0.3 m are dug and the topsoil and subsoil is separated. Each hole is filled with 40 kg farmyard manure, 30 kg compost and topsoil. The manure is augmented with 4 kg bone meal and 2 kg of wood ash. Holes are irrigated two times daily and planting is done 15 days after irrigation. Posts are constructed according to the training systems used.

Planting

Grapes are planted from mid-October to February, which is the best period for establishing grapes in Myanmar. Normally planting is done in the evening. A small hole 15 cm wide and 30 cm deep is dug at the centre of the planting hole. The plastic bag is removed without damaging the soil core of the seedling. Then it is planted in the small hole gently and the soil is pressed down well. The level of the soil core of the cutting must be the same as that of the planting hole and deep planting or shallow planting should be avoided.

5. CARE AND MANAGEMENT OF VINEYARDS

The plants are irrigated at least once a week depending on the moisture of the soil.

- Cyan or Furadan is used to prevent termite damage.
- Hand weeding around the plants is done as necessary, weeding in inter rows is also done.
- Inter-cultivation is carried out occasionally using harrows or other cultivators.
- New shoots usually come out about one month after planting.
- When the vine is 30 cm long, it is tied to the poles already erected near the plant.
- The strongest shoot is left and other shoots are pruned and any new shoots are also pruned.
- At three months after planting, the weak plants that do not show normal growth are removed and replaced.
- Gap filling for dead plants is done if necessary. To get the required plant population it is important to plant in time with similar sized plants. If planting is late, those plants will not be able to compete with surrounding plants.

5.1 Training and Pruning of Plants

Training

There are three kinds of training systems in Myanmar. They are Arbor, Kniffin and Y-type or Cordon. Training systems depend on the growth habit of the variety and climatic conditions of the place where grapes are going to be planted.

If the grape variety has good growth and branching habit, Arbor system is used. When grape is grown in areas of less rainfall the Arbor system is preferred. As the grape growing areas of Myanmar are in the arid region of Central Myanmar, most of the farmers use the Arbor system. Kniffin and Y-type systems are used only in the State farms as an experimental study. If the area has higher rainfall and humidity, the Kniffin and Y-types should be used.

Arbor System

The height of the Arbor is 1.8 - 2.4 m, however 1.8 m is preferred because of convenience in pruning and other cultivation practices. The buds on the trunk of 1.8 m height are rubbed off leaving only the main stem. When the main stem reaches the top of the Arbor, it is cut out at the tip of the trunk. Then the shoots come out from the tip of the trunk, but they are not pruned unless they have abnormal growth. When the canes have grown long enough, topping is done at 1.5 m from central trunk.

Kniffin

In Myanmar, the four-cane Kniffin system is being tested. The trunk is cut at a height of 0.75 m and three canes are left to grow. Two canes are allowed to grow on the first wire, and one cane to grow up until the second wire where it is topped again to let the new canes come out. The canes are tied to the wires. The lateral four canes are cut at 0.9 m from the trunk. The main trunk is supported by a pole until the second year of growth.

Y-type or Cordon

The trunk is cut at a height of 1.2 m and the strongest two shoots are allowed to grow. These two canes are tied to the bottom wire of the Y, and are cut 1.2 m from the trunk. The new shoots that come out of the canes are allowed to grow, and are tied to the upper wires of the Y.

Pruning

There are two kinds of pruning practiced in the country - light pruning and heavy pruning. Light pruning is done occasionally to prune unwanted canes and leaves for better light penetration and removal of diseased canes. Heavy pruning is done two times a year. The first pruning is done in mid-October to mid-November and the second pruning in mid-March to mid-April.

In the first year of planting, some flower clusters that come out after the first pruning (mid-October - mid-November) are removed, and only a few clusters are left for evaluation of the fruit quality. Otherwise heavy fruiting in the first year will weaken the growth of the young vines. Commercial harvesting is done from the second year onwards.

If the trunk is wounded by some diseases or other means, it is cut leaving the healthy portion of the trunk and new shoots are allowed to grow and are trained again.

5.2 Application of Manure and Fertilizers

Basal application at planting

Farmyard manure	-	40 kg/plant
Compost	-	30 kg/plant
Bone meal	-	4 kg/plant
Ash	-	2 kg/plant

At 6 months age

Fertilizer mixture	-	Urea	1 part
		TSP	3 part
		MOP	2 part
Application	-	115 g mixture/plant	
	-	2 applications per year	

2nd Year onwards

Farmyard manure	-	10 kg/plant/application
Urea	-	130 g/plant/application
TSP	-	390 g/plant/application
MOP	-	520 g/plant/application

Fertilizer application is done at the pruning time.

5.3 Weeding

Hand weeding	-	Once in two months

5.4 Supplementary Irrigation

Rainy season (June to October)	-	once per month
Winter season (November to February)	-	2 times per month
Summer season (March to May)	-	once per week
Irrigation method	-	Furrow irrigation, Basin irrigation

5.5 Pests and their Management

The major insect pests are termites, may-june beetles, and red spider mites. Other pests are bats, which destroy the fruits. Pests and their control are briefly shown below.

Pest	*Control Measure*
Termites	Cyan, Furadan
May-june beetle	Malathion
Red spider mites	Lime sulphur and Monochrotophos
Bats	Manual

5.6 Diseases and their Management

There are three major diseases of grapes in Myanmar. They are anthracnose or black spot, downy mildew and powdery mildew. Diseases and their control are shown below.

Disease	*Control Measure*
Anthracnose	Bordeaux mixture Copper Nordeaux
Downy mildew	Bordeaux mixture Copper Nordeaux
Powdery mildew	Lime sulphur Cumulus Labellite Topsin Dithane

5.7 Quality Improvement

GA3, at the rate of 45 ppm is used to increase berry size and cluster length. At flowering GA3 is sprayed; and young berries which are 3-4 weeks after flowering are dipped in GA 3 solution for a few seconds. Testing with GA 3 to produce seedless berries is underway.

6. HARVESTING AND YIELD

Irrigation is stopped one month before harvest to reduce water content of the berries, which will increase sugar percentage of the fruit. Manual harvesting is done when the berries are ripe enough. The peak season of production is February to May.

The total production of grapes in Myanmar is 8,310.09 tonnes from an area of 747.31 hectares giving an average yield of 11.12 t/ha. The low yields are due to lack of knowledge of the growers about the training and pruning practices and disease control measures. The poor quality of grapes in Myanmar is due to diseases, especially powdery mildew and variety.

7. MARKETING

There is no export or import of grapes in Myanmar. The local demand is always higher than production. The harvested grapes are sent to the two main purchase depots in Mandalay (Upper Myanmar) and Yangon (Lower Myanmar). From those main centres, grapes are sold at retail prices in small shops and roadside stalls.

8. POTENTIAL FOR GRAPE PRODUCTION DEVELOPMENT

There is potential for the development of grape production by area extension and yield improvement. Grapes can be extended in the divisions of Central Myanmar such as Mandalay, Magway, and Sagaing Divisions.

Moreover, there would be a substantial increase in production of grapes if the growers are educated in the training and pruning techniques and given high yielding quality grape varieties.

9. CONSTRAINTS IN GRAPE PRODUCTION DEVELOPMENT

There are some constraints for yield increase and area extension of grapes in Myanmar. Lack of technical knowledge such as training and pruning is a major factor that contributes to low yield. Fungus diseases are also difficult to control because the outbreaks of these are dependent upon weather conditions. Therefore, variation of yield losses due to diseases is observed every year. Lack of high yielding varieties of good quality is also a factor contributing to low yield.

The most important factor for extension of grapes is the high investment cost for the establishment of vineyards. The establishment costs for the first year are shown below.

Training System	*Cost per hectare*
Arbor	3,200,000 kyats
Kniffin	370,000 kyats
Y-type	490,000 kyats

10. GOVERNMENT POLICIES AND PLANS FOR RESEARCH AND DEVELOPMENT OF GRAPES

It is realized that research investigations are essential for the development of the grape crop. Therefore, the Government is planning to promote research programmes. At present, some simple research programmes have been started in the State Farms.

- Germplasm collections.
- Comparison of training systems.
- Live-post substitution in training systems.
- Compost and fertilizer trials.
- Mulching techniques.
- Irrigation systems.

- Methods to increase fruit quality.
- Off-season fruit production.
- Top-working techniques.
- Stock and scion relationship.
- Effects of GA.3.
- Weed control techniques.

11. CONCLUSIONS

- To promote production of grapes, agricultural education is needed by training, field visits, demonstration plots, workshops, and by other media.
- High yielding varieties of good quality should be introduced and adaptability trials carried out in different regions.
- Effective and feasible cultivation techniques should be investigated for higher production.
- Agro-climatic conditions should be studied in conjunction with methods for efficient control of major diseases.
- Study tours are needed to improve the knowledge of the government staff.

GRAPE PRODUCTION IN THAILAND

Surasak Nilnond [*]

1. INTRODUCTION

Before 1960, table grapes were imported from the United States and Australia to Thailand, incurring high costs. At that time more than one hundred varieties were also introduced for testing from the United States and other countries. It was found that grapes can be adapted and grown well in the country. In 1956, Professor Pavin Punsri and his colleagues of the Department of Horticulture, Kasetsart University, Bangkok, tried to study and solve the problems of grape culture. The grape industry in Thailand has been a success since this time. The initial commercial table grape production areas were located in the Central Plain region at Nakhon Pathom, Ratchaburi, Samut Sakhon and Samut Songkhram provinces, which are near Bangkok. At present, the grape industry has expanded to the Northern, Northeastern and the Western regions.

The climatic and soil features of the grape growing areas are described below. In the Central Plain area the range of temperature, average rainfall/year, range of relative humidity and altitude are 25-30^{o} C, 1300-1450 mm, 60-90 percent and 2-3 m, respectively. The soil is of a clayey type and drainage is often very poor in this region. It is, therefore, necessary to improve the drainage system by using the 'ditch and dyke system' which involves constructing raised beds alternating with ditches. The soil pH is about 5-5.5. Lime and manure are also needed to improve chemical and physical properties of these soils. The water sources in the Central Plain come from rivers and canals. In the Northern region the range of temperature, average annual rainfall, range of relative humidity and altitude are 10-20^{o} C, 1400-1500 mm, 60-90 percent and 1200 m, respectively. The soil is a clay loam type and well drained with a soil pH of about 4-5. The water source comes from reservoirs that have been constructed for irrigation. In the Northeastern part of the country the range of temperature, average rainfall/year, range of relative humidity and altitude are 19-30^{o} C, 1200-1300 mm, 60-90 percent and 450 m., respectively. The soil is a clay loam type with a pH of about 3.5-5, while the water sources also come from reservoirs.

2. PRESENT STATUS OF GRAPE CULTIVATION IN THE COUNTRY

The production status of grapes in Thailand in 1998 is shown in Table 1.

At present, there are about 2,717 hectares producing 31,677 tonnes/year with an average yield of about 15 t/ha. The main areas of grape production are located in the Central Plain area at Ratchaburi, Samut Sakhon and Nakhon Pathom, which mainly produce table grapes. However, some private firms use these table grapes for wine making. In the Northeastern region, growers grow both table and wine grapes. There are two wineries at Loei and Nakhon Ratchasima provinces. In the Northern region, the growers produce table grapes in Chiang Mai and Nan provinces and wine grapes in Phichit province. In these

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northern parts of Thailand, grape varieties were introduced into the highlands under the auspices of the Royal Project in 1981. Research work aims to improve the living conditions of hill tribes and use grape as a substitute crop for opium poppy. Results indicated that the varieties Beauty Seedless, Ruby Seedless and Early Muscat gave good growth, production and quality. Extension activities are currently being continued.

Data on the production of table and wine grapes are presented in Table 2. The main varieties for table grapes are white Malaga and Cardinal, which produced about 27,556.7 and 4,043.9 tonnes, respectively. These two varieties are mainly used for table grapes as well as for wine making. Other less important varieties are Kyoho, Beauty Seedless, Early Muscat and Carolina Black Rose. The major varieties of wine grapes are Chenin blanc and Shiraz, which produced a premium, table white wine and a red wine, respectively.

3. PRODUCTION OF PLANTING MATERIAL

There are no Government nurseries to produce grape planting materials. However, the growers can buy the planting material from private nurseries, which are situated in the grape growing areas.

Grapes are commercially propagated by asexual methods. The common practices of propagating are by marcotting (air layering), marcotting followed by budding, or raising cuttings and subsequently budding onto these rooted cuttings. The methods of marcotting - budding and cutting - budding techniques are accepted by nurserymen and growers.

Solonis x othello 1613 is the only rootstock which is used for table and wine grape varieties. It is vigorous, nematode and phylloxera resistant, drought and waterlogging resistant, less resistant to lime, while at the same time it roots and grafts easily.

Table 1. Production Status of Grape in Thailand in 1998

Province	Total [1/] Planted Area (ha)	Total Production (tonnes)	Average Yield (t/ha)	Table Grape (ha)	Wine Grape (ha)
Whole Kingdom	2,717.9	31,677.1	15.2	2,377.5 (87.4%)	340.4 (12.6%)
Northern Region					
Chiang Mai	8.0	0	0	8.0	-
Nan	11.5	22.5	9.4	11.5	-
Phichit	6.4	0	0	-	6.4
Total	25.9	22.5	-	19.5	6.4
Northeastern Region					
Nakhon Phanom	2.4	0	0	2.4	-
Nakhon Ratchasima	90.2	1,045.0	14.5	18.2	72
Buriram	13.3	52.2	16.3	13.3	-
Loei	224.0	2,800.0	12.5	112.0	112.0
Si Sa Ket	2.4	0	0	2.4	-
Surin	2.2	0	0	2.2	-
Ubon Ratchathani	3.7	0	0	3.7	-
Total	338.2	3,897.2	-	154.4	184.0
Central and Western Regions					
Saraburi	39.7	49.0	17.0	39.7	-
Ang Thong	5.1	108.0	25.0	5.1	-
Ratchaburi	1,427.8	16,894.5	17.0	1,339.8	88.0 *
Samut Songkhram	3.2	20.0	6.3	3.2	-
Samut Sakhon	647.7	9,525.5	15.7	587.7	60.0 *
Nakhon Pathom	92.2	1,160.4	23.7	90.2	2.0 *
Suphan Buri	12.2	0	0	12.2	-
Kanchanaburi	125.9	0	0	125.9	-
Total	2,353.8	27,757.0	-	2,203.8	150.0

Source : Department of Agriculture Extension
Remark : [1/] Nonbearing, includes planting
* Estimated planted area by amount of processing used.

Table 2. Production Statistics for Table Grape and Processing Varieties in 1998

Varieties	Total Production (tonnes)	Table Grape (tonnes)	Wine Grape (tonnes)	Wine Cooler (tonnes)	Others[1/] (tonnes)
Main Varieties					
White Malaga	27,556.7	25,956.7	100*	1,500*	<1
Cardinal	4,043.9	3,293.9	50*	700*	<1
Kyuho	22.5	22.5	-	-	-
Beauty Seedless	53.0*	53.0	-	-	-
Chenin blanc	150.0*	-	150*	-	-
Shiraz	100.0*	-	100*	-	-
Other Varieties					
Eary Muscat	8.0*	8.0	-	-	-
Carolina Black Rose	10.0*	10.0	-	-	-
Total	31,944.1	29,344.1	400	2,200	<1

Source : Department of Agriculture Extension
Remark : * Personal communication
[1/] Fruit salad, Juice

4. ESTABLISHMENT OF VINEYARDS

In the Central Plain vines are grown on raised beds (about 6 m wide) in areas that have a high watertable or are waterlogged. The beds alternate with the ditches (about 1 m wide and 1 m deep) which provide for irrigation as well as for drainage. The water is also used for mixing with fungicide and insecticide for spraying. The vines are usually grown at the centre of the bed, about 2 m apart or at the two edges of the raised beds. The number of vines per hectare varies from 550 to 1,100 vines.

In the upland areas where a high watertable does not pose a problem raised beds are not necessary. Land preparation and digging planting holes should be done after the rainy season. The size of the hole is usually 0.5 x 0.5 x 0.5 m (width x length x depth). The spacing is about 1.5 - 2 x 3.5 - 4 m with the number of vines planted at 1,250-1,875 density per hectare. Soil in the planting holes is allowed to dry for one month before planting. Manure or compost should be mixed with the soil and filled up in each hole. The suitable schedule for planting is in January or February.

5. CARE AND MANAGEMENT OF VINEYARDS

Support

Grapevines cannot be grown satisfactorily without some support. There were many kinds of training systems during the early years of grape culture in Thailand. At the present, the arbor system is preferred to a trellis. The height of the arbor is about 1.5 m above the

ground level. The top is about 2-3 m wide. However, the training systems are dependent on the varieties of grapes, climate, and objectives of the growers.

Training and Pruning

In training a vine, the canes are spread out evenly to cover the area of the arbor, with no definite or regular training design. When the vine is 10 to 12 months old, the mature canes are pruned in order to force out the buds.

Fertilizer Application

Grapevines can adapt themselves to a wide range of soil fertility conditions. However, fertilizers are necessary for vigorous growth, high yield and to give better quality fruits. The main areas of grape culture in Thailand have clay soil types and were formerly rice fields. These soils need a large amount of organic matter and, therefore, manure is used a great deal. Complete fertilizers are usually applied to grapevines in the following manner:

- During the early growth phase of young vines obtained by budding, grafting or marcotting or before the first pruning, ammonium sulphate, urea or complete fertilizer (15:15:15) at the rate of 200-300 g/plant are usually applied every month.

- One to two months before the regular pruning period, fertilizer (9:25:25) at the rate of 200-300 g/plant is applied to promote flower bud development.

- Two weeks after fruit set, complete fertilizer (15:15:15) at the rate of 200-300 g/plant is applied to facilitate fruit growth and development.

- During the beginning of fruit softening or during colour change about one month before harvesting, complete fertilizer (13:13:21 or 12:12:17:2 or 9:25:25) at the rate of 200-300 g/plant should be applied to enhance fruit quality.

Weeding

In the Central Plain area, weeds are usually controlled by hand hoeing and application of herbicides. The herbicide used is grammoxone, which destroys the green parts of the weeds as the farmers prefer clean cultivation. In the uplands, weeds are controlled by hand hoeing, ploughing and using herbicides.

Irrigation

Water source and supply are important for the vineyards. Reservoir and groundwater tube wells are suitable for surface irrigation. Pipeline systems and hose irrigation would be practical and more economical for the farmers. However, mulching with rice straw is also very necessary during the dry season. In the Central Plain areas, the vines are grown on raised beds alternating with the ditches, which can provide the water supply needed for the vines.

Insects and Diseases

Insect problems are not that serious but diseases such as downy mildew, powdery mildew, anthracnose, bitter rot and fruit rot are quite harmful.

Insects: There are several kinds of insects that attack leaves, flower and berries e.g. leaf hopper, leaf roller, thrips and mites. The insecticides used for control are carbaryl, methomyl, carbosulfan, and dicofol, etc.

Diseases: The important diseases of grapes are described below:

a) Downy Mildew: The fungus (*Plasmopara viticola*) thrives best and becomes most destructive during still, cool and moist weather. Although primarily a foliage disease, the fungus also attacks flower clusters. The fungicides used for control of downy mildew are Zineb, Maneb, Captan, Mancozeb and Metalaxyl.

b) Powdery Mildew: The causal fungus (*Oidium tuckeri*) unlike most other diseases of grapes, which are favoured by moist conditions, thrives best in a dry climate. It attacks during berry growth and these developing berries will crack later. For the control of powdery mildew, the vines are sprayed with wettable sulphur.

c) Anthracnose: The causal fungus (*Gloeosporium ampelophagum*) attacks all parts of vines. The fungal attack is usually serious during the rainy season. For the control of anthracnose, the vines are sprayed with Mancozeb, carbendazim or benomyl.

d) Dead Arm: The fungus (*Melanconium fuligeneum*) attacks during fruit maturity, particularly during 2-3 weeks before harvesting. The affected canes will die and the fruit will soften and shrink. For the control of this fungus a spraying of copper fungicide or difenoconazole is given to all parts of the vines.

e) Berry Rots: There are several fungi which will attack the berries and fruit clusters during fruit maturity such as Blue mold (*Penicillium* spp.), Rhizopus rot (*Rhizopus* spp.), Ripe rot (*Collectotrichum gloeosporioides*), Bitter rot (*Greeneria uvicola*) and Botrytis bunch rot (*Botrytis cinerea*). The fungal attack is usually serious during the rainy season. The control of these fungi is by spraying common systemic fungicides.

Special Practices for Improving Grape Quality

There are some special practices to improve the yield and quality of grapes such as:

- Improving bud break or bud burst is achieved by treating canes with hydrogen cyanamide.
- Cluster elongation, cluster loosening, berry enlargement and seedlessness are induced by treating with gibberellic acid (GA).
- Increasing fruit colouration can be achieved by ethrel (2-chloroethylphosphonic acid) application.
- Rain and bird damage can be controlled by using a plastic roof and bagging of bunches.

6. HARVESTING AND YIELDS

Thailand has a tropical climate, which seems to stimulate the growth of grapes immensely. The first crop can be expected only 14 to 16 months after planting. The harvest can be timed at will because planting and pruning can be done at anytime of the year. The buds of the canes can be forced to sprout at any time of the year by pruning and consequently, two to three crops can be harvested from an individual vine in a year. In practice, however, the growers prune their vines twice a year and get two crops, one in the rainy season (May to October) and the other crop in the drought season (November to April). The latter crop is superior due to higher sugar content and better appearance. In the Central Plain area, grapes are grown under the ditch and dyke system. The pruning can also be done at any time of the year. However, in this intensive culture system disadvantages can be expected as the vines have a short life span of only 7 to 10 years. In general, the crop is inferior in quality during the rainy season and vineyard management is also quite intensive.

In White Malaga, which is a late variety, growers can have two harvests a year per vine or five harvests per vine every two years. The average yield is 15-20 kg per harvest. With Cardinal, a very early variety, one can have even three to four harvests a year per vine. The average yield of a vine is 12-15 kg per harvest.

7. MARKETING

Marketing of grapes in Thailand is not organized as there is no organization or association for marketing of this crop. Hence, the sequence of marketing is usually from the growers to middlemen (1 or 2) who transport to markets from which the produce is retailed to consumers. Most of table grapes are for domestic consumption. The export of table grapes is only a small amount (Table 3). The price of table grapes depends on the variety, quality, season and demand. The average farm price of old varieties like white Malaga and Cardinal is about 30-37 baht/kg, while that of the new variety of seedless grapes is about 100-150 baht/kg.

Table 3. Quantity and Value of Grape Exports (1993-1997)

Item	1993		1994		1995		1996		1997	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Grapes Fresh	40	861	34	707	31	545	22	509	38	839

Source: Office of Agricultural Economics
Remark: Quantity: metric tonnes
Value: 1,000 baht

The data in Table 4 and 5 show the quantity and value of table grapes and wine imports. The quantity and value of table grapes and wine have increased since 1993 up to the present time.

Table 4. Quantity and Value of Grape Imports (1993-1997)

Items	1993		1994		1995		1996		1997	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Grape Fresh	1,633	131.7	2,326	177.4	2,318	183.4	2,591	191.6	3,640	262.7
Grape Dried	81	4.9	53	2.5	79	3.5	189	6.9	206	9.3
Total	1,714	136.6	2,379	179,9	2,397	186.9	2,780	198.5	3,846	272

Source: Office of Agricultural Economics
Remark: Quantity: metric tonnes
Value: 1,000 baht

Table 5. Quantity and Value of Wine Imports (1993-1997)

Items	1993		1994		1995		1996		1997	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Champagne (1000 litres)	157	30.9	189	25.92	396	39.6	89	21.5	76	18.0
Wines (1000 litres)	111	10.1	114	11.8	193	40.7	258	42.8	123	10.3
Other wines (1000 litres)	1,824	141.5	1,907	169.9	3,657	360.8	8,579	784.8	5,734	410.6
Total	2,092	182.5	2,210	207.6	4,246	441.1	8,926	849.1	5,933	438.9

Source: Office of Agricultural Economics
Remark: Quantity: 1,000 litres
Value: 1,000 baht

8. POTENTIAL FOR GRAPE PRODUCTION DEVELOPMENT

In the past, table grapes were imported from foreign countries at great cost. Since 1960, grape growers have succeeded in producing grapes locally and even have exported to foreign markets. In 1987, however, new varieties of good quality table grapes continued to be imported in increased quantity and value (Table 4) although the imported table grapes were expensive. Both table and wine grapes have a very good potential as a horticultural fruit crop, although it requires an intensive crop management. Nevertheless, it is a lucrative enterprise for farmers. The data of Table 5 shows the quantity and value of wine imports which is of great interest to the private commercial sector. At the present time, grape growing areas have expanded to many new provinces.

9. CONSTRAINTS IN GRAPE PRODUCTION DEVELOPMENT

Thailand is located within the tropical climatic belt characterized by a hot climate, high rainfall and humidity. However, the vines can be adapted to grow well. Although the fruit produced in the dry season is of very good quality, the production, productivity and quality of grapes is far below that of sub-tropical climatic regions. Grape production can be useful for local consumption and export to some countries in the Region. The advantage of grape production in the country is that growers can predict the harvesting time of the year by pruning, and the vines can be harvested two to three times a year.

There are several constraints to be considered that affects the development of the grape industry in Thailand.

- In the Central Plain or lowland areas, the growers have to construct raised beds or dykes alternating with ditches. The growers allow too much over-cropping, often harvesting two-three times a year. The vines, therefore, have a short life-span of about 7-10 years under this intensive cropping system.

- The temperature, rainfall and high humidity are limiting factors that affect produce quality.

- The growers spray a lot of fungicides and insecticides to protect their crops without considering residual effects of the chemicals. The growers learn their grape cultivation from nearby grape growers and they also use these potent chemicals on the advice of the chemical suppliers.

- High initial investment, especially high cost of new good varieties, trellising, constructing reservoirs and irrigation systems, agricultural tools, framework for plastic roofs to protect from the rain, high cost of insecticides, fungicides and fertilizers are constraints to the expansion of the grape industry.

- Lack of knowledge on diseases and pest control measures and quality control technologies.

- Inadequacy of sufficient Government policy support for the grape industry.

10. GOVERNMENT POLICIES AND PLANS FOR RESEARCH AND DEVELOPMENT OF GRAPES

The priority of the important economic fruit crops are considered by the Committee of the Horticulture Research Institute under the Department of Agriculture, Ministry of Agriculture and Cooperatives. The grape crop has been given the lowest priority among fruit crops. There are some plans for wine and table grape production development in 1977-2001 and the period of the next ten years beyond 2001. The aim is to study all aspects of production. In the past, there were only a few research papers on grapes. However, the Department of Horticulture, Faculty of Agriculture, Kasetsart University, has tried to study and carry out research on table and wine grapes since 1960 up to the present time.

11. CONCLUDING REMARKS

The grape industry in Thailand has progressed greatly since 1960. The main areas are located in the Central Plain, which is diversifying into the rice growing lands. The major grape varieties are White Malaga and Cardinal, which are used for table grape and wine making. At present, the grape industry has expanded to Northern, Northeastern and the Western regions. The total planted area of 2,717 hectares produces 31,677 tonnes/year and the average yield is about 15 t/ha. Of the total grape production, 87.4 percent is used as table grapes and 12.6 percent for wine production, respectively. Vineyard management is quite intensive and often costly to growers. There are many diseases and insect problems. Grape

growing, however, is a highly remunerative enterprise as the crop is easily marketable. The grape industry development should be supported by the Government through the cooperation of the researchers and the growers. Considering the increasing demand and the ingenuity of local farmers, the grape industry has much potential for further expansion in the years to come.

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GRAPE PRODUCTION IN VIET NAM

Le Quang Quyen, Vu Xuan Long, et al. *

1. INTRODUCTION

In Viet Nam, grapevines can be seen everywhere. For a long time, the people in Hanoi Capital have grown grapevines around their houses for ornamental purposes and for shade; but these grapevine trellises have produced small berries and bunches with very sour taste and low food value. Grapes are now grown commercially only in the South. Their quality is not really ideal but is not inferior to other fruits (Vu Cong Hau, 1997).

In other parts of the world viticulture has existed for thousands of years, but in Viet Nam it has just begun to be developed in recent years. Since its economic value is superior to that of other crop plants, areas under grapes in Viet Nam have quickly increased since the early 1990's when only table grapes were the main article of commerce from grape cultivation.

The research work on grapes in Viet Nam has mainly been carried out by the Cotton Research Centre, which has a Food and Fruit Crops Department serving local agriculture. To understand more about the viticulture situation in Viet Nam and help the vine growers to solve production problems in varieties and techniques, since 1989 the Cotton Research Centre (an agricultural scientific research organization of the Government based in Ninh Thuan province) has carried out research on some urgent problems for the development of viticulture.

2. PRESENT STATUS OF GRAPE CULTIVATION

Major Vine Growing Regions

Growing grapes for commercial purposes began in the late 1970's in the North of former Thuan Hai province (including Ninh Thuan province and Tuy Phong District of Binh Thuan province). In Northern provinces such as Bac Giang, Ha Tay, Hai Duong, Quang Ninh and Vinh Phuc, vines have begun to be planted on a small scale for experimentation. Hence, the research work has only been carried out in the vine growing region of Ninh Thuan province.

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Area Under Grapes

The statistical data on the areas under grapevines in Viet Nam are presented in Table 1.

Table 1. Areas under Grapevines in Viet Nam in Recent Years

Provinces	Areas under Grapevines (hectares)				Notes
	1985	1990	1995	1999	
A. In the North:					Both table grapes and grapes for processing (wine and raisins)
1. Bac Giang	0	0	23	3	
2. Ha Tay	0	0	16	10	
3. Hai Duong	0	0	17	0	
4. Quang Ninh	0	0	7	0	
5. Vinh Phuc	0	0	12	12	
B. In the South:					Only table grapes
1. Binh Thuan	0	0	100	250	
2. Ninh Thuan	26	306	1952	2400	
Total (hectares)	**26**	**306**	**2127**	**2675**	

The data show that grapes have mainly been grown in Ninh Thuan and Binh Thuan provinces. Today, the areas under grapevines are mainly located in Ninh Thuan province (occupying 90 percent of the total area) and in Binh Thuan province (occupying 9 percent of the total area under grapes in the whole country).

Up to now, statistical figures on the production of grapes in Viet Nam have not been given by the State Statistical Department because the area under grapes is very small in comparison to other crops.

Variety Information

In the middle of 1980's, the four grape varieties that were popular in former Thuan Hai province were Muscat blanc, Alden, Ribbier and Cardinal (Vu Xuan Long et al, 1992). In the 1990's, only the Cardinal variety became popular. This variety has some advantages such as high yield potential, difficult separation from pedicels, and short growing duration in comparison with Muscat blanc, Alden and Ribbier varieties. Duration of each cropping cycle is about 85-95 days from pruning to harvesting, with one month resting of vines before pruning again. Such a cycle needs about four months duration and three harvests per year can be possible.

Viet Nam did not introduce any new grape varieties for nearly 30 years. Hence, both producers and consumers have not been able to select other varieties at will and they have had to depend on the Cardinal variety to meet their urgent needs for local consumption.

Climatic Conditions in Grape Growing Regions

The rainfall in the Northern grape growing regions is much higher than that of Ninh Thuan. Annual rainfall in these provinces varies from 1,500 to 1,900 mm (Appendix 1). High rainfall is the main impediment that caused areas under grapes in the North not to

increase but to be reduced, which was also based on experimental studies carried out for some years.

Ninh Thuan is a dry region with a mean temperature of 24-28^{o} C, a low relative humidity of 72-85 percent, high sunshine hours per month ranging between 130-287 hours, an annual average rainfall of 750-900 mm, and a lesser number of rainy days per year (Appendix 2). These climatic conditions are fairly favourable for the growth and development of grapes.

Soil Conditions in Ninh Thuan Grape Region

The results from a survey on the nutrition status in the soil of 800 hectares in Ninh Thuan showed that the soil conditions were very suitable for the growth and development of grapes, which included neutral to low acidity, high availability of phosphorous and potassium, and medium level humus content.

3. PRODUCTION OF PLANTING MATERIAL

Many years ago, there were no Government or private nurseries producing planting material of grapes in Viet Nam. Hence, farmers had to produce planting material of grapes for themselves by using cuttings and a few by layering.

Today, there are three organizations that have been tasked to produce planting material of grapes for farmers, namely the Cotton Research Centre, Ninh Thuan Domestic Animal and Crop Breeding Centre and Binh Thuan Socio-Economic Development Centre. All of them are researching on rootstocks to identify suitable planting materials for different soil and climatic conditions of the various grape growing regions. Besides, the Cotton Research Centre is conducting studies to propagate grapes by the in vitro method.

4. ESTABLISHMENT OF VINEYARDS

Land Preparation

Some operations that need to be carried out before planting include deep plowing and harrowing to improve good porosity and aeration of the soil. The land is then divided into plots following the general gradient of the land to facilitate appropriate irrigation and drainage layout. This is followed by fine leveling of the surface of each plot, digging holes, and filling with a mixture of topsoil, phosphate fertilizer and lime (if necessary) before commencement of planting.

Planting Season

In Ninh Thuan and Binh Thuan provinces, the farmers usually plant grapes at the end of the rainy season and at the beginning of the dry season. The most suitable planting time is in December and January.

Spacing

Grapes are planted at a spacing of 2.5 x 2.0 m, which gives a density of about 2,000 plants per hectare. In Ninh Thuan and Binh Thuan grape growing regions, the farmers have only used the overhead arbor system for training vines. The height of the trellis depends on the convenience of the worker.

5. CARE AND MANAGEMENT OF VINEYARDS

5.1 Training and Pruning of Plants

Training

In Viet Nam, vine branches are trained into a cobweb-like design. When vines climb to the top of the trellis (about 2-3 months after planting), the tops of main stems are cut in order to promote 2-3 main arms or branches. After 1-1.5 months, the tops of these arms are pruned back to induce 2-3 secondary branches, and canes are spaced at convenient distances along the secondary branches to achieve the required network. Ninh Thuan farmers have a habit of pruning bearing canes for the first harvest after allowing vines to grow for about 8-10 months.

It is necessary to tie branches to the trellis and pluck unwanted axillary buds in time before the blooming period. Vine branches are usually tied along the horizontal plane on the surface of the trellis for better flowering. Plucking axillary buds is regularly done in order to create good conditions for growth and development of the main branches.

Pruning

Vines in Ninh Thuan can be induced to produce at any time of the year (2.5-3 harvests a year), so grape pruning time is possible all the year round. A grape season lasts about 4 months, and 25-30 days after each harvest vines are pruned again for the next crop. The 8-month old branches are usually pruned in winter-spring for the first crop and every 4 months thereafter. Pruning positions on the canes are from the eighth to the twelfth nodes for the strong branches, and from the fourth to the sixth nodes for the weak canes.

5.2 Application of fertilizers

The results from a survey on fertilizer use are presented in Table 2.

Table 2. Fertilizer Doses for Grapes in Ninh Thuan (Cotton Research Centre, 1992)

Kinds of Fertilizers	Total (kg/ hectare/crop)	Percentages of Weights on Different Stages (%)		
		Before Pruning	Pruning-Flowering	Flowering- Ripening
1. Humus	25.300 ± 7.850	100	-	-
2. N	539 ± 68	54.76	26.19	19.05
3. P_2O_5	339 ± 56	65.30	10.20	24.68
4. K_2O	288 ± 73	45.25	11.21	43.53

Application of nitrogenous fertilizer was mainly carried out before pruning (55 percent N), from pruning to flowering stage (26 percent), and 19 percent at berry enlarging stage.

Almost all phosphorous fertilizer was given before pruning, the rest was applied at the bud, flower and berry enlarging stages in the form of mixed fertilizers. However, it was observed that fertilizing nearly 25 percent of the total amount of phosphorous fertilizer in the berry growing stage was rather high.

Potassium fertilizer used for grapes before pruning was 45 percent and 44 percent for the berry enlargement and colour break stages.

5.3 Weeding

Average vineyard size of each household is very small, usually about 0.1-0.4 hectares. Hence, controlling weeds is only carried out by hand. In recent years, roundup herbicide has begun to be used. At present, the Cotton Research Centre has been carrying out some research on polyethylene film mulching as a measure for control of weeds in grapes.

The results from the survey on farming techniques showed that 70 percent of vine growing households turned up the soil at least once per crop and others did it once per year. Turning up the soil is often carried out after the last harvest together with the incorporation of organic and inorganic fertilizers before the next pruning.

5.4 Supplementary Irrigation

According to Ninh Thuan farmers, irrigation and fertilization are the main inputs for ensuring high grape productivity and quality. Irrigation is only necessary in the dry season but not important in the wet season. Farmers have often used the flooding method of irrigation on the surface of grape beds. The quantity of water and the irrigation frequency together with inorganic fertilizer application are the most important practices of all the field operations. Vineyards are usually irrigated according to a 10-15 day schedule, but in sandy soils it is shorter, usually about 5-7 day intervals.

5.5 Insects and Diseases

Insects

Vines are attacked by some destructive insects such as mealy bug *(Ferrisiana virgata*), thrips (Thrips sp.), red spider mites (*Eotraniclus carpini*), and yellow spider mites etc. These pests usually exist on vines and cause great damage in dry seasons.

The main kind of chewing pest is the army worm (*Spodoptera exigua*). It bites young leaves, buds and flowers. It occurs and causes serious damage in dry seasons.

Diseases

Grapes are infected by several diseases that are economically important.

Downy mildew disease caused by *Plasmopara viticola* fungus infects mostly young and fully grown leaves. The population dynamics and damage caused by this pest indicate that the disease is persistent in vineyards and causes damage all the year round, especially in the rainy season (May to November).

Bunch rot disease caused by *Diplodia natalensis* fungus infects the peduncles of bunches at flowering and young berry stages. Hence, it is very difficult to control this disease when vines are infected which causes serious losses to grape yields. Population dynamics and nature of damage indicate that this disease seems to occur nearly all the year round, especially in the rainy season (May to November).

Powdery mildew disease caused by *Uncinula necator* fungus infects berries and old branches. Population dynamics and damage show that this disease exists in vineyards and develops and causes damage all the year round, especially in dry seasons (December to April).

Rust disease is caused by *Kuehneola vitis* fungus, which infects fully grown leaves. This disease often develops and debilitates vines only in the rainy seasons (June to November).

Table 3. Some kinds of Pests and Diseases Recorded on Grapevines in Viet Nam

Common Name	Scientific Name	Infected Part
Diseases:		
Downy mildew	*Plasmopara viticola*	Young and full leaves
Bunch rot	*Diplodia natalensis*	Peduncles of bunches
Powdery mildew	*Uncinula necator*	Berries and old branches
Rust	*Kuehneola vitis*	Full and old leaves
Pests:		
Army worm	*Spodoptera exigua*	Leaves, squares and flowers
Mealy bug	*Ferrisiana virgata*	Branches
Thrips	*Thrips sp*.	Leaves, Berries, Branches
Spider mites:		
Red spider mites	*Eotraniclus carpini*	Leaves
Yellow spider mites	*Unknown*	Leaves
Nematodes:	*Unknown*	*Roots*

Pest and Disease Management

As mentioned above, the Cardinal variety in Ninh Thuan has degenerated and possesses weak pest resistance. Moreover, haphazard pruning at any time of the year without any organized cropping system always causes conditions favourable for pests and diseases to develop and cause damage. Hence, controlling them becomes one of the important factors that affect the yield and economic effectiveness in viticulture programmes.

In the past, lime-sulphur, copper sulphate and bordeaux mixture were mainly used to control diseases of grapes. These chemicals were cheap but had to be sprayed many times per crop. When new foreign-made chemical fungicides and pesticides were used to control diseases and insects of grapes, some remarkable results were obtained including fewer

spraying times, long-lasting effect from each spraying, and lower labor costs. Since 1989, the Cotton Research Centre has screened many fungicides and recommended some of them to farmers, including Rovral, Rozin, Ridomil MZ, Ridomil combi, Score, Topas, Anvil, Antracol, Copperhydroxide, Tilt, Baycor, Curzate, and Bayfidan, etc.

For army worm (*Spodoptera exigua*), it has been found that it is very difficult to control this kind of pest with chemical insecticides. However, researchers found it easy to control army worm with a biological product, Nuclear Polyhedrosis Virus (NPV_{Se}) made at the Cotton Research Centre.

Nematodes, such as the vine-damaging nematode, were mentioned by scientists of the Cotton Research Centre some years ago. However, this problem has not yet been studied due to lack of budget resources.

6. HARVESTING AND YIELDS

Grape yields are shown in Table 4.

Table 4. Grape Yield (t/ha) Based on Different Age of Vines and Crops (By Vu Xuan Long, et al. 1992)

Plant age (year)	1992 Spring-Summer Crop (Pruning in April and in May)	1992 Autumn-Winter Crop (Pruning in Sep. and in Oct.)	1992-1993 Winter-Spring Crop (Pruning in Dec. and in Jan.)	Total of 3 crops/year
1	-	-	8.00	8.00
2	10.55 ± 4.75	2.67 ± 3.46	18.67 ± 4.71	31.89 ± 10.90
3	20.00 ± 11.32	8.10 ± 7.19	20.61 ± 5.87	40.71 ± 22.20
4	15.56 ± 4.45	8.70 ± 5.85	16.73 ± 3.29	41.33 ± 9.82
5	14.90 ± 4.70	10.24 ± 6.61	16.30 ± 2.98	41.44 ± 13.06
6	9.38 ± 3.74	6.13 ± 2.93	10.62 ± 4.08	26.12 ± 5.35
7	22.50	5.00	5.75	33.25
12	5.33	7.33	-	12.66
Average grape yield (metric tonnes/hectare/year)				29.43

From the data in Table 4, the following observations have been made:

- Grapes in Ninh Thuan age fast and become senescent due to severe exploitation of vines. Normally, the vine growers have to get rid of old vines for replanting after they are cropped for about 10 years. This seems to be a bad way of forcing culture (pruning and harvesting 2.5-3 times per year) and the vines consequently degenerate fast.
- The grape yield of the Autumn-Winter season is the lowest in a year, which is only about 50 percent in comparison with other seasons. The main reason for low productivity is that, in the pruning period of this season (in September and October), heavy and continuous rains often appear, which cause root rot and disadvantages for the blossoming process.

The results from a random investigation of 50 vineyards of different plant ages in 1995 and 1996 showed that mean grape productivity in Ninh Thuan was over 30 tonnes per

hectare/year. Planting grapes could bring a profit of over VND 100 million per hectare/year. Grape yield is high and stable in Winter to Spring or Spring to Summer seasons but low and unstable in Autumn to Winter (Appendix 3).

7. MARKETING

Up to now, most grapes produced in Ninh Thuan and Binh Thuan provinces have been consumed in the form of table grapes, and a small quantity of grapes with very poor quality are processed into local juice and wine. Grapes are transported everywhere in Viet Nam by dealers and middlemen.

At present, Viet Nam is importing 2 kinds of table grapes from abroad. Consumers are aware that they are produced in the United States, Australia or Thailand. Table grape prices are shown in Table 5.

Table 5. The Prices of some Kinds of Grapes at the Free Markets in Viet Nam (April 2000)

Kind of Table Grapes	Place of Production	Wholesale Price (VND/kg)	Retail Price (VND/kg)
1. A kind of table grape with very big berries, red colour, few seeds	Abroad	Unknown	90,000-110,000
2. A kind of table grape with big berries, green-yellow colour, seedless	Abroad	Unknown	60,000-80,000
3. Cardinal	Viet Nam	5,000-10,000	10,000-15,000

Note: Exchange Rate VND 14,000/USD

8. POTENTIAL FOR GRAPE PRODUCTION DEVELOPMENT

The potential for grape production development in Viet Nam, especially in Ninh Thuan and Binh Thuan provinces, is very good because of some salient factors that are linked to high demand for grapes. These are as follows:

- Consumer needs for grapes keep increasing.
- Market potential for grapes in Viet Nam is still very large for fresh grapes and processed products.
- The vine growing region of Ninh Thuan and Binh Thuan have relatively dry conditions with the lowest rainfall in the country.
- There is considerable wasteland on the hills and near the low mountains that can be utilized for expanding viticulture.
- The vine growers have a lot of experience on intensive cultivation of grapes.
- Both Government and local authorities are interested in the development of the grape industry.

9. CONSTRAINTS IN GRAPE PRODUCTION DEVELOPMENT

In 1998 and 1999, like other provinces in the centre of Viet Nam, Ninh Thuan was affected by natural disasters (storms and floods) that caused serious damage to viticulture. The total area under destroyed vineyards by storms and floods was 1,487 hectares (occupying more than 50 percent of areas under grapes at the beginning of 1998). Storms and floods weakened the crop that survived and it may take a long time for them to recover.

Due to the economic advantages of viticulture, some farmers have diversified from other crops to grow grapes, even in double-cropped rice fields or in the sandy soils near the coast. Hence, there were some vineyards established in unsuitable soils such as in sunken terrain which floods frequently, soils with high acid content, as well as in very infertile soils. In order to get reasonable harvests from such soils, farmers had to invest more in comparison to other areas.

Heavy rains often occurred at the end of the year (August to November) together with high temperature, when some diseases develop very quickly. Large quantities of fungicides have to be used in this period.

Up to now, cultivation techniques for grapes have not been properly studied. Farmers have had to toil in their vineyards in order to gain experience for themselves. As a result, the harvests are unstable, uses of fertilizers are excessive and consequently, production tends to suffer.

10. GOVERNMENT POLICIES FOR VITICULTURE DEVELOPMENT

The Government of Viet Nam has issued several general policy directives for development of fruit crops all over the country, including grapes. These policies include encouraging farmers to change crop planting composition to diversify agriculture and farm products, providing loans to farmers at low interest rates, and constructing new water reservoirs as well as main channel systems for agricultural production. In recent years, Viet Nam Agriculture and Rural Development Ministry has made initial investments for research and agriculture extension including surveys on grape cultivation techniques for farmers, forming agro-extension models for planting new varieties, as well as IPM programmes. These investments are, however, too small in comparison with the grape growers' needs, especially on production techniques.

Since Ninh Thuan province was re-established in 1992, the provincial authorities have affirmed that the development of viticulture is one of the key tasks in its socio-economic programme. Hence, they have begun to show their concern for the development of viticulture by investing more for research on variety collections, surveying the suitable areas for grapes, and building wineries for processing, etc. However, these investments are still insufficient in comparison with production needs.

Research Work on Grapes in Viet Nam

Research on Vine Collections

There are four organizations in Viet Nam maintaining and researching on vine collections. These are the Cotton Research Centre, Hanoi Vegetable and Fruit Research Institute, Ninh Thuan Domestic Animal and Crops Breeding Centre and Binh Thuan Social and Economic Development Centre.

At the Cotton Research Centre these varietal studies carried out from 1994 to 2000 have included the collection and introduction of 61 accessions. Among them there are 12 domestically collected accessions and 49 accessions introduced from abroad (France, United States, Australia, India, Thailand, China and Germany) including 34 table grape accessions, 25 wine grape accessions and 3 rootstock varieties. Through the results of research on this collection, some specific promising accessions were identified and presented for further research. Table grape accessions selected are NH-01-08, NH-01-48 and NH-01-60; wine grape accessions selected are NH-02-04, NH-02-10 and NH-02-17 and the raisin grape accession is NH-01-11.

At Hanoi Vegetable and Fruit Research Institute, 5 accession wine grape collections introduced from France have been studied since 1995. As a result, Vilard noir accession has been identified as a variety having the highest productivity and the best quality (By Nguyen Quoc Hung, Tran The Tuc, Vu Manh Hai and Stephen Desmazieres, 1999). Besides, this Institute has just introduced some additional vine accessions. There are 28 accessions in the collection here at present, including 16 table grape and 12 wine grape accessions.

At Ninh Thuan Domestic Animal and Crop Breeding Centre, the grape collection mainly contained wine grape accessions introduced from Australia from 1995. In 1996, the Germans supplemented some table grape and rootstock accessions to this collection. Now, there are 33 accessions in the collection including 17 table grape accessions, 13 wine grape accessions and 3 rootstocks. From the result of the research on the vine collection, Black Queen table grape variety has been released for screening on an experimental and pilot production scale.

At Binh Thuan Social and Economic Development Centre (established by the Germans together with local authorities in Binh Thuan province) one of its tasks was to research on vine varieties for farmers in Tuy Phong district. Hence, up to now a 42 accession vine collection has been established here. Among them there are 32 table grape accessions, 5 wine grape accessions and 5 rootstocks. Today, this Centre has also released the Black Queen table grape variety for screening and pilot production on a small scale.

Research on Some Promising Table Grape Varieties

Initial results of studies on grape yield and quality in preliminary investigations showed that NH-01-48 table grape accession has more advantages than the Cardinal variety. Hence, this accession was selected for testing on a large scale. From these demonstrations carried out over several seasons, the following results were obtained:

The growth duration of NH-01-48 grape variety (from pruning to the last harvest) was about 25-30 days longer than that of the Cardinal variety. The NH-01-48 variety could

resist downy mildew, bunch rot and powdery mildew better than Cardinal variety. Finally, the yield of this new variety was higher than that of the Cardinal check variety.

NH-01-48 grape variety had better quality characteristics compared with Cardinal, which included higher sugar content, fewer seeds, and sweeter taste and aroma.

Research on Micro-element Mixtures

The Cotton Research Centre succeeded in studying several kinds of mixed foliar fertilizers from macro, semi-macro and micro fertilizers, called "Duong nho". Spraying "Duong nho" on grapes increased yield and sugar content. It also increased farmers profit from VND 3 to 5.76 million per hectare (Nguyen Huu Binh, Le Quang Quyen, Vu Xuan Long, et al. 1997). This product was recognized as a technical achievement and was released for trial on a large scale by the Scientific Commission of the Agriculture and Rural Development Ministry.

Research on Growth Regulators

Based on research on the effectiveness of some growth regulators for grapes, a yield-increasing product called LH1 was found for grapes. This product contained α-Naphtyl acetic acid, gibberellic acid and some micro-elements. Berry weight, bunch weight, number of the berries per bunch and yield increased when LH1 0.1 percent was used, which especially brought profit for farmers exceeding over VND 7 million per hectare (Vu Xuan Long, Nguyen Quang Thach, 1997).

Research on Cultivation Techniques for Grapes

Currently, the Cotton Research Centre has been carrying out some research on cultivation techniques for grapes which included research on polythene film mulching, vine planting using a ditch and dyke system of land reclamation in low-lying areas, grape bunch covering techniques, use of rootstock and grafting techniques, use of economical irrigation methods, and research on some methods of agricultural extension.

11. CONCLUSIONS

- In Viet Nam, grapes have mainly been grown in Ninh Thuan and Binh Thuan provinces. Today, the areas under grapevines are some 2,400 hectares in Ninh Thuan (occupying 90 percent) and 250 hectares in Binh Thuan (occupying 9 percent of the total areas under grapes in the country). In the North of Viet Nam, grapes are being planted on a small scale for experimentation.

- The climatic and soil conditions of Ninh Thuan province are very suitable for the growth and development of vines. It is in this region that grapevines can be pruned at any time of the year giving 2.5-3 harvests a year.

- At present, Cardinal is an unique variety popularly grown in Viet Nam. This variety has a high yield potential but not excellent berry quality and is especially weak in pest and disease resistance. Vines are mainly propagated by cuttings.

- Ninh Thuan and Binh Thuan farmers have only used the overhead trellis system for vines. Grape planting time is mainly carried out in December and January every year. Popularly used plant density is some 2000 plants per hectare. The system of vine training is similar to a cobweb-like design. Pruning is done at any time of the year and irrigation is given usually every 10-15 days. Inter-cultivation is mainly done once per season together with the application of organic and inorganic fertilizers. Fertilizer doses used are rather high, most of which are given before the pruning stage.

- Vines in Ninh Thuan are infected by four kinds of diseases: downy mildew, bunch rot, powdery mildew, and rust. Among them, downy mildew, bunch rot and rust diseases often develop and cause serious damage in the wet season, but powdery mildew occurs in dry weather. In addition, vines are attacked by army worm, thrips, mealy bug and spider mites. These insects and spider mites mainly cause damage in the dry season.

- Vines in Ninh Thuan age soon because of intensive exploitation. Normally, vine growers have to get rid of old vines for replanting after about 10 years. Average grape yield in Ninh Thuan was estimated at about 30 tonnes per hectare a year. High grape yield is focused on Winter-Spring and Spring-Summer seasons but it is low and unstable in Autumn to Winter.

- There are four organizations maintaining and researching on grape collections, which are the Cotton Research Centre, Hanoi Vegetable and Fruit Research Institute, Ninh Thuan Domestic Animal and Crops Breeding Centre, and Binh Thuan Socio-Economic Development Centre. The quantities of accessions in these collections are 61, 26, 33 and 42 respectively.

- NH-01-48 table grape variety has more advantages than Cardinal variety in characters such as easy blossoming after pruning, high yield, high sugar content, delicious taste and good disease resistance.

- Because Viet Nam is a poor country, the Government has not yet been able to invest much capital for the development of viticulture. Although leaders at all levels have begun to show their concerns for viticulture development and invested on grape research, these investments are too small in comparison with the grape growers' needs in the domains of basic and applied research techniques.

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APPENDICES

Appendix 1. Average Annual Rainfall in some Vine growing Regions in Viet Nam

Stations (Prov.,City)	Months												Total (mm)
	1	2	3	4	5	6	7	8	9	10	11	12	
1. Lang (Hanoi)	18.6	26.2	43.8	90.1	188.5	239.9	288.2	318.0	265.4	130.7	43.4	23.4	1676.2
2. Moc Chau (Son La)	14.8	21.2	34.0	98.7	165.5	220.8	266.3	331.4	257.2	106.4	31.8	11.8	1559.9
3. Vinh Yen (Vinh Phuc)	19.4	24.1	30.4	106.5	174.1	240.2	262.8	333.4	221.0	127.2	48.2	16.2	1603.5
4. My Duc (Ha Tay)	30.4	17.2	33.0	129.8	208.5	263.5	238.7	372.9	329.1	201.8	70.3	20.0	1915.2
5. Nha Ho (Ninh Thuan)	7.7	2.4	7.8	12.1	77.1	66.4	74.7	149.1	169.8	150.4	140.1	55.0	912.6

Appendix 2. Average Meteorological Data at Nha Ho Station (1979-1998).

Month	Temperature (^{o}C)			Relative humidity (%)	Sunshine hours/ month	Rainfall (mm)	Rainy days/ month
	Mean	Max.	Min.				
1	24.4	33.5	16.3	72	213.6	7.7	1
2	24.8	35.2	17.3	72	225.6	2.4	1
3	26.1	36.5	18.0	75	286.6	7.8	1
4	27.7	36.8	20.4	76	236.9	12.1	2
5	28.2	39.0	19.9	79	198.4	77.1	10
6	28.4	40.5	22.2	79	218.9	66.4	11
7	28.2	39.6	21.9	76	183.2	74.7	9
8	28.2	39.5	21.2	78	205.9	149.1	10
9	27.0	37.7	20.8	82	141.4	169.8	14
10	26.6	34.5	19.3	84	169.5	150.4	15
11	26.0	34.5	17.7	84	136.4	140.1	15
12	24.9	34.0	16.4	80	129.5	55.0	8

Appendix 3. Yield and Economic Return of Grapes in Ninh Thuan Province. (by Nguyen Huu Binh, Vu Xuan Long, et al. 1996)

Crops	Yield (kg/ha)	Total income (1000 VND /ha)	Expenditure (1000 VND/ha)		Profit (1000 VND/ha)
			Materials	Labour	
1. Spring-Summer 1995	12293.6	63184.17	16844.24	6900.07	43258.13
2. Autumn-Winter 1995	7735.6	42885.78	16840.33	7021.20	19024.25
3. Winter-Spring 1995-1996	12677.8	70063.95	16477.02	6852.29	46734.67
Total/year	32707.0	176133.90	50161.59	20773.56	109017.05

Note: Total income and expenditure at market prices in May, 1996.

CONCLUSIONS AND RECOMMENDATIONS

1. Grape is one of the most important fruit crops of the world and it contains many of the most valuable elements necessary for life. The crop has a wide adaptability, and grapes can be grown under temperate, sub-tropical and tropical climatic conditions and varied agro-ecological settings. The food, nutrition, medicinal and economic values of the crop could be of significant importance for the population of the Region. Therefore, the Consultation recommended that every effort should be made to realize the full agricultural potential of the crop.

2. Remarkable success has been achieved in grape production and productivity levels in certain countries of the Region (such as India and Australia), while in other countries the progress is very limited. The opportunities for further development of the grape industry appear to be very good. However, at the same time the problems to be addressed are many and serious. There is, therefore, a need for the various countries to consider taking appropriate action to address the existing problems to the extent possible.

3. The number of grape cultivars throughout the world is very large but in many countries in the tropical zone only a relatively small number of cultivars are present and have been evaluated for suitability to local climatic conditions. The introduction of many cultivars (table, wine and raisin) for field evaluation under local conditions was considered an important objective for the advancement of grape industries throughout the Region, in producing fresh and processed grape products of a quality which meets the requirements of specific markets. The opportunity exists for the field evaluation to occur through a collaborative effort involving interested countries, to address common problems whilst also addressing the individual needs of each country's industry. Some countries in the Region have many grape cultivars and could become a germplasm resource for other countries. Also developing linkages with cultivar-rich countries outside the Region would provide an additional supply of cultivars for evaluation of their suitability to local growing conditions.

4. Several countries in the Region have grape breeding programmes notably Japan, the Republic of Korea, Viet Nam, China and Australia. Currently each breeding programme is operating in isolation to achieve objectives specific to the industry in that country. There exists the opportunity for communication and information sharing between grapevine plant breeders in the Region as well as exchange of genetic material to enhance both the individual breeding programmes and quality of cultivars grown by the industry. However, the need to recognize breeder protection rights over their genetic material must be recognized and may make access to new grape cultivars too expensive for some countries. In both breeding and the evaluation of existing cultivars the attributes sought are high bud fruitfulness under tropical conditions, disease resistance, and productivity, despite increased vine vigor (e.g. Marroo Seedless).

5. All grape producing countries in the Region have one or more soil derived problems, notably phylloxera, nematodes, salinity, drought and adverse soil chemistry, which impinge upon successful grape production. Some countries in the Region have experience in the ability of rootstocks to tolerate adverse soil conditions

and the positive impact of rootstocks on fruit quality and vine fruit yield. These countries also have a large number of rootstocks whereas most countries in the Region have only a few. The introduction of many rootstocks into countries throughout the Region and their evaluation for suitability under local conditions to fulfil industry requirements was considered an important objective. Initially this could be achieved through collaboration between those countries with the diversity of grapevine rootstocks and those countries with production problems that potentially can be overcome through the use of appropriate rootstocks.

6. Grapevine plant material used in countries throughout the Region was either of unknown health status or known to be infected with specific micro-organisms (viruses, mycoplasmas, bacteria) which are detrimental to vine performance. A supply of grapevine plant material free of debilitating organisms is critical for the development of a successful grape industry. Techniques for determining the virus status (Elisa, PCR) and controlling debilitating organisms (hot water treatment) are available in several countries throughout the Region. It is feasible for these techniques to be transferred to other countries in the Region for further dissemination by local staff. In addition, grapevine material of a higher health status available in some countries could be introduced to those countries in the Region requiring improved plant material.

7. Several production issues were highlighted as constraints to grape production in the Region. These were understanding and managing vine nutrition in the tropics, efficient irrigation management, manipulation of bud burst, optimizing crop load, maximizing bud fruitfulness, managing flowering, fruit set and berry growth and effective practices for grape production under protected (temporary and permanent) systems.

7.1 The need to determine the nutrient requirements of vines under tropical conditions and petiole interpretation standards for the accurate monitoring of vine nutrients status was identified as important for effective and efficient vine nutrition management. This has implications for fruit quality, cost of production and environmental preservation.

7.2 Water resources in many countries are limited and water quality is often declining (salinity), hence the need to increase water use efficiency. Firstly, it is necessary to quantify the amount of water required under each local growing condition for optimum yield and fruit quality. Subsequently, an efficient irrigation programme will have to be developed and the grape grower trained in the use of irrigation scheduling. Some countries are experienced in irrigation scheduling and sharing of their knowledge could expedite achieving greater water use efficiency and sustained grape production.

7.3 The factors affecting bud break under tropical conditions are not well understood yet poor bud break has a huge impact on vine productivity and hence profitability of the grape grower. This is a major problem affecting all countries in the Region with grape production in hot environments. A collaborative effort to understand the physiology

involved and subsequently the development of management practices to optimize bud break would have a considerable impact upon industry viability.

7.4 Under tropical conditions efforts to increase vine yield often lead to other problems of fruit quality (water berry, low sugar concentration). To increase yield but still achieve desired fruit quality and harvest time it is necessary to determine maximum crop load in relation to leaf area index (LAI). Many of the table grape industries throughout the Region have a narrow market window, outside of which competition from other fruits or adverse weather conditions affects price and fruit quality.

7.5 Knowledge of the factors contributing to floral initiation in the tropics is poor and in many countries there is a lack of vineyard management practices that enhance floral initiation. To increase vine yield it is important for grape growers to be able to successfully manipulate floral initiation.

7.6 Several problems were identified with flowering, berry set and berry growth, all of which impinged upon fruit quality and yield. It was considered important to develop labour saving practices (chemical treatments and other techniques) for cluster elongation, flower thinning and berry sizing. Some countries have progressed in developing chemical treatments (GA, BA, and CPPU) and a large amount of work has also been undertaken in the temperate zones. However, it was noted much higher rates of GA are usually required under hot and humid conditions common in the Region, compared to levels used in temperate climates.

7.7 Several countries have developed protected culture of table grape, both permanent and temporary coverings, to improve fruit quality, reduce pesticide applications and prevent rain damage to fruit. Yet the production techniques need further refinement to overcome several problems associated with protected culture. This in turn will improve the viability of grape production and enable the grower to meet the additional cost of the protective cover.

For each of the previously mentioned vineyard management problems limiting grape production, research is being conducted in one or more of the countries in the Region. The forum concluded that there were opportunities for collaboration between countries to maximize the outcomes from individual efforts and that this would enhance development of the grape industries in the Region.

8. The high use of chemical pesticides, current spray practices and the spray equipment used has led to chemical residues on the fruit and a reluctance of consumers to purchase grapes, as well as poor control of pests and diseases and increased pressure on the environment. Many advancements in grape production will result from improved grower knowledge of the weather conditions conducive for disease and pest outbreaks, the critical times to apply sprays for effective control, and

selection of the appropriate chemical for each disease/pest. Training of grape growers in the safe handling of chemical pesticides is required to reduce the risk of contamination, both to the environment and vineyard workers. Improving the knowledge of grape growers in the critical factors in preparing spray solutions (water quality, solution pH) will increase the efficacy of pesticides applied in controlling the target disease or pest. The reluctance of grape growers in several countries to adhere to the chemical registration and safe use of chemicals was considered to be a major contributing factor to high residues on fruit in the market. The forum recognized a change in grower attitude was necessary and that this could be facilitated both through grower training and greater implementation by governments of residue testing of fruit. Several countries in the Region have strengths in training of growers in pesticide application. The forum concluded that improvements in pesticide use were vital for the success of the grape industries in the Region.

9. Several examples in the Region of successful biological control of pests were noted. The forum agreed it was important to identify locally occurring parasites and predators for the biological control of pests. Further, the greater adoption of integrated pest management (IPM) by growers was seen as important for minimizing chemical use and residues on fruit, which in turn will reduce the cost of production and increase consumption. To achieve this will require a change in attitude of growers. Disease forecasting models currently being used in several countries should be furthered refined for accuracy under local conditions and made available to countries in the Region. However, for maximum grower adoption such models must be simple to use and affordable. The forum recognized that developing and encouraging organic grape production would be important for future viability of regional grape industries.

10. The quality of table grapes in several countries is adversely affected by the lack of cool storage infrastructure, lack of a continuous cool chain from vineyard to consumer and inadequate sulphur dioxide technology. If these issues are not addressed, the long-term viability of regional grape industries will be at risk. Imported table grapes of superior quality have already eroded the market share of the local industry in some countries in the Region. The forum recognized the need to establish cool storage infrastructure close to vineyards as well as cooling facilities throughout the supply chain to provide optimum post-harvest temperature for grapes. It was noted that in some countries most problems with sulphur dioxide (SO_2) damage was caused by breaks in the cool chain. Training of growers and packers in the correct use of SO_2 releasing pads and cool handling of grapes could minimize the loss in fruit quality. It was noted that developments in SO_2 technology and packaging have been made in other countries, and concluded that to evaluate and modify these technologies for local conditions would be the most cost effective strategy for countries in the Region.

11. The health benefits of moderate wine consumption were noted. However, this benefit is not widely known within the populations of many countries and could be promoted to enhance wine consumption. Well developed wine industries are present in some countries but are absent or relatively small in others. For successful wine industries to develop in these countries the winemaking skills of winemakers must be improved. The opportunity exists for countries aiming to develop a wine industry to utilize the experience and training programmes in winemaking available in other

countries with well developed wine industries. In some countries, a change in government policy is needed in order to promote the health benefits of wine over other alcoholic beverages for the development of the wine grape industry.

12. Juice production was not common in the Region and is the smallest of the viticulture industries. The quality of grape juice is often variable and inferior which results in reduced consumption and consumer acceptance of the product. Modern equipment and training to improve juice-making skills of operators was considered vital for the production of nutritious, good quality grape juice. There is also the opportunity for other value-added grape products to be developed.

13. Export trade in grape products (wine, table grapes, raisins) by countries in the Region was relatively small, with many countries requiring imports to satisfy local demand. However, exports are an important means of increasing the wealth of a country and consequently should be encouraged and assisted wherever possible. A major impediment to growth in exports of table grapes was the lack of market intelligence and local contacts, as well as understanding of local business and cultural practices. The forum considered that those countries whose objective is to increase grape exports should develop the necessary market intelligence.

14. It was noted that locally produced wine, table grapes and raisins sold in the domestic market now face strong competition from high quality imported products. Hence, for the long-term viability and survival of grape industries in the Region it is necessary for grape growers and winemakers, to produce a product that is both cost and quality competitive. This will require the development of cost effective production practices and technologies adapted to regional conditions. Over-supply of table grapes, particularly in short supply seasons, seriously reduces price and grower income. Development of production practices to spread the supply season was considered important for sustaining the income of grape growers and industry viability.

15. The forum recognized that there was considerable potential for the development and long-term viability of the viticulture industries in most countries throughout the Region. To achieve this goal it is important to identify in each country the districts with the climate and soils suitable for successful grape growing. It was noted that these optimum growing conditions will vary for grape type (wine, table, raisin). Once identified it is necessary to encourage grape growers to establish vineyards in the preferred districts, where production costs are least and high fruit quality can be achieved. The identification of locally suited multipurpose varieties which can be used for table, wine and raisin production is desirable, as this would improve the economic stability of grape growers and hence industry viability.

16. The development and expansion of wine grape industries in most countries of the Region is highly promising because of the anticipated large increase in local wine consumption. Currently wine imports are required to satisfy this increasing demand. In several countries consumers prefer imported wines as locally produced wine is more expensive and of inferior quality. The forum strongly advised that in countries with developing wine industries, cost effective production practices should be developed and training undertaken to improve the skills of winemakers. This will enable industries to achieve the potential for growth and increase the value of the

local economy. Collaboration between countries in the Region was encouraged instead of individual efforts.

17. The limited experience and viticulture knowledge of scientists and advisors working in the grape industries was recognized as a constraint to growth of the industry in several countries. Training of scientists and production viticulturists is vital if growth and development of the grape industries is to be achieved. Several countries in the Region have well developed grape industries and viticulture education programmes. Staff and grower exchanges for training in viticulture was considered an effective way of improving the knowledge of grape specialists and ultimately promote development of the industry.

18. It was proposed that the information presented at the Consultation be collated and published in the form of proceedings, which can subsequently be distributed to the grape growing countries of the Region.

19. It was noted that despite the efforts of most countries to upgrade aspects of grape production, there are still many constraints hindering further development. Most of the problems appear to be common to all countries. The Consultation therefore recommended that assistance should be sought for the formulation, funding and implementation of a Regional Project to address the existing problems.

20. The possibility of setting up a Network for Research and Development of the Grape Industry in Asia was discussed during the meeting. It was felt that such a Network may facilitate pooling and sharing of resources for the development of viticulture. The Consultation endorsed this approach for Regional Cooperation and recommended the establishment of such a Network. It is expected that if a Regional Project on Viticulture is implemented it will eventually lead to the establishment of a Regional Network.

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