

CHINESE-AMERICAN  
JOINT COMMISSION ON RURAL RECONSTRUCTION

Plant Industry Series: No. 8

RECENT IMPROVEMENT ON PINEAPPLE AND CITRUS FRUIT  
PRODUCTION IN TAIWAN

By

Luh, Chi-lin



TAIPEI, TAIWAN CHINA

MAY, 1956

SECOND EDITION (REVISED)

AUGUST 1958

The Joint Commission on Rural Reconstruction  
25 Nanhai Road, Taipei, Taiwan, China.

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# CONTENTS

	Page
Foreword	
Introduction	1
I. Pineapple	1
Background Information	1
A. Acreage and production	2
B. Planting and harvesting season	3
C. Economic importance	4
Varietal Improvement	5
A. Varieties grown at present	5
B. Prewar hybridization work	6
C. Varietal improvement work in progress	6
1. Introduction of pineapple strains	7
2. Strain selection from local stock	8
a. Procedure of the seedling selection program	8
b. Criteria employed in the seedling selection program	8
c. Procedure of seedling purification	9
d. Result of the seedling selection program	9
3. Eradication of bad mutation	11
Multiplication and Distribution of Planting Materials	13
Important Problems Confronting Pineapple Improvement in Taiwan	15
A. Maintenance of purity	15
B. Regulating maturity	15
II. Citrus Fruits	15
Background Information	15
A. Acreage and production	16
B. Producing area	17
C. Planting and harvesting season	18
Varietal Improvement	19
A. Varieties grown at present	19
B. Varietal improvement work in progress	20
1. Mother-tree survey	20
2. Selection of superior varieties from local stock	22
3. Introduction of varieties from abroad	23
Multiplication and Distribution of Planting Materials	27
A. Scheme of multiplication	27
B. Result of multiplication	28

## Foreword

Both pineapple and citrus fruits had a glorious past in Taiwan during the prewar days, and both have experienced serious setback in their production during the war. The strains of pineapple became badly mixed due to the appearance of numerous off-types and prolonged negligence in eradication and selection. The loss sustained by the citrus fruit was manifested in the numerous missing plants, the prevalence of insects and diseases and the decline of yield and quality of fruits.

After the war, therefore, the first thing done by local agricultural organizations for rehabilitating pineapple production in Taiwan was to embark on a long range seedling selection and purification program, which was followed by work on pest control and improvement of cultural methods. For citrus fruits, the variety improvement work was started both by introduction of improved strains from abroad and by survey and multiplication of local superior stocks. Pest control and cultural improvement work was started at about the same time.

In this report, the progress made on the variety and strain improvement work of pineapple and citrus fruits during the postwar years are summarily presented.

H. T. Chang, Chief  
Plant Industry Division

# Recent Improvement on Pineapple and Citrus Fruit Production in Taiwan, China

## Introduction

Pineapple and citrus fruits are two of the most important horticultural crops of Taiwan. They are both popular fruits on the local market. Pineapple is furthermore the fourth largest exportable agricultural products of Taiwan in 1955, led by sugar, rice and tea. Both of these two crops have had a glorious past before the Second World War, and both have suffered setback during the War. In the postwar rural reconstruction program, the rehabilitation of pineapple and citrus production forms an important part, which includes the improvement and purification of the varieties, multiplication of superior planting materials, improvement of cultural methods, and extension of pest control methods.

In this paper, only the work on the improvement of varieties and multiplication of the planting materials will be discussed.

## I. Pineapple (*Ananas comosus*)

### Background Information

The earliest record on the growing of pineapple in Taiwan is in 1694. Since 1912, many improved varieties of pineapple have been introduced and grown. In 1914, the Shilin Horticultural Experiment Station collected pineapple varieties from Hawaii, Philippines and Singapore and conducted varietal trial with the introduced material. This work was shifted later to the Chiayi Branch Station of the Taiwan Agricultural Research Institute because geographically Chiayi area is better adapted to pineapple growing. In 1925, the farms for multiplying the seedlings of "Smooth Cayenne" were established at Fengshan of Kaohsiung Prefecture, and in 1927, at Wantan of Pingtung Prefecture. In May 1940, the Fengshan Tropical Horticultural Experiment Station was inaugurated to take up research work mainly on subjects related to pineapple and the Fengshan propagation farm was incorporated into the Fengshan Tropical Horticultural Experiment Station in 1942. Since then there was a rapid expansion of the pineapple industry in Taiwan. In 1939, as much as 10,391 hectares of pineapple were grown. At present, though the acreage and production of the pineapple have not yet reached the prewar record, it is among the principal fruit crops of Taiwan, ranking second only to banana in the acreage, production and quantity of export. It is also one of the most popular table fruits, either fresh or canned, for the domestic market.

### A. Acreage and production:

The area and production during the past few years are shown in the following table:

Year	Planting area	Harvesting area	Average unit yield	Total production
	(ha.)	(ha.)	(kg/ha.)	(M. T.)
1939*	—	10,391	—	145,817
1945**	—	3,429	—	17,522
1951	—	5,662	9,203	52,105
1952	—	5,848	10,731	62,760
1953	7,310	5,670	12,076	68,471
1954	6,971	5,489	11,945	65,567
1955	7,916	5,671	12,437	70,537
1956	9,184	6,441	12,896	83,065
1957 (est.)	9,500	7,380	14,000	103,320
1958 (goal)	9,500	7,500	14,000	105,000

\* All time high during the Japanese occupation period.

\*\* Year of the restoration of Taiwan to the Republic of China.

The producing area of the pineapple in Taiwan may be quantitatively expressed by the following figures, which show the planting area for 1958:

	Acreage	Percentage
	(ha.)	(%)
<b>Central Taiwan</b>		
Taichung Prefecture	370	
Changhwa Prefecture	2,800	
Nantou Prefecture	1,550	
	<u>4,720</u>	49.69
<b>Southern Taiwan</b>		
Yunlin Prefecture	250	
Chiayi Prefecture	350	
Tainan Prefecture	1,600	
Kaohsiung Prefecture	1,000	
Pingtung Prefecture	550	
	<u>3,750</u>	39.47

<b>East Coast</b>		
Taitung Prefecture	800	
Hwalien Prefecture	$\frac{100}{900}$	9.47
<hr/>		
Plantations scattered in other areas:	130 ha.	1.37
Total area to be planned as planned for 1958:	9,500 ha.	100%
<hr/>		

Pineapple is mostly planted on hillsides of from 50 to 500 meters in altitude. The most important pineapple producing area at present is central Taiwan, especially the Changhwa and Nantou Prefectures. In the past, the growing of pineapple in southern Taiwan has been limited by the prevalence of pineapple wilt caused by mealy bug infestation. With the extension of the chemical control, using Folidol dipping of seedlings and subsequent field application of Folidol and Aldrin, in 1955, the acreage of this crop in southern Taiwan is expected to expand more rapidly than before. With the planned establishment of a modern cannery in Taitung in 1957, eastern Taiwan will become another important pineapple producing area in the near future. In northern Taiwan, the temperature during the growing season proves to be too low for profitable commercial planting of pineapple, and the hills of the north are taken over by citrus fruits and tea.

#### **B. Planting and harvesting season:**

Pineapple in Taiwan is mostly planted from August to October, but a small amount is planted in March or April. This is because most of the planting materials are available from the harvest of summer fruit crop in July and August. After October, rainfall becomes insufficient for the growing of new plants in central and southern Taiwan. Though there is yet no local experimental data at present to show the relationship between the rainfall and the development of sucker and slip, field observation shows that adequate rainfall in spring has a significant effect on the number of the usable slips and the earliness of the emergence of suckers, which, in turn, will affect the earliness of the fruit maturation of the ratoon crop. Therefore, most planting materials become available in the fall, and fall planting is the common practice in Taiwan. The first ratoon crop developed from the suckers normally attends full growth and starts to show flower differentiation six months after the picking of fruit from the plant crop. The second ratoon crop follows the same growing schedule as

the first ratoon crop.

The peak harvest season is in July and August, which yields about 75 percent of the year's harvest. The remainings are harvested either during November/December or during March/April.

The following data on the number of cases packed by a leading pineapple cannery in 1957 are indicative of the seasonal distribution of the supply of fruits:

Month	No. of cases of pineapple packed
January	4,716
February	382
March	1,178
April	23,754
May	9,643
June	8,842
July	144,254
August	254,399
September	138,146
October	10,277
November	40,342
December	36,534
<b>Total:</b>	<b>672,467 cases</b>

If irrigation could be made available to pineapple fields, the planting as well as harvesting might be regulated to a certain extent to give a better seasonal supply of fruits to the canneries so that the cost of the production may be reduced.

### C. Economic importance:

The economic importance of the pineapple production to the nation's economy may be indicated by the quantity of canned pineapple exported and amount of foreign currency earned annually in recent years.

Year	Number of cases of pineapple exported	Foreign currency earned US\$1,000
1952	263,621	1,995
1953	459,355	2,611
1954	622,019	3,963
1955	927,000	5,563
1956	1,008,101	6,000
1957	837,977	5,028
1958(goal)	1,350,000	8,000

Some 24,000 farm-families are estimated to be engaged in the pineapple farming in Taiwan. Assuming an average of 6.2 people per farm-family, there would be some 148,800 people depending on the growing of pineapple for living in rural Taiwan. Pineapple production does contribute handsomely to the rural economy of Taiwan.

## Varietal Improvement

### A. Varieties grown at present:

Varieties grown in Taiwan are of three groups, i.e. (1) indigenous, (2) introduced, and (3) improved or hybrid. Their names and varietal characteristics are as follows:

Group	Varietal name	Characteristics
Indigenous	1. Spineless red-skin	Leaves spineless, fruit skin dark-red, fruit flesh yellow and of coarse texture, good flavor, fruit large.
	2. Spiny red-skin	Leaves spiny, fruit skin red, fruit flesh pale-yellow and of coarser texture, flavor fair.
	3. Yellow-skin	Leaves spiny, fruit skin yellow, fruit flesh deep-yellow, fruit poor quality, vigorous in growth and drought resistant.
	4. Dark-skin	Leaves spiny, fruit skin red but turned into dark brown when matured, fruit small.
Introduced	Smooth Cayenne	Leaves spineless, high yield, fruit flesh pale-yellow, flesh juicy and of fine texture, good flavor, early maturity, not so resistant to diseases and pests.
Hybrid	Tainung No. 4	Resistant to diseases, leaves spiny, flesh of fine texture, good flavor and high keeping quality, early maturity, good to be served fresh, not juicy and light in fruit weight.

Generally speaking, the indigenous varieties can be grown under rather adverse conditions, such as in soil of low fertility, land of higher slope or under shade. They could be left in the field for years without replanting. But the fruits produced are small, deep eyed, seedy, of coarse-texture, and not so sweet. The introduced variety produces large fruits of good quality and of fine texture

suitable for canning. But it needs more intensive management in its culture and is not so adaptable to adverse conditions. At present, only a few varieties of pineapple are grown commercially in Taiwan, among which Smooth Cayenne is leading. The native varieties have been gradually replaced by Smooth Cayenne during recent years. The Smooth Cayenne itself, being brought into this Island before the War from Hawaii, however, has greatly degenerated and is badly mixed with off-types in to-day's farmers' fields.

#### **B. Prewar hybridization work:**

Hybridization work of fairly large scale was carried out by the Chiayi Branch Station of the Taiwan Agricultural Research Institute in 1925 and again in 1927. The following eight varieties were selected and are now planted by very few farmers on a very small scale.

Tainung No. 1: Smooth Cayenne x Yellow Skin

Tainung No. 2: Smooth Cayenne x Yellow Skin

Tainung No. 3: Yellow Skin x Smooth Cayenne

Tainung No. 4: Smooth Cayenne x Singapore

Tainung No. 5: Smooth Cayenne x Singapore

Tainung No. 6: Singapore x Smooth Cayenne

Tainung No. 7: Smooth Cayenne x Yellow Skin

Tainung No. 8: Smooth Cayenne x Yellow Skin

Among these hybrid varieties, Tainung No. 4 is considered to be the best and is grown by farmers in small acreage at present for the fresh fruit market. It produces excellent table fruit with good flavor and little fiber. But its fruits are not suitable for canning because of 1) its very short maturation period, 2) low juice content, 3) low fruit weight, 4) low yield, being only 2/3 of the yield of the canning varieties, and 5) spongy texture of the flesh. The other 7 hybrid varieties have the same drawback and are not suitable for canning; they are therefore grown in negligible amount.

#### **C. Varietal improvement work in progress:**

During the World War II and the early postwar years, the pineapple plantations in Taiwan were neglected by farmers due to lack of market. The introduced variety became greatly degenerated and badly mixed with off-type in most pineapple fields. In order to rehabilitate the pineapple production in Taiwan, JCRR began to give financial and technical support to the Taiwan Pineapple Corporation and the agricultural stations of the Taiwan Provincial Department

of Agriculture and Forestry in 1950 on a long range pineapple strain improvement program.

### 1. Introduction of pineapple strains

In the fall of 1950, JCRR assisted the Chiayi Branch Station of the Taiwan Agricultural Research Institute in the introduction of seedlings of two improved varieties, namely, "Smooth Cayenne" and "Rough" or "Queen" from Australia. The introduced planting materials were planted at Chiayi Station for observation. The planting, growth and fruit quality of the introduced varieties as reported by the Chiayi Station in 1953 are tabulated as follows:

Source of supply	Variety	Kind and quantity introduced	Planting made in	Date of 1st fruit setting	Adaptation & growing condition	Fruit quality
Nambour Farm Queensland, Australia	Rough or Queen	6 pieces of sucker	October, 1950	July, 1953	Good	Fair
Ditto	Smooth Cayenne	6 pieces each of crown, slip and sucker	October, 1950	July, 1953	Good	Good for canning

Based on the measurement and analysis of three plant crops from the fall of 1950 to February 1957, the plant characteristics and fruit quality of these two introduced varieties as studied and recorded by the Chiayi Agricultural Experiment Station and reported in 1958 are as follows:

#### Plant measurement

Variety	Plant height cm.	No. of leaves	Length of leaf cm.	Leaf width cm.	Average No. of spine per leaf
Smooth Cayenne	68.4	50.0	76.2	5.7	Over 20 spines Very spiny
Rough or Queen	67.4	42.3	69.9	5.4	

#### Fruit quality

Variety	Average fruit weight kg.	Fruit height cm.	Fruit diameter cm.	Number of fruitlets	Flavor
Rough or Queen	1.721	15.9	12.6	128	Excellent Sweet but no acid
Smooth Cayenne	1.251	15.1	11.1	143	

Due to the small quantity of planting materials introduced, the amount of propagating material produced by both varieties as of February 1958 is still very much limited. It is expected by the Station that some seedlings of Smooth Cayenne may be made available for comparative study in 1960. The variety of Rough or Queen, after close observation and study of the plant cycle during the past five years, has been considered not worth further study due to its small-sized fruit with too low acid content.

## 2. Strain selection from local stock

According to A. D. Shamel's investigation in Hawaii, the rate of occurrence of off-type bud mutations amounts to as high as 25%. It was apparent that in order to maintain the purity of the local stock of Smooth Cayenne, a long range pineapple seedling selection program must be conducted in Taiwan. The Taiwan Pineapple Corporation, with the assistance of government agricultural stations and financial subsidy from JCRR, started the program in 1950.

a. *Procedure of the seedling selection program*—During flowering period, a preliminary reconnaissance survey is made. After that, a selection team of trained personnel is organized to do the actual field selection work during the period from May to June. The selected individual plants are carefully examined at least twice by team members for desirable plant characters. A color paint or color plastic label is tagged on the leaf of each acceptable progeny for identification. Eradication of pineapple plants of inferior character is made at the same time. A final check is conducted by the team leader before the collection of the selected seedlings.

b. *Criteria employed in the seedling selection program*—in the first two years the emphasis of pineapple seedling selection was placed on education the extension worker as well as pineapple growers on the importance and technique of making selection of seedlings plants true to type. The following criteria for the selection of seedling have been employed since 1952:

- (1) Only pineapple fields of plant crops are chosen for making seedling selection. Selection is not made on fields of ratoon crops because the true nature of the plant character on ratoon crops are generally not so clear as on plant crop.
- (2) Only plants of normal and healthy growth and free from disease/insect infestations are selected as mother-plants.
- (3) Fruit character should be true to the type of normal Smooth Cayenne.
- (4) The pineapple seedling selection is only practised on summer fruit crop.

c. *Procedure of seedling purification*—In the first two years, a mass selection was conducted to select seedlings from farmers' fields, which were then planted in the mass selection farms operated either by agricultural stations, the Pineapple Corporation or contracted farmers. A re-selection is made from the plants on the mass selection farms after these plants bear the first fruit crop. The plants so selected are planted on the re-selection farms. Superior plants selected from the re-selection farms are considered as "strains" to be used for the establishment of the strain nurseries at the farms of the Taiwan Pineapple Corporation and the stations of the Taiwan Provincial Department of Agriculture and Forestry. The other steps to be followed will be the purification of strains, regional adaptation test, multiplication and extension to farmers.

d. *Result of the seedling selection program*—Following the above procedure, the following amount of seedlings have been selected and planted in nurseries since 1950:

Scheme of selection and period (JCRR Project Code Number)	Amount of JCRR subsidy extended (NT\$)	No. of seedlings selected	Area planted (ha.)
1. Mass selection			
a. 1950 TW-A-87	208,675	2,510,000	97.38
b. 1951 TW-A-172	630,960	2,750,000	106.69
2. Re-selection			
a. 1952 TW-A-256	416,631	1,375,000	55.00
b. 1953 TW-A-336	296,720	1,000,000	40.00
3. Strain selection and establishment of nurseries			
a. 1954 TW-A-437	186,630	120,701	4.80
b. 1955 TW-A-503	150,000	226,767	9.00
4. Purification and clone test			
a. 1956 TW-A-592	150,000	400,000	15.00
b. 1957 (goal)		1,000,000	40.00
5. Regional adaptation test			
a. 1958 (as planned)		2,000,000	80.00
b. 1959 (as planned)		4,000,000	160.00
6. Multiplication & extension			
a. 1960 (as planned)		10,000,000	400.00
b. 1961 (as planned)		20,000,000	800.00

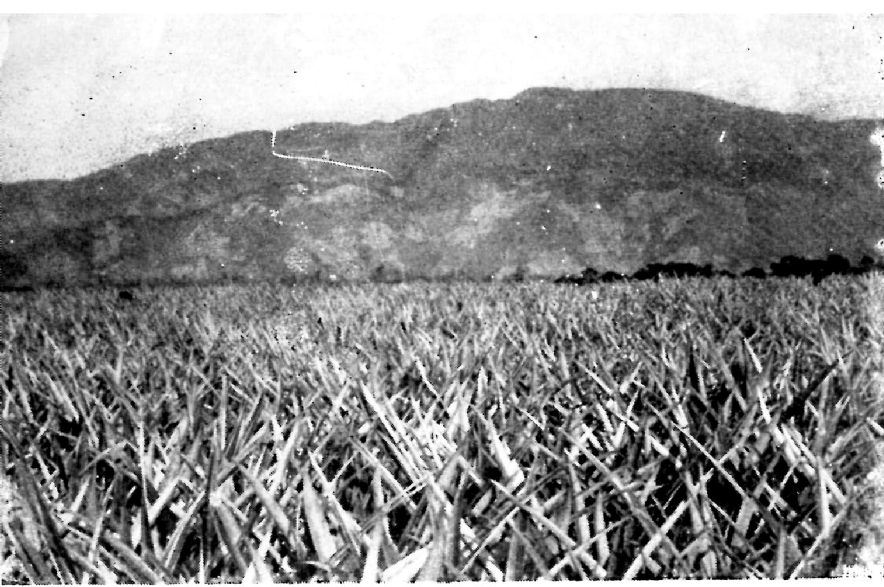


Fig. 1. Uniform growth of the pineapple plants from selected seedlings.

So far, the progress of this phase of the work is very encouraging. Each project was successfully carried out by the Taiwan Pineapple Corporation with the assistances from PDAF stations concerned. To support financially the seven pineapple seedling selection projects of the past, JCRR alone made a total contribution amounting to NT\$2,039,616 to various sponsoring agencies. It is expected that the Taiwan Pineapple Corporation will continue the program independently and follow closely the selection scheme as originally projected. It would be more reasonable and logical to have the program undertaken by the said Corporation on a commercial scale, as JCRR has given full support at the initiative stage for seven years already and the said Corporation has been transferred to private ownership (formerly a government operated organization).



Fig. 2. Bumper crop of well-shaped pineapples, as a result of the seedling selection work.

### 3. Eradication of bad mutation

The eradication of the off-type progenies of Smooth Cayenne from farmers' fields is another approach for maintaining the purity of the variety. While the Taiwan Pineapple Corporation worked on seedling selection, the Taiwan Provincial Department of Agriculture and Forestry carried out a project, also with JCRF assistance, on the elimination of off-type pineapple seedlings from the farmers' fields.

Numerous kinds of off-type plants may be found in the farmers' field. In order to simplify the eradication program, farmers were advised only to eradicate progenies from plants bearing any one of the following undesirable characters:

- a. Multiple crown
- b. Tumor at fruit base
- c. Bottle neck
- d. Multiple fruit
- e. Eyes beauty
- f. Long-tom
- g. Small fruit

Fig. 3. Different kinds of off-type pineapple fruit.



(a) Multiple crown



(b) Tumor at fruit base



(c) Bottle neck



(d) Multiple fruit

(e) Eye beauty



(f) Long-tom

(g) Small fruit





Fig. 4. Tool and method employed in eradicating off-type progenies

The field practice of elimination of off-type progenies was done before the harvest of fruit. Farmers were urged to remove the young seedlings as early as possible for saving the labor needed to carry the removed seedlings from the field. The elimination of off-type progenies from a total of 433,500 plants was accomplished by the farmers themselves in the summer of 1955 through education demonstration and award of small compensation for encouragement. After the completion of the eradication done by farmers, the fields were inspected and checked by extension workers from the Township Public Offices concerned.



Fig. 5. Young off-type slips removed from pineapple plant.

#### Multiplication and Distribution of Planting Materials

Early in 1925, farms for propagating the stocks of "Smooth Cayenne" for extension were established at Fengshan of Kaohsiung Prefecture, and in 1927, at Wantan of Pingtung Prefecture. The Fengshan Propagation Farm was incorporated

into the Fengshan Tropical Horticultural Experiment Station in 1942, while the Wantan Farm was abandoned in 1943 because of financial stringency during the World War II. In 1932, the former Taiwan Pineapple Marketing Company loaned pineapple seedling stocks of the introduced varieties, fertilizer and agriculture credit to the pineapple farmers. It is regrettable that data on the quantity of seedlings propagated and extended to farmers is no longer available. However, the extension at that time must be limited to southern Taiwan, because only a few farmers in that area could to-day recall that they had received pineapple seedling loan from the Propagation Farm.

Since the restoration of Taiwan to China in 1945, the propagation and distribution of pineapple seedlings have not been practised. There have been no farms specifically assigned to do the propagation work under the Taiwan Pineapple Corporation or under the agricultural stations of the Provincial Department of Agriculture and Forestry, as there are no seedlings worthy of propagation and distribution. Farmers have been getting their planting materials principally from other farmers having seedlings available for sale.

The demand of planting materials for new plantings or for replantings on the old plantations is growing. The seedlings of the improved strains selected under the JCRR financed program are yet limited in quantity and not available for large scale extension as of to-day. In order to insure that new plantings be made as much as possible with seedlings of good plant character, seedlings on farms of growers who possess comparatively large amount of seedlings of better character should be utilized to the best advantage as a stopgap measure for meeting the pressing need of new plantings and for preventing the spreading of the inferior seedlings. Starting the summer of 1956, farmers who possess good stocks of planting materials of Smooth Cayenne are encouraged to do better distribution through government support and certification. They are approached by local governments concerned and assisted technically by the technical personnel from the Fengshan Horticultural Experiment Station for the eradication of off-type progenies of Smooth Cayenne from these fields, so that only those of good characters are allowed to remain. After the eradication, the remaining good seedlings will be painted with red paint and tagged with labels before distribution. After trimming and sun-curing, all seedlings will be treated with Folidol at a concentration of 1:1,500. The superior seedlings so selected and treated will be bought from the owner by the Prefectural Governments concerned at a reasonable premium price. The recipient farmers are asked to pay for these seedlings at the time of delivery. Seedlings so allocated and planted will form a source of supply of better seedlings in the various Prefectures. The Prefectural Governments

concerned will give close supervision, and seedlings produced from these plants will be bought by the Prefectural Governments for further distribution.

### **Important Problems Confronting Pineapple Improvement in Taiwan**

#### **A. Maintenance of purity:**

Due to the frequent somatic mutations and high heterogeneity of the plant, it is difficult to maintain the pineapple variety from degeneration. Therefore, even after the completion of selection and extension of the selected strains, the pineapple breeders and extension workers must keep on watching closely every year for appearance of off-types in the farmers' field. And the work of eradication of off-type plants must be made a universal and regular practice of the farmers in order to preserve the purity of the selected strains.

#### **B. Regulating maturity:**

About 75 percent of the fruits are harvested in the summer season in Taiwan, leaving only 25% for the winter and spring. Storage of fresh pineapple is a difficult problem under the rainy and hot weather in central and southern Taiwan. As of now, the fruits must be either marketed or canned immediately after harvest. In order to improve the seasonal supply of raw material to canneries, to produce varieties with different maturity season should be another major subject for the pineapple breeder in the future.

## **II. Citrus Fruits (Citrus spp.)**

### **Background Information**

The exact date of the introduction of citrus fruit trees into Taiwan is not known. It is quite possible that people living on the coast of Fukien and Kwangtung Provinces of the Mainland China who made an extensive migration to Taiwan at the end of the Seventeenth Century brought citrus seeds and seedlings with them and thus started the citrus production on this Island. The commercial cultivation of citrus trees was however not developed until the early years of the Twentieth Century. At present, citrus fruits rank third in acreage among three major fruit crops in Taiwan being next only to banana and pineapple. Due to limited production, citrus fruits are mostly consumed locally. Export has been very small in recent years.

The average size of the citrus orchard in Taiwan is only about 0.3 hectare per farm-family. For growing some 8,000 hectares of citrus plantation, about 30,000 farm-families are engaged in citriculture. Taking an average of 6.2 people per farm-family, there would be some 200,000 rural people depending

wholly or partly on citrus production for their livelihood. The 40,800 M.T. of fruits projected to be produced in 1958 is estimated to worth over one hundred million New Taiwan dollars, constituting a significant factor in the rural economy of the citrus producing areas of Taiwan.



Fig. 6. Over crowded old plantation, with trees planted at a distance about 12 feet apart both ways.



Fig. 7. Newly established citrus orchard with trees planted at 18-20 feet apart between trees and between rows.

#### **A. Acreage and production:**

The acreage and production of citrus fruits in Taiwan are shown in the following table:

Year	Planting area (ha.)	Harvesting area (ha.)	Average unit yield (kg/ha)	Total production (M.T.)
1941*	—	5,436	—	38,747
1945**	—	3,584	—	16,878
1951	—	4,899	5,573	27,293
1952	—	4,611	5,015	27,770
1953	5,915	4,763	6,164	29,357
1954	6,379	4,831	5,742	27,755
1955	7,014	5,246	5,763	30,235
1956	7,938	5,808	6,033	35,332
1957(est.)	8,020	6,085	6,200	37,140
1958(goal)	8,000	6,000	6,800	40,800

\* All time high of the prewar record.

\*\* Year of the restoration of Taiwan to China.

**B. Producing area (as planned for 1958):**

Area	Acreage (ha.)	Percentage (%)
<b>Northern Taiwan</b>		
Yangmingshan Dist.	400	
Taipei Prefecture	1,700	
Taoyuan Prefecture	530	
Hsinchu Prefecture	2,200	
Miaoli Prefecture	540	
Ilan Prefecture	350	
	<u>5,720</u>	72
<b>Central Taiwan</b>		
Taichung Prefecture	280	
Changhwa Prefecture	500	
Nantou Prefecture	200	
	<u>980</u>	12
<b>Southern Taiwan</b>		
Yunlin Prefecture	140	
Chiayi Prefecture	360	
Tainan Prefecture	200	
	<u>700</u>	9
<b>Eastern Taiwan</b>		
Hwalien Prefecture	220	
Taitung Prefecture	160	
	<u>380</u>	4
Total	7,780	97
Plus other kinds of citrus fruit trees scattered in other areas:		
	220	3
	<u>8,000ha.</u>	<u>100%</u>

The important kinds of citrus fruit trees under cultivation are Ponkan, Tankan, Pummelo & Sweet oranges. Other citrus fruit trees grown include Satsuma, lemons, grapefruit and kamquat which are cultivated in scattered localities and at very limited amount.

From the above table, it may be seen that the citrus trees are mainly concentrated in the northern part of Taiwan. In central and southern Taiwan, the dorminancy is taken over by pineapple and banana, as the climate becomes warmer and drier. When more improved varieties, especially the sweet oranges, are introduced from abroad or selected locally, it is expected that the adaptable areas for citrus production may be expanded. Eastern Taiwan is especially promising for such expansion.

### **C. Planting and harvesting season:**

Citrus nursery trees of 2 or 3-year old are usually set into field in early spring and, when managed properly, a marketable fruit crop could be harvested 5-6 years later. Varying with varietal character, the pic'ing season of citrus fruits of early varieties begins in September and that of the late varieties may last to the end of March or early part of April of the next year.

Fig. 8. Old citrus orchard on hillside without soil conservation practice.



Fig. 9. New citrus orchard on hillside with trees planted on contour terraces.



The harvesting and supplying season of the important citrus fruits in Taiwan are roughly as follows:

<u>Kind of citrus fruit</u>	<u>Harvesting and supplying season</u>
Ponkan	October through December
Tonkan	January through March
Pummelo: Buntan	September to November
Tou-you	October to January
Pai-you	November to February
Sikan	November to January
Valencia	March through May
Satsuma	October to November

## Varietal Improvement

### A. Varieties grown at present

There are a number of citrus species either grown wild or under cultivation in different parts of Taiwan. Among them only seven are of economic importance. In the order of quantity of production and importance, they are:

Scientific name	Common name	Important variety	Important producing areas
<i>Citrus poonensis</i>	Ponkan	var. Kao-jian var. Tee-jian	Changhwa and Hsinchu Prefectures
<i>Citrus tonkan</i>	Tonkan	var. Hai-li var. Common tonkan	Hsinchu, Taipei and Ilan Prefectures and Yangming-shan District
<i>Citrus grandis</i>	Pummelo	var. Mato-Buntan var. Pai-you var. Tou-you	Tainan, Yunlin and Changhwa Prefectures
<i>Citrus sinensis</i>	Sweet orange	var. Valencia var. Sikan var. Washington Navel	Taitung, Changhwa, Hwa-lien, Hsinchu and Taipei Prefectures and Yangming-shan District
<i>Citrus unshiu</i>	Satsuma orange	var. Wanchow early	Ilan Prefecture
<i>Citrus sunki</i>	Sunki	var. Sunki	Hsinchu Prefecture
<i>Fortunella margarita</i>	Kumquat	var. All season	Ilan Prefecture

## **B. Varietal improvement work in progress:**

Citrus fruits are rich in kind in Taiwan, but they have definite drawbacks. Firstly, the main kinds, the Ponkan and Tonkan, are of the loose skin type. Though with excellent flavor, they are not suitable for storage and long distance shipping. As mentioned before, their combined supplying season is from October to March. From April to September, therefore, Taiwan is in lack of the orange/tangerin type of citrus fruits. Secondly, the varieties grown by the farmers are mixed. There is a dearth of reliable source of supply of nursery trees of superior quality. With the above drawbacks in mind and with the aim to gradually improve the local stock, JCRR began to support a citrus improvement program along the following lines of work in 1951:

### **1. Mother-tree survey**

As the first step for propagating nursery trees of good quality by supplying scionwood sticks from superior local trees, a mother-tree survey of sweet orange was conducted during 1951 through 1953, and another of Ponkan and Tonkan since 1954, by horticulturists of agricultural stations of the Taiwan Provincial Department of Agriculture and Forestry and the National Taiwan University, with JCRR financial and technical assistance. With the cooperation of citrus growers, the following number of mother-trees was surveyed during 1951 and 1956:

<u>Period</u>	<u>Number of trees surveyed</u>
December 1951-January 1952	2,400
"    1952-    "    1953	2,849
"    1953-    "    1954	1,800
"    1954-    "    1955	2,400
"    1955-    "    1956	1,100

The number of mother-trees surveyed fluctuated from year to year due mainly to the elimination of mother-trees which were no longer good for supplying propagating materials and to the addition of mother-trees newly found in different groves where no survey was made previously. The selected mother-trees are inspected from time to time and are used as parent stock for multiplication of nursery trees. The items surveyed are given in the following form:

### **Mother-tree Survey Form for Sweet Orange**

#### **A. Grove**

1. Name and address of the owner of the grove
2. Location and topography of the grove
3. Soil texture of the grove

B. Mother-tree						
1. Variety	2. Source of supply					
3. Rootstock	4. Position of the tree.	Row No.	Tree No.			
5. Age of the tree	6. Height of the tree					
7. Pests	8. Diseases					
9. Growing condition:		1951	1952	1953	1954	1955 ...
a. Height of tree top (m.)						
b. Width of tree top (m.)						
c. Fruit yield (kg.)						
d. Density of the foliage						
e. Foliage coloration						
f. Tree growth or vitality						
C. Fruit characteristics						
1. Fruit height (cm.)						
2. Fruit width (cm.)						
3. Fruit weight (g.)						
4. Rind coloration						
5. Rind thickness						
6. Size of the oil-gland or oil cell						
7. Number of segment or septa						
8. Thickness of the segment membrane						
9. Size of the core						
10. Number of seeds contained.						
D. Fruit quality						
1. Flesh coloration						
2. Juice content (ml.)						
3. Juice weight (gm.)						
4. Soluble solids (Brix)						
5. Acidity (%)						
6. Flavor & aroma						
7. Date of picking & analyzing						
8. Beginning and end of sampling date						
E. Outcome of the survey						
1. Number of scionwood sticks to be collected						
2. Number of fruit samples to be collected						
3. Accepting factors						
a. Tree growth 30%						

- b. Yield 30%
- c. Fruit quality 40%
- 4. Date of collecting scionwood
- 5. Price awarded for scionwood
- 6. Fruit value paid NT\$/kg.
- 7. Farmers' comment
- 8. Date of survey
- 9. Name of person in charge of survey

Remarks:

- 1. Tree age - Trees of over 20 years old are not qualified to be accepted as mother-trees.
- 2. Yield - Tree yield below 100 fruits will not be selected as mother-tree.
- 3. Standard level of fruit quality:
  - a. Fruit height and width: 6-7 cm.
  - b. Fruit weight: 150-200 gm.
  - c. Rind thickness: 2-4 mm.
  - d. Number of seed: 0-10 seeds
  - e. Number of segment: 10-12 segments
  - f. Quantity of fruit juice: 80-100 ml.
  - g. Brix degree: 10-15 Brix degrees
  - h. Acidity: 0.8-1.2%

2. Selection of superior varieties from local stock

From the result of the five years' work on mother-tree survey, the following varieties of citrus fruits have been located and identified for multiplication of nursery trees in the future:

- a. Dwarf Ponkan:-It was found at Mr. C. S. Wang's orchard in Linkou Township of Taipei Prefecture during the 1954 survey. The characteristic of this variety is its low and spreading tree growth which facilitates orcharding practices such as spraying and fruit picking. The fruit quality is as good as the common Ponkan. Multiplication of this variety has been started.
- b. Golden Seal:-It was discovered in Changhwa Prefecture by the author during the 1953 survey. The fruit of this variety has low acid content, rich flavor and soluble solid. Multiplication of this variety has been started.

c. Tonkan Late:-Its late maturation was noticed during the mother-tree survey in the spring of 1956 at farmers' orchard in Yangmingshan and Hsintien of Taipei Hsien. Normal maturing season for the common Tonkan is in December, but this variety does not reach full maturation till April and May. Its late maturation will be observed for one more year, before doing actual multiplication.

### 3. Introduction of varieties from abroad

a. A total of 177 budsticks of nine citrus varieties were introduced into Taiwan from the Grand Island Nurseries, Eustis, Florida, U.S.A. in February 1953. The varieties introduced are as follows:

- |                                |               |                     |
|--------------------------------|---------------|---------------------|
| 1) Parson Brown                | 2) Jaffa      | 3) Avon Everbearing |
| 4) Lue Gim Gong                | 5) Drake Star | 6) Pineapple        |
| 7) Nucella Minneola<br>Tangelo | 8) Cleopatra  | 9) Dream Navel      |

The introduced scionwood sticks were grafted on the limbs of 10-year old and fruit-bearing orange trees at three specially selected citrus growers' orchards in Hsinchu area. According to the record kept by the Department of Horticulture, National Taiwan University, 33 trees out of 43 top-grafted have survived.

In the two years of growing in the selected orchards in Hsinchu Prefecture the 8 varieties of sweet orange and one Cleopatra showed vigorous growth and good fruit bearing character. And according to fruit analysis conducted by the Department of Horticulture, National Taiwan University, the following varieties are recognized to have good fruit qualities:

- |                 |                 |                |
|-----------------|-----------------|----------------|
| 1) Pineapple    | 2) Jaffa        | 3) Dream Navel |
| 4) Lue Gim Gong | 5) Parson Brown |                |

The general fruit character of the introduced citrus varieties as analyzed by the Department of Horticulture, National Taiwan University, in 1955 and 1956 are tabulated as follows:

Fig. 10 Scionwood sticks of nine citrus varieties, introduced from Florida, U.S.A., wrapped in plastic bags, ready for top-grafting in February 1953.



General Fruit Character of the Introduced Citrus Varieties

Date of analysis	Variety	No. of sample	Average Fr. wt. (g.)		Av. juice content (%)		No. of seed		Soluble Solids		Citric acid		Solids/acid ratio	
			54-55	55-56	54-55	55-56	54-55	55-56	54-55	55-56	54-55	55-56		
Dec. 15	Jaffa (grove 1)	20	125.5	136.0	62.67	63.49	3	6	11.4	11.2	0.70	0.99	16.28	11.29
Dec. 15	Parson Brown	14	110.0	94.0	53.10	57.34	11	11	14.4	12.5	0.61	0.93	23.60	13.40
	(grove 1)	8	166.8	—	59.52	—	19	—	14.1	—	0.67	—	20.98	—
Nov. 1														
Dec. 15	Pineapple	10	86.3	—	57.69	—	16	—	14.8	—	0.68	—	21.78	—
Nov. 1	(grove 1)	9	166.9	—	62.05	—	16	—	13.9	—	1.03	—	13.49	—
Nov. 11	(grove 2)	10	—	145.6	—	60.91	—	19	—	—	—	0.91	—	12.68
Dec. 15	Lue Gim Gong	10	58.7	108.0	54.63	55.93	14	15	15.2	13.5	0.79	0.87	19.24	15.60
Nov. 1	(grove 1)	9	164.4	—	59.73	—	22	—	12.6	—	0.71	—	11.59	—
	(grove 2)	10	—	123.4	—	54.45	—	18	—	—	—	0.71	—	16.16
Dec. 15	Avon Everbearing	10	67.2	—	49.61	—	12	—	12.8	—	1.30	—	9.85	—
	(grove 1)	18	105.3	102.2	60.71	54.35	11	11	13.0	12.2	1.59	1.46	8.17	8.38
Dec. 31	Nucellar Minneola													
	Tangelo	10	—	152.6	—	50.0	—	19	—	—	—	0.93	—	—
	(grove 1)	10	151.6	131.6	63.15	52.74	15	19	14.5	10.8	0.85	0.79	16.92	11.60
	(grove 2)													14.53
Nov. 1	Dream Navel	6	206.7	—	79.35	—	3	—	13.9	—	0.61	—	22.55	—
	(grove 1)													



Fig. 11. Top-worked trees show luxuriant growth after one year growth in testing plot.

As a result of an unusual drought in the fall of 1954 and spring of 1955, the crop produced in all three testing orchards in the spring of 1955 and 1956 was light. Consequently, the quantity of fruit samples taken and analyzed, as presented in above table, was rather small. However, judging from the good adaptation of the introduced sweet orange varieties and in view of the increasing need of the supply of propagation material for multiplication in future, the top-grafting work was enlarged in the spring of 1955 and 1956 under a continuation plan sponsored by the College of Agriculture, National Taiwan University and the Taiwan Provincial Department of Agriculture and Forestry. The total number of trees top-grafted with introduced sweet orange varieties since 1953 under various JCRR financed projects is shown as follows:

Year	Project Code No.	No. of trees selected for top-working	
		No. top-worked	No survived
1953	TW-A-307	50	33
1955	TW-A-488	80	32*
1956	TW-A-533	100	35
1957	GBS(A)-124	504	Data not yet available

\* Affected by the 1954-55 drought. 48 trees have been regrafted in the spring of 1956.

Since all agricultural stations do not have suitable citrus orchards to-day, the top-graftings so far are being conducted in farmers' orchards.

b. In March 1956, a total of 240 pieces of one-year old citrus nursery trees were introduced into Taiwan from Armstrong Nurseries, Ontario, California. Immediately after delivery, the introduced nursery trees were distributed to various localities for planting and observation. The introduced nursery trees consist of the following kinds and varieties:

1) Sweet orange	
a) var. Valencia Late	60 trees
b) var. Seedless Valencia	60 trees
2) Lemon	
a) var. Eureka	30 trees
b) var. Lisbon	30 trees
3) Grapefruit	
a) var. Ruby	60 trees
<b>Total:</b> 3 crops, 5 varieties	<hr/> 240 trees



Fig. 12. Checking introduced citrus nursery trees immediately after the arrival of the shipment in March 1956.

Fig. 13. JCRR specialist examining the grafting union and root system of the introduced citrus nursery trees.



Fig. 14. Planting introduced nursery trees at Taitung District Agricultural Improvement Station's farm for observation and study.



### Multiplication and Distribution of Planting Materials

Following the mother-tree survey, propagation of nursery trees using scionwood taken from the selected mother trees was conducted firstly by the Taichung Fruit and Marketing Cooperative and the Taitung District Agricultural Improvement Station of PDAF and later by the Provincial Department of Agriculture and Forestry with JCRR technical and financial assistance and the cooperation of the prefectural governments concerned.

#### A. Scheme of multiplication:

1. The scionwood sticks from selected mother-trees are distributed to contracted nurserymen for grafting and multiplication in selected nurseries.

Fig. 15. Multiplication of sweet orange nursery trees at one of selected nurseries.



Fig. 16. Another view of selected nurseries showing individual stakes indicating varieties and sources of scionwood supplied.



These scionwood sticks are provided free to the nurserymen designated. However, the owners of the mother-trees from which the scionwood sticks are taken receive some fertilizer or cash money as a reward for their cooperation.

2. The nurserymen are required to multiply the nursery trees by grafting the allocated scionwood sticks on 2-year old root stock, and after one-year growth in the nursery, the nursery trees are permitted to be sold to growers at prices fixed by the nurserymen themselves. Assistance from the local government is usually extended to the nurserymen during the season of extension.

### **B. Result of multiplication:**

The following number of nursery trees has been multiplied and sold by contracted nurserymen to citrus growers:

Year	No. of citrus growers who bought the trees	No. of trees extended	No. of prefectures covered
January 1953	93	21,224	10
January 1954	115	52,898	13
January 1955	50	12,801	14
January 1956	Data not yet available	89,500 (goal)	Data not yet available

Through the above-mentioned work, citrus growers in Taiwan have come to realize more and more the importance of using nursery trees of good quality, especially, those that mature either earlier or later than the prevailing harvesting season. Demand for improved nursery trees is mounting each year. It seems that the citrus improvement work in Taiwan has made a successful start. The present multiplication work, however, is but on a very small scale. The number of nursery trees multiplied from the selected mother-trees is far from sufficient to meet the growing demand of the farmers. In the future, the introduction and testing of the foreign citrus varieties and the selection and management of the mother-trees of local stock should be continued, but the multiplication of nursery trees should be gradually put on a commercial basis and expanded in scale.

With the improvement made in cultural practices, pest control and fruit handling methods, it is hoped that better citrus fruits may be made available to local market over a longer supplying season. When sufficient quantity is produced, even expansion of export may be attempted.

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