General Discussion

Chairperson : Yamaguchi, A. JFCA (Japan) and Sanada, T. FTRS (Japan)

Chairman : Yamaguchi, A. (JFCA) : Now the symposium is open for the general discussion. It is a great pleasure for me to share the chairmanship with Dr. Sanada. We would like to discuss general problems of common interest. At first, the chairman of each session will present a brief summary of each presentation and comments. Then, we will proceed to a more detailed discussion concerning each topic. Finally, general problems will be dicussed.

Chairman : Sanada, T. (FTRS, Japan) : I would like to ask Dr. Soejima to summarize the reports presented during Session I.

Soejima, J. (FTRS, Japan) : Four speakers gave presentations on the collection and utilization of tropical and subtropical fruit tree genetic resources.

Dr. Arora (IPGRI) reported on the role of IPGRI in the collection, conservation and utilization of tropical and subtropical fruit tree genetic resources. IPGRI and its predecessor IBPGR, for the past two decades, have promoted the collection, characterization, evaluation, documentation and conservation of germplasm of tropical and subtropical fruit trees for effective utilization. It supplied global information on germplasm holdings, descriptor lists, it initiated systematic and eco-geographic studies on tropical fruits, promoted research on conservation techniques and organized working group meetings and symposia. Dr. Arora introduced some of the highlights of the activities of IPGRI and IBPGR. He indicated the present and future role of IPGRI in promoting the conservation and utilization of tropical fruits in a global perspective and strategy for diversity in development.

Dr. Agarwal (India) reported on the collection and utilization of tropical and subtropical fruit tree genetic resources for breeding in India : mango, banana, citrus, guava, pineapple, grapes, and papaya are the most important tropical and subtropical fruit crops grown in India. The problems associated with successful growth of these crops include alternate bearing and several bacterial and virus diseases. Some of these problems have been solved by developing new cultivars and further improvement is needed. Attempts have been made to collect both indigenous and exotic germplasm of various fruit crops for use for improvement. These collections are being maintained mainly in field gene bank. The extensive use of this vast germplasm collection has resulted in the development of new fruit varieties in India.

Dr. Wong (Malaysia) reported on the collection and evaluation of under-utilized tropical and subtropical fruit tree genetic resources in Malaysia. More than 100 tropical and subtropical fruit species both indigenous and introduced are cultivated in Malaysia. In addition, there is a wide diversity of wild fruit species in the natural forests of Malaysia. A large number of rare fruits were presented. These species are faced with the threat of genetic erosion due to human activities. Many of the under-utilized and unutilized fruit species show an economic potential. Collection and evaluation of these fruit genetic resources have been performed. These materials could be used as new fruit crops and rootstocks and as a source of germplasm for breeding and improvement of the presently cultivated fruit crops.

Dr. Daito reported on the utilization of genetic resources of tropical and subtropical fruit trees in Japan. About 20 kinds of tropical and subtropical fruit trees have been introduced and grown in the southwestern area of Japan. The distribution of these fruit crops in the country varies according to the geographical and socio-ecological conditions. Citrus has been the leading fruit crop in Japan for a long time and loquat was introduced from south China to the western part of Japan. Other tropical and subtropical fruit crops such as passionfruit, avocado, papaya, mango, etc. have been recently introduced. Some of the fruit crops are grown in plastic houses commercially. In addition to domestic production, since many tropical and subtropical fruits are imported to Japan from several countries, some of these fruits are popular with the consumers.

Chairman : Sanada, T. (FTRS) : I would like to suggest that the discussion be focussed on the storage of tropical and subtropical fruit tree genetic resources.

Omura, M. (FTRS) : I would like to ask Drs. Agarwal and Wong what is the meaning of "multi-purpose" collection of tropical and subtropical fruit germplasm. In the case of citrus, for example, some of the collections are made for medicinal or pharmaceutical purposes. Also are there any examples of multipurpose collections in fruit germplasm? How do you obtain and record the information about multipurpose collections during exploration and collections?

Agarwal, P. K. (India) : Presently we are collecting citrus germplasm for evaluation and use in breeding improved varieties of citrus with regard to fruit quality and disease resistance.

Wong, K. C. (Malaysia) : The purpose of evaluation of the collected under-utilized fruit tree genetic resources is twofold, that is firstly to develop them into new fruit crops, and secondly, to evaluate their potential to improve the existing fruit crops. We do not evaluate their medicinal potential although the nutritive values were analyzed.

Arora, R. K. (IPGRI) : There is a need for collecting more genetic diversity and study the distribution of the resources along with their characterization, utilization and for promoting conservation, including specific conservation methods or techniques for recalcitrant seed species, using *in vitro* and cryopreservation techniques apart from maintenance in field gene banks (complementary conservation strategies) as advocated by IPGRI. More research is required and IPGRI is supporting such programs. Data documentation/cataloguing is stressed for better utilization of diversity held at different locations. The importance of postharvest technology, quarantine system, safe movement of germplasm should be emphasized. The expertise of IPGRI could be utilized for the implementation of training programs and transfer of technology for maintenance and conservation.

Chairman : Sanada, T. (FTRS) : To conclude, I would like to mention that in this session the importance of genetic resources was emphasized for the promotion of the tropical and subtropical fruit industry. For vegetatively propagated crops such as fruit trees, it is important to develop a preservation system through the promotion of international cooperation. Exchange of germplasm among countries is also important for the effective utilization of genetic resources.

Now, I would like to ask Dr. Hidaka to summarize the reports presented during Session II.

Hidaka, T. (JIRCAS) : During Session II there were three presentations, the first two on the cultivation of grapevine in Brazil and Indonesia and the last one on the breeding of temperate zone fruits requiring low chilling in Brazil.

In Brazil, regions in the temperate zone are the main producing areas for both wine and table grapes. In the subtropical region, there are two main areas, the nothwestern state of Sao Paulo and northern state of Minas Gerais where grapes can be cultivated continuously. The main varieties used for table grapes are Italia and Rubi. There are two types of pruning: regular production pruning and regulating pruning for the following productive cycles. In the northwestern state of Sao Paulo the vineyards are covered with nylon screens to protect them from bird and bat attacks, strong wind, sunlight, etc. Reduction of phenological cycles is about 30 days compared with the temperate zone. Sao Franscisco River Valley is a promising production area in the tropical zone of Brazil, mainly for table grapes, the main varieties being Italia and Piratininga and the only rootstock being IAC 313 Tropical. Pruning is performed immediately after harvest. Reduction of the phenological cycles ranges from 100 to 120 days, allowing for 2.5 harvests per year. Cluster thinning is practiced in the subtropical region, using adapted plastic brushes. Two chemicals are used for breaking the dormancy calcium cyanamide and hydrogen cyanamide which is recommended. One of them must be applied immediately after production pruning. For increasing the berry size, GA 3 is used for Italia and its mutants in the half berry phase. The subtropical and tropical regions of Brazil are extremely favorable for viticulture, in particular for table grapes.

In Indonesia, table grapes are grown in East Java, Bali and Central Sulawesi. Main varieties are Bali 1 and Probolinggo Biru 81. They are mostly propagated by cuttings and grown on trellis. Pruning occurs in April and August, two times a year, leaving 1 to 10 buds. Berry thinning is preferable to flower or cluster thinning. Dipping bunches in GA 3 is occasionally used to increase the cluster and berry size. Two to three crops a year are obtained in June, October and February,

yielding 50 kg per tree or 25 tons per hectare. Pests and diseases are controlled by spraying chemicals. Seedless and powdery mildew-tolerant varieties are required for further development of viticulture.

The report from Australia dealt with breeding research for the development of temperate zone fruits with low chilling requirement. Treatment with hydrogen cyanamide is used to promote uniform budburst in grapes and cherries. For pistachio, it can be used to promote uniform budburst and bloom synchrony. In areas where fruits are continuously grown, pruning is practiced twice a year for viticulture. Introduction of new crops into subtropical and tropical areas is important and various fruit crops including tropical and subtropical fruit crops have been introduced so far. There are nine breeding programs for stonefruits in Australia. These programs deal with a wide range of stonefruits cultivated in various areas of the country. Some of the programs include low and medium chilling requirements. Since pistachio is a dioecious and wind-pollinated species, it requires sufficient winter chilling to ensure uniform budburst, growth and synchrony of flowering. Selection for early ripening consists of indirect selection pressure for low chilling requirement. It is possible to breed and select for chilling requirement if earliness is a function of winter chilling. Rather than developing and using controlled chilling requirements screening tests, Australian stonefruit breeding programs are being conducted in the regions where improved cultivars are required and hybrid populations are evaluated under specific-local conditions. In conclusion, genetic improvement may require the use of low and medium chill germplasm. Cultivars should be bred and developed under local conditions regarding winter chill which is only one of the main characteristics.

Chairman : Sanada, T. (FTRS) : I would like to suggest that the discussion be focussed on the quality and productivity of temperate zone fruits in the tropics and subtropics.

Bessho, H. (FTRS) : Are there any differences in fruit quality and productivity between the tropical area and the temperate zone?

Winarno, M. (Indonesia) : The yield of grapevine is usually lower than in the temperate zone due to the incidence of diseases. The quality is often lower also as the skin is thicker and sweetness is reduced.

Chairman : Sanada, T. (FTRS) : In this session on the cultivation of temperate zone fruits in the tropics and subtropics, emphasis was placed on the need to evaluate low chilling requirement and fruit quality in the breeding materials. The utilization of such valuable genetic resources is important.

I would like to ask Dr. Ieki to summarize the reports presented during Session III.

Ieki, H. (FTRS) : In Session III, two papers were presented. Dr. Koizumi reported on the incidence of virus or virus-like diseases of citrus in the tropical and subtropical zones. He introduced four major citrus diseases.

The most important one, citrus greening disease consists of two types, Asian and African types. The bacterium-like pathogen is transmitted by two types of *Psylla* as vectors as well as by grafting and layering. Integrated control was recommended.

The second disease was caused by Tristeza virus which is transmitted by *Toxoptera citricidus*. This vector is moving to Central America and has already been reported in Panama, Costa Rica, etc. There are other vectors, namely aphids. In addition to both North and South America, the disease has ben reported in Spain and Israel (*Aphis citricola* as vector). Outbreak of severe pitting disease was recorded in Brazil, Peru, Australia and South Africa. The disease was also recorded on sweet orange in Indonesia but not in other tropical Asian countries.

Citrus variegated chlorosis (CVC) was first detected in Brazil in 1987 and subsequently spread to South America. The causal agent is a gram-negative xylem-limited bacterium (*Xylella fastidiosa*). Vector transmission has not not been confirmed.

Witches'broom disease first occurred in the 1970 s on acid lime in the Sultanate of Oman. The causal agent is a mycoplasma-like organism (MLO). A leafhopper, *Hishimonus phyctis* has been incriminated as vector.

Dr. Nguyen Ngoc Kiem reported on the prevention and control of harmful insects on tropical and subtropical fruits in Vietnam. He described the damage caused by several important insect

pests on tropical and subtropical fruits as well as methods of control, including the banana core weevil borers, pineapple root borers, citrus core borers and other citrus pests as well as the litchi sting bug and mite.

Chairman : Sanada, T. (FTRS) : I would like to suggest that the discussion be focussed on studies on the development of cultural and biological control of pests and diseases through international collaboration.

Winarno, M. (Indonesia) : I am wondering about the tolerance of mandarins, calamondin and rough lemon to greening disease. As far as I know no mandarins are tolerant to greening disease. If some were tolerant, I would appreciate receiving the materials.

Koizumi, M. (FTRS) : At Nan Experimental Station in North Thailand, we introduced mandarin trees from France. These trees have been growing vigorously and the fruits showed few symptoms during almost ten years (1986). If this cultivar (Som-pan) could be propagated and found to be tolerant to the disease, materials free from the pathogen through shoot-tip grafting could be propagated and cultivated. These materials could be crossed with susceptible cultivars and cultivated over a long period of time.

Iwanami, T. (FTRS) : How could international cooperation contribute to the effective control of pests and diseases in the tropical and subtropical areas?

Koizumi, M. (FTRS) : Due to the lack of facilities which are often very expensive in the developing countries, it is preferable to develop advanced methods in developed countries, such as USA, France, Japan, etc. and then cooperate with the developing countries in the transfer of technology.

Martin-Prevel (France) : Regarding the contribution of international cooperation to the eradication of citrus bacterial and viral diseases, I would like to indicate that there is a large project involving 7 Asian countries under UNDP/FAO which was initiated several years ago and is still going on. The implementation of projects on control procedures must be region-wide and is very costly, hence the need for funding by international organizations.

Koizumi, M. (FTRS) : Such methods of eradication as the production of virus-free materials are indeed very costly. It may be preferable to develop resistant varieties and rootstocks.

Chairman : Sanada, T. (FTRS) : In this session, it was emphasized that international cooperation was very important, in particular for pest control.

I would like to ask Dr. Yoshioka to summarize the reports presented during Session Ⅳ which dealt with the storage and postharvest physiology of tropical fruits.

Yoshioka, H. (FTRS) : In general tropical fruits are grown and harvested at relatively high temperatures which hasten ripening and accelerate the consumption of sugars and organic acids in the fruit cells during transportation and storage. As a result, the storage life of the fruits is shortened. However the introduction of postharvest technology such as cold storage or CA storage is limited. Several problems associated with postharvest technology for tropical fruits were highlighted in the reports.

Dr. Ketsa reported on the storage of tropical fruits in Thailand which produces many kinds of tropical fruits either consumed locally or exported. Cold storage is only used by a few companies. The storage potential is limited by chilling injury and rapid ripening. These constraints are further limited by the lack of appreciation and application of proper postharvest handling practices.

Dr. Lizada reported on the postharvest physiology of tropical fruits in The Philippines. Banana, mango, pineapple and papaya are important tropical fruits in The Philippines. Only pineapple is a non-climacteric type of fruit while the others are climacteric. These fruits vary in their physiological characteristics. Banana is harvested at the mature green stage and always prior to the initiation of any changes associated with ripening, while mango and papaya are harvested at a stage when ripening of the fruit had started and ethylene production had been initiated. The differences in the physiology of these fruits give rise to differences in their response to postharvest conditions (temperature, atmosphere) and to differences in their requirements for postharvest technology such as modified or controlled atmosphere and low temperature storage. It was indicated that the understanding of the physiological characteristics of the respective fruits was important for the development of techniques for postharvest handling and storage. Also a new technique for prolonging the storage life of mango fruits was reported.

Dr. Inoue reported on the postharvest physiology of avocado. Methods of cultivation of avocado in Japan were also discussed. Avocado is a climacteric fruit and the ripening process is associated with an increase in respiration. Physiological and biochemical changes related to maturation, including softening and the changes in the fatty acid composition of the lipids during storage were described. The effectiveness of MA, CA storage and removal of ethylene from CA storage for the prolongation of the marketable life of avocado was outlined. In conclusion, it was suggested that studies on the physiological characteristics of tropical fruits after harvest and on the evaluation of various postharvest methods may enable to play a role in the development of a suitable technology for postharvest handling of tropical fruits.

Chairman : Sanada, T. (FTRS) : I would like to suggest that the discussion be focussed on the storage conditions of main tropical fruits.

Tanaka, K. (FTRS) : The productivity of tropical and subtropical fruits is high but there are problems associated with the storage and the transportation of the fruits. Regarding postharvest technology, in the case of temperate zone fruits, there are certain transport and storage systems such as cold chain system. What kind of technology would be suitable for the transport and storage of tropical and subtropical fruits?

Ketsa, S. (Thailand) : Fruits could be transported by plane. However the cost is very high. Transportation by boat would be cheaper but requires the manipulation of the temperature which should be low but not too low to cause chilling injury.

Lizada, M. C. C. (The Philippines) : In a JICA-sponsored study mission, we learned that typically cold chains for fruits remain uninterrupted only in export-oriented industries. Low temperature storage definitely enables to extend the postharvest life of fruits. However, if the cold chain is not maintained, the fruits may be subjected to temperature extremes, leading to chilling or hyperthermal injuries. It may be worth studying heat shock proteins which appear to be synthesized in response to stress. These proteins may provide some protection against either type of temperature stress.

Kishimoto, O. (Japan) : It seems that there is a marked discrepancy in the level of technology for the storage of bananas between plantations and local markets. Could you indicate how the transfer of technology could be promoted to improve the conditions in the local markets.

Lizada, M. C. C. (The Philippines) : In The Philippines, the marketing of bananas is a risky enterprize. As a very small proportion of the market is willing to pay a premium for good quality fruit, market segmentation results. The marketing system is highly inefficient. Traders targetting most of the market are not willing to adopt postharvest technologies because of added cost. For example the boats are not refrigerated. However, market segmentation is sometimes advantageous since it is one way to introduce postharvest technology to traders/farmers aiming at the upscale markets, such as supermarkets. When other traders have the opportunity to observe the benefits, they may also find some way to adopt these techniques.

Kawashima, K. (JIRCAS) : It seems that durian (the "king of fruit") has a big potential market even in Japan. However, durian is usually preserved in a frozen state. Would it be possible to extend the storage life of durian and keep the freshness by using other methods? Is it possible to remove the offensive odor of durian without altering the taste? As you may have an overproduction of durian or second grade fruits, what kinds of processed products can you develop? Also is the University attempting to develop new methods of processing of durian products?

Ketsa, S. (Thailand) : Fresh durians are very sensitive to low temperatures during storage. At 15°C they develop chilling injury first at the husk level and can not be stored for more than two weeks. CA storage may enable to preserve the fruits in the fresh state over a longer period of time than by conventional storage. If the fruit is open, the pulp which is less sensitive than the husk to chilling injury could be wrapped with PVC film and stored at a lower temperature than 15°C. Attempts have been made to remove the odor of durian by using chemicals. I do not know how much the taste was affected by this procedure. Processed products of durian include paste, fried chips (unripe fruit), candy, glazings, etc.

Chairman : Sanada, T. (FTRS) : During this session a large number of problems relating to the storage of tropical fruits, evaluation of fruit maturity, transportation technology were discussed. Emphasis

was placed on the need for studies on the physiological characteristics of the fruits and on the evaluation of the suitability of various postharvest methods for the respective fruits based on these physiological studies. During the four sessions, it was indicated that international cooperation was very important for research relating to various aspects of fruit production to promote the development of the fruit industry in the tropics and subtropics. I would therefore like to suggest that the role of international cooperation to achieve these objectives be discussed.

I would like to ask Dr. Yamaguchi to lead the discussion on this subject.

Chairman : Yamaguchi, A. (JFCA) : During the symposium, the role of international cooperation in various steps of research was emphasized. Indeed, the production and exports of tropical fruits are expanding to respond to an increase in the demand of such products. However, many constraints must be overcome to secure a sufficient and stable supply of fruits, including the development of high quality cultivars, improvement of the methods of cultivation, control of pests and diseases, postharvest technology, storage and transportation of fruits, etc. It is assumed that the alleviation of these constraints may lead to a considerable increase in fruit production and a highly profitable industry. To achieve these objectives, international cooperation is essential. I would like to suggest that these aspects be discussed in more detail.

Winarno, M. (Indonesia) : We have benefitted from international cooperation in research and development for projects relating to horticultural crops, namely vegetables and citrus.

Tsuchiya, S. (FTRS) : The Fruit Tree Research Station was established in 1902. Up to now, research subjects were focussed on the development of techniques for the breeding and cultivation of temperate zone fruits in relation to the promotion of fruit production in Japan. We have also dispatched short-term experts to several tropical and subtropical countries to participate in the Horticultural Development Projects sponsored by JICA and we have received many trainees from these countries. In addition, we have received several researchers from tropical and subtropical countries under the fellowship program of the Science and Technology Agency (STA). On the other hand, the Okitsu Branch of the Fruit Tree Research Station was designated as the Far East Citrus Preservation Center by the former IBPGR (presently IPGRI). Researchers from the Branch had the opportunity to participate in explorations for the collection of citrus genetic resources in collaboration with their colleagues from various countries located in South and Southeast Asia under the sponsorship of IBPGR. Presently our germplasm collection totals about 8,000 accessions of citrus and a small amount of tropical and subtropical fruits. Through the exchange of germplasm we have established close contacts with several research institutes in these countries. Since tropical and subtropical fruits display characteristics which are different from those of temperate zone fruits, it is difficult to apply directly methods of cultivation or postharvest techniques used in the temperate zone. However, basic techniques relating to breeding or other fields of research are common to fruits in both the tropical or subtropical zone on the one hand, and the temperate zone on the other hand. I am convinced that this symposium will pave the way for the promotion of research collaboration between tropical and subtropical countries and Japan.

Kainuma, K. (JIRCAS) : The involvement of JIRCAS and its predecessor, the Tropical Agriculture Research Center, in research on tropical and subtropical fruits has been limited so far. However our relationship with the Fruit Tree Research Station is very close and several researchers of the Station have participated in joint projects with TARC and recently with JIRCAS. In addition one unit at the Okinawa Subtropical Station of JIRCAS is in charge of the collection of genetic resources of various tropical and subtropical fruits, including mango, pineapple, papaya and guava. The materials are grown in fields and studies are carried out on acclimation, methods of breeding and cultivation, etc. Within the framework of the Visiting Research Fellowship Program currently implemented at the Okinawa Subtropical Station and scheduled to be initiated in Tsukuba next year, advanced research on various aspects pertaining to tropical and subtropical fruit tree production could be envisioned.

Arora, R. K. (IPGRI) : IPGRI supports activities on germplasm collection and recently we have organized a meeting on tropical and subtropical fruit priorities in Malaysia (MARDI). The priority fruit species identified included mango, citrus, litchi, rambutan, durian. We would like to further pro-

mote cooperation with national programs. In the case of citrus and litchi, collections will be promoted in the southern part of China while for durian and rambutan studies will be carried out in Malaysia and Indonesia. For mango, there is a need to obtain a documented information on national program holdings, including the publication of data bases and catalogues. A status report on genetic resources of mango including the location of gene banks will be compiled in collaboration with the Indian Council of Agricultural Research since India harbors a wide diversity of mango germplasm. This information will be disseminated to the national programs for wider utilization of the genetic resources. IPGRI could offer its expertise in training programs on maintenance and conservation methods including *in situ*, *ex situ*/field gene banks, cryopreservation, problems relating to recalcitrant seeds such as those of mango, litchi, rambutan, jackfruit, durian, *in vitro* preservation in the case of citrus, etc. Emphasis should be placed on the preparation of catalogues, documentation, information on passport and evaluation of data, dissemination of information for utilization. IPGRI could contribute to the publication of materials on the safe movement of accessions. Ethnobotanical studies on minor fruits and underexploited resources could be carried out with the assistance of IPGRI.

Chairman : Yamaguchi, A. (JFTSCA, Japan) : Thank you Drs. Kainuma, Winarno, Tsuchiya and Arora. Important proposals were made. Among them, it was strongly pointed out that the exchange of information between researchers is essential. In this regard, the role of government and non-governmental organizations will also be important to promote international cooperation.

Now, we have come to the end of the discussion. This is the first international symposium dealing with the production of fruits. We are highly indebted and appreciate the efforts of JIRCAS and FTRS. However, this is only the first step. I do hope, that similar symposia or workshops aimed a more specialized subjects such as breeding, pest control, postharvest technology or biotechnology, etc. will be held in the future. I would like once more to thank all of those who participated in the general discussion.