

## Summary of Research Achievement in 2000

### 1. Banana Variety Improvement

**Selection For Fusarium Wilt Resistance:** In 2000, a total of 10,664 banana plantlets of semi-dwarf cultivars were used for the screening of resistance to *Fusarium* wilt (race 4) by the screen house method. 250 plants (2.34%) showing no or little disease symptoms were selected for clonal evaluation. Another 13,223 plantlets of "pei-Chiao" were screened for resistance directly in a diseased field. After 2 consecutive selections, 39 plants were selected for further study. In 2001, 200 clones were verified for *Fusarium* wilt resistance. Three clones were highly resistant and 10 were intermediately resistant. In 2000, an improved clone, TC1-229 which is semi-dwarf and resistant to *Fusarium* wilt was registered as Tai-Chiao No.3'. About 100,000 plantlets were multiplied for planting by growers.

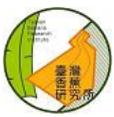
**Selection For plant With Improved Horticultural Traits:** In 5 preliminary varietal trials, 27 selected clones were evaluated. Two clones, GC-1118 (early flowering) and TC2-705 (semi-dwarf and high yielding) continued to show the selected traits. Other advanced clones, TC3-600 and TC3-1035 continued to perform well in the advanced evaluation trials.

**Induced Mutation Breeding:** Tissue-culture plantlets of a semi-dwarf cultivar were irradiated by 40 Gy  $\gamma$ -ray. After multiplication, plantlets were subjected to *Fusarium* wilt resistance screening. 90 plants were selected for future testing. In a field trial, 1000 irradiated plantlets were planted for investigation, in which 23.7% were morphological mutants. Among them 6 plants with advantageous traits were selected for further study.

**Banana Variety Diversification:** Characterization of 6 non-Cavendish banana cultivars was completed and the information is published by the China Association of Seed Improvement. These varieties include Pisang Lilin, Morado, Latundan, Mysore, Namwa and Fen Chiao.

### 2. Banana Tissue Culture

**Improvement In Banana Micropropagation technique:** The effect of Thidiazuron (TDZ) 2.0 mg/L in the induction of adventitious buds from the meristem of suckers in the cultivar "pei-Chiao" is better than 6-benzylamino purine (BA) 4.0 mg/L. The adventitious buds induced by TDZ were more in number and larger in size. In the comparison of different combinations of Dropp (agrochemical grade of TDZ wettable powder) and Paclobutrazol (PP333), the medium formulation D7 containing Dropp 0.1 mg/L and PP333 0.5 mg/L is more effective in the induction of adventitious buds through 3 successive subcultures than using BA (4.0 mg/L). The number of adventitious buds



increased with the increase in time of culture while BA did not exhibit this effect. In the past 3 years, a total of 14,000 plantlets treated by TDZ and PP333 showed normal growth during the nursery stage and also after field establishment. The occurrence of off-types is similar to the plants treated by BA which is less than 5%.

**Characteristics of GCTCV-218 In Micropropagation:** In this high yielding, *Fusarium* wilt resistant clone, the multiplication rate of adventitious buds during subcultures is lower than the cultivar “pei-Chiao”. Adventitious buds during the second to fourth subcultures have a higher tendency to become necrotic after 5 to 6 weeks in culture which affects the efficiency in micropropagation.

**Temporary Immersion System:** Adventitious buds of “pei-Chiao” in liquid culture using the temporary immersion system (immersion time 5 minutes every hour) showed a higher multiplication rate than adventitious buds cultured in agar medium within 4 weeks of culture. The combination of Dropp and PP333 used in the temporary immersion system also yielded a larger number of buds than in the BA medium.

**Micropropagation of Ornamental Banana (MUSA):** The technique for the multiplication of adventitious buds is established in 5 cultivars of ornamental bananas (*Musa acuminata* spp *zebrina*, *Musa ornata*, *Musa laterita*, *Musa beccarii* and *Musa velutina*). The use of Dropp and PP333 could effectively increase the multiplication rate.

### 3. Disease and Pest Control

**Breeding for Fusarium Wilt Resistance:** Production of Cavendish banana in Taiwan has been seriously jeopardized by the *Fusarium* wilt (race 4) in the past 2 decades. A commercially acceptable resistant variety is, therefore, urgently needed. During the last 4 years banana selection based on somaclonal variation has made a headway leading to the development of a vigorous, higher-yielding, and *Fusarium* resistant variety with considerable potential to replace its parent “Giant Cavendish”, the major cultivar grown in Taiwan. To my best knowledge, this new variety is the most productive Cavendish worldwide and is considered a breakthrough in banana breeding. It was discovered by a grower in his infested farm planted with tissue cultured plantlets of “Giant Cavendish” provided by Taiwan Banana Research Institute (TBRI). This somaclone designated “GCTCV-218” propagated by tissue culture at TBRI and its resistance to *Fusarium* wilt and superior agronomic characteristics were confirmed initially at the TBRI experimental farm and subsequently at a number of growers’ farm.

In 2000, an extensive trial on this new variety was conducted on 40 ha involving a total of 197 farmers in central and southern part of Taiwan, and on a 15 ha corporate farm at TBRI. Results of this study revealed that both the disease resistance and higher-yielding characteristics of this new variety were fairly stable across a wide range of environment regimes. The *Fusarium* wilt incidence on “GCTCV-218” averaged 4.1%, ranging from 1.6 to 12.2%, which is significantly lower than 9.8% of the wilt-tolerant variety “Tai Chiao No.1” and 29.6% of the wilt-susceptible variety “Giant Cavendish”. The higher



rates of disease were usually found on farms with poor drainage, sandy and acidic soil, or inadequate application of herbicides for weed control. The weight of bunches harvested from “GCTCV-218” during February-June averaged 30.6kg, ranging from 26 to 45 kg/bunch, which is 10.1 kg on the average heavier than that of “Giant Cavendish” . The huge increase in bunch weight is due largely to the increased number both in hands and in fingers, but not to the size of hand. The last point is important because the hands if too large would lose their appeal to the consumers.

The new variety, about 2.8 m tall, also beats the “Giant Cavendish” in other agronomic traits such as having more robust pseudostem, stronger and shorter petioles, thicker leaves, and better hand formation, and being more uniform in the size of hands. The fruit ripened normally and uniformly with the sweetness, flavor, and shelf life essentially the same as those of “Giant Cavendish” . The fruit was of high quality and received favorable feedbacks from both the Japanese and local market.

Based on field observation, “GCTCV-218” and “Giant Cavendish” were similar in susceptibility to major diseases and pests such as the freckle disease, black Sigatoka, leaf streak, bunchy top virus, cucumber mosaic virus, and corm borer. The only exception is that the new variety appears to be more vulnerable to the corky scab thrip which causes a grey-brown to reddish roughening symptom on the fruit skin.

Because of the advantages of resistance to *Fusarium* wilt and high yield, most farmers expressed great interest in planting this new variety. It is estimated that planting this new variety to replace “Giant Cavendish” would result in an increased yield from 32.4 to 51.6 tons/ha on *Fusarium*-infested soil, and from 38.4 to 54.5 tons/ha on clean soil, accounting for 59% and 42% of yield increase, respectively. For this reason, the Fruit Cooperative decided to release it for commercial planting, beginning January 2002. Mass propagation of tissue cultured seedlings of this new variety is in progress, with a target of producing 2 million for distribution to farmers in the first year.

For commercial planting, field management such as planting density, fertilization, and disease and pest control program recommended for use in cultivating the 'Giant Cavendish' are also applicable to the new variety. Cultivating the new variety demands attention to the following particulars.

- (1) Because the crop cycle is slightly longer, the new variety must be planted about one month earlier than usual, to assure that most bananas can be harvested in the spring season, the most demanding period in both domestic and foreign market.
- (2) With respect to the disease and pest control, special attention should be given to the control of corky scab thrips at shooting stage.
- (3) Planting of this new variety is not recommended on the farms with poor drainage or insufficient water supply, or having too sandy and too acidic soil. Under these unfavorable conditions, the growth of banana is relatively poor, and the level of *Fusarium* wilt resistance would be reduced. It is important that field practices like over use of nitrogen and inadequate application of herbicides such as diuron and glyphosate, known to prevent the full expression of *Fusarium* resistance, should be avoided.



**Weed Control:** Forty-five days after applying two different herbicides at different testing plots of a banana orchard in Chiuju, weed incidence was 12% and 100% respectively after spraying with 80% Azafenidin WG 500g+13.5% Basta S 3.5 L/ha and 13.5% Basta S 7 L/ha. Results indicate that the control efficacy of 80% Azafenidin WG500g +13.5% Basta S 3.5 L/ha was better than that of 13.5% Basta S 7 L/ha.

**Major Diseases Affecting Tissue Cultured Plants on Farm:** A large scale field survey in Kao-Ping area revealed that survival rate of tissue cultured plantlets after transplanting to field averaged 92.5% in 2001. The major causes of the death of plantlets were identified to be CMV and heart rot.

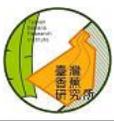
**Insects on Exported Banana:** During the period from February 2000 to July 2001, random inspection of bananas (12.5 kg/carton) at the Kaohsiung Port revealed that among 70 incidence of packing stations having bananas rejected for export to Japan, 43.3% to 69.1% were due to insect damage. The kind of insect observed and percentage of packing stations having bananas rejected were due to moth (coconut and scab moth) 3 to 9.5%; mealybug 3.3 to 5.4%; stem borer 0 to 0.4%; damage suspected to be caused by larva of cluster caterpillar 0.3 to 0.7%, respectively. Comparing to the fact that 13.8% of packing stations per month was affected by insect problem, the decline of rejection rate down to 8.7% for bananas inspected at different packing station at the port in Kaohsiung and Japan should be related to the improvement of insect control in the banana orchards.

#### 4.Cultivation and Post-Harvest Physiology

**Prevention and Management of Newly Developed Clones:** For banana bunch of two newly developed clones emerging in February and March of the year, i.e., tissue -cultured plants of “GCTCV-218” , a clone of *Fusarium* wilt-resistant and high yielding , and ratooned plants of “TC2-425” , a clone of high yielding , it is an optimal operation to retain nine hands and ten hands, respectively. Annual application rate of Tai-Fei compound fertilizer No. 4 is recommended at 1.0-2.0 kg per plant for “GCTCV-218” . In the plantation of “TC2-425” with a double-row planting pattern, planting density at 2,110-2,460 per hectare or plant spacing at 1.8-2.1 meters gives rise to a higher bunch weight.

**Ripening process of Newly Developed Clones:** “20°C-18°C-16°C” is a desirable temperature mode in the artificial ripening process of “GCTCV-218” and “TC2-425” .

**Prevention of Uneven Degreening Bananas:** In the cropping year 89/90, two third of banana plantations in Kaohsiung and Pingtung areas were still using blue polyethylene (PE) bunch bag, instead of kraft paper bag. Kraft paper bag, quasi-kraft paper PE bag and silver color overlaying blue PE bag had similar effect on the occurrence of sunburn and uneven degreening of banana bunch.



**Organic Cultivation of Bananas:** Organic farming of bananas would result in a delay of bunch emergence by two to four months, depending upon the clones, and less healthy leaves at the stage of bunch emergence due to infection by leaf freckle, as compared to conventional farming. There were little differences in the vegetative growth, bunch weight and total soluble solids of banana between the two cropping systems.

**Causes And Prevention of Rubbery Banana:** Results of investigations conducted in both banana packing houses and field trials in Kaohsiung and Pingtung areas indicated that the occurrence of rubbery banana was between 2 and 3% during the 88/89 cropping cycle. Applications of dolomitic lime (42% CaO), Chung-Hwa Pulp organic fertilizer No. 1 (15% CaO) and potassium chloride to banana plantations with rubbery proneness and strong acidity did not show any promoting or inhibiting effects on the occurrence of rubbery bananas. The low occurrence rate was presumed to be related to a shortened duration of low temperature and a temperature rise in winter.

Pulp analysis revealed that potassium content was significantly higher ( $p < 0.05$ ) and calcium content lower in the rubbery banana than in the normal banana. Water content and total sugar content of banana pulp were also significantly lower in the rubbery banana, however, starch content was significantly lower in the normal banana. The activities of pectinesterase, polygalacturonase and  $\alpha$ -amylase in the rubbery banana were unexpectedly higher than those in the normal banana. The opposite outcomes were explained by the in vivo compartmentation of enzymes from the substrates, which gave rise to the incomplete starch hydrolysis and consequently the rubberiness in the banana pulp.

To reduce the occurrence of banana rubberiness, the following operations are recommended (1) Growing low rubberiness-prone banana varieties, e.g. "pei-Chiao" and "Tai-Chiao No.2". (2) Recognition of chemical properties of plantation soil and rectification of acid soil by replenishing calcium compounds. (3) Irrigation and mulch of banana plantation prior to the arrival of cold front. (4) Early planting and harvesting of bananas before February and March, respectively.

## 5. Technical Service

**Propagation and Extension of Disease Free Banana Plantlets:** Plantlets of "pei-Chiao" 2,009,404, "Tai-Chiao No.1" 93,367, "Tai-Chiao No.2" 421,920 and "Tai-Chiao No.3" 120,181, totalling 2,644,872 were propagated and supplied to the Fruit Cooperative for distribution to banana growers during the period from February to June, 2001.

**Estimate of Harvesting Time and Production:** According to the result of shooting survey, the season of banana production this year was predicted to be later and the average bunch weight was lower than that of the 1999/2000 season due to the influence of typhoon in November 2000. The bunch weight of banana plants harvested was lower than that of the corresponding period of last year. The total production in Kaohsiung and Pingtung



area during the period from January to July 2001 was estimated at 2.3 and 2.5 million cartons (12.5kg/carton) respectively.

***Forecast of Disease and Pest Control:*** Based on the information of disease forecast, ground spray for the control of foliar diseases was carried out 8 times. Disease severity survey carried out in February 2001 revealed that the banana plants derived from suckers at shooting stage had retained only 8 healthy leaves in the sprayed areas, indicative of an unsatisfactory result.

***Education and Extension Program:*** To promote banana production and improve fruit quality, demonstrations and lectures for banana growers were conducted in cooperation with the Fruit Cooperative. A total of 1,000 banana growers attended the meeting this year.