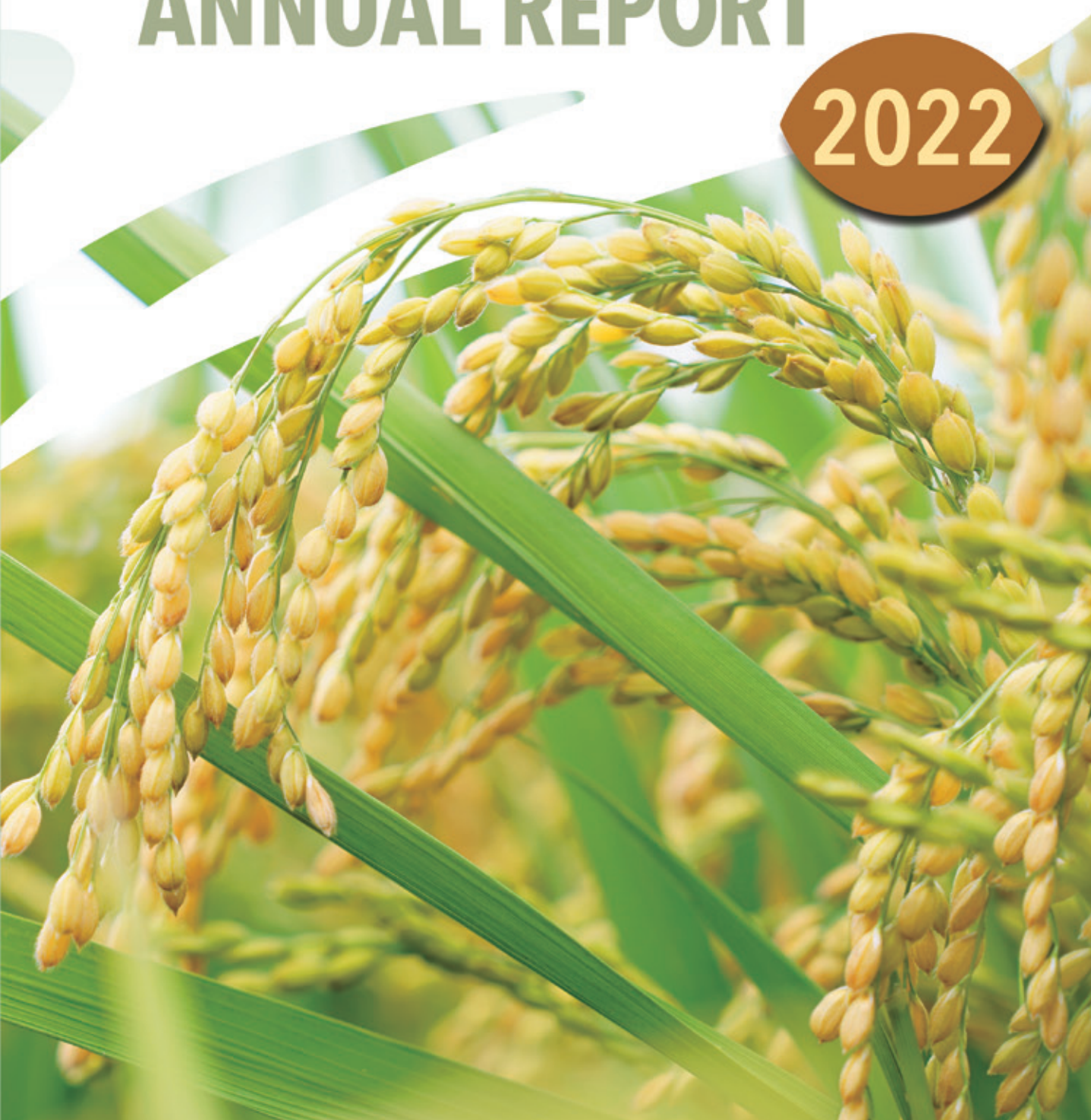


# TARI

ANNUAL REPORT



2022





## Taiwan Agricultural Research Institute

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**Cover photo** Rice 'Tainung No. 85', the variety can resistant to brown  
planthopper biotypes.

**Published in October, 2023**

# CNTENTS

2

Foreword from the Director General

6

Important Annual Activities of TARI

9

Selected New Varieties in 2022

16

R&D of New Technologies

23

New Services

26

Theme - Rice Research and Dr. Yong-Pei, Wu

29

Achievements of International and Academic Cooperation

31

Resource Introduction of TARI

# Foreword from the Director General



Taiwan Agricultural Research Institute (TARI) engages in technological research and development affairs related to the agriculture and food industry. It is founded based on agricultural science and applied scientific theories as well as demands from the industry, in the hopes of becoming the pioneer of agricultural scientific research in the country. It is committed to the breeding of new crop varieties and improvement of agricultural production technology. In addition to strengthening fundamental research, it has also created value-added applications for agricultural products. In 2022, a total of 248 agricultural science and technology research projects were executed. All colleagues at TARI have worked hard to achieve various goals, and TARI's R&D performance has also won praise from the Council of Agriculture (COA), and was ranked No.3 in the group of agricultural research institutes and extension stations affiliated to COA.

The annual publication of important research and development achievements namely includes three new crop varieties, (strains)-cherry tomato, oncidium, and dianthus, 20 new techniques, such as breeding and reproduction, processing and value-adding, energy-saving and carbon reduction, safe agriculture, etc., and two new services, a module for calculating sunburn on citrus fruit, and a system for crop yield forecast and remote real-time monitoring in the facility. The new tomato variety 'Tainung No.2' is a type of cherry tomato with a yellow ellipsoid shape and indeterminate growth habit. It has the ability to naturally set fruit and turn color during the spring season, which helps to meet the current needs of facility cultivation in Taiwan; the newly-developed batch processing multi-line mushroom stem-cutting technology can cut more than 6,000 mushroom stems per hour with a cutting rate error of less than 2%, reducing the concern of mechanical oil pollution during the operation process. To reduce food waste, TARI actively develops and applies processing techniques, extends the BBD of

agricultural produce, and changes the sales mode of agricultural produce. Through the freezing process, pineapples and guavas are transformed into frozen fruits with their flesh and nutrients retained. TARI also utilizes the high starch content of green bananas to develop frozen pre-cooked green bananas as novel starch-based ingredients and develops derivative foods with diverse applications. The new service- parameter values of the "citrus sunburn damage threshold" developed by the sunburn calculation module on citrus fruit, combined with data from the Central Weather Bureau's "Open Weather Data", can predict the occurrence of sunburn damage in the next seven days. Notifications can also be sent via text messages, e-mails, or apps to provide farmers with precise, real-time warning information to prevent and reduce citrus sunburn damage.

Two plant variety rights have been obtained, namely, potato 'Tainung No.4' and papaya 'Tainung No.11-Little Baby'. Two new patents have also been acquired for "Automatic stripping device for flammulina-velutipes shaping-protective-film and method thereof, and Lighting device for preventing *Conopomorpha sinensis* Bradley pest". TARI has promoted the transfer of 42 agricultural techniques to 47 businesses or farmers, with an authorized amount of NT\$3.415 million and an annual royalty income of NT\$514,000.

As countries around the world have gradually lifted COVID-19 restrictions, TARI has also actively engaged in in-person exchange activities and international cooperation, including sending personnel to Australia to collect information on the local lychee and pineapple industry, attending the International Horticultural Society Conference (IHC 2022) in Angers, France, the 4 per 1,000

Initiative Day event held in Sharm el-Sheikh in Egypt, and the 2022 Bilateral Meeting on the Cooperative Program in Agricultural Sciences between AIT/TECRO and USDA/COA in the United States, as a discussion with the USDA-ARS (United States Department of Agriculture-Agricultural Research Service) was made about future agricultural cooperation programs.

I would like to thank all our colleagues at TARI for their efforts over the past year. With the instability of the agricultural production environment, I hope that everyone can comprehensively grasp the production information on the agricultural and water environment, refine important agricultural image base data, gear to the international net-zero trend, implement the commercialization and industrialization of agricultural research achievements, and deepen international competitive advantages. TARI also needs to catch up with technological development, uses AI to assist in building a sustainable agricultural environment, and enhances the resilience of the agricultural industry to improve the value chain.

As the Council of Agriculture, Executive Yuan, underwent restructuring and was renamed the Ministry of Agriculture (MOA), TARI remains committed to implementing agricultural adaptation and net-zero emission policies in response to climate change, and building resilient agriculture. TARI will continue to serve as the strong support for MOA to solve agricultural problems through agricultural science and technology, and to become a provider for comprehensive technological solutions on the agricultural industry.

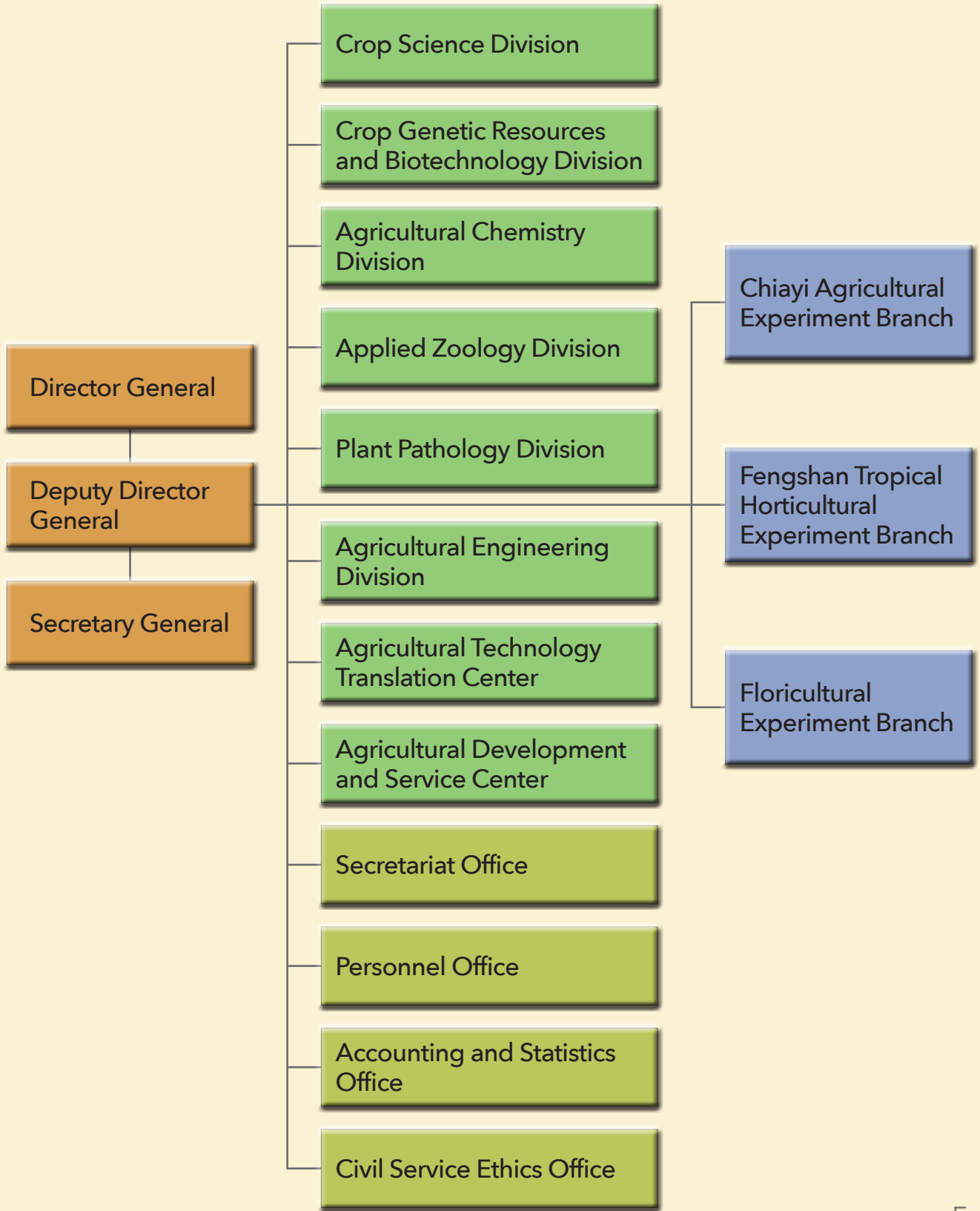


Hsueh-Shih Lin Ph.D.

October, 2023



**Remarks:** After the establishment of the MOA, TARI is a third-level institution affiliated to MOA. TARI's organization now includes six divisions, four offices, three branches, and two centers. The administrative units involve four offices, namely Personnel, Civil Service Ethics, Accounting and Statistics, and Secretariat. The research units comprise six divisions, including Crop Science, Crop Genetic Resources and Biotechnology, Agricultural Chemistry, Plant Pathology, Applied Zoology, and Agricultural Engineering. Two centers, the Agricultural Technology Translation Center and Agricultural Development and Service Center, are established in response to technological development and industrial needs. Additionally, three fourth-level institutions, the Chiayi Agricultural Experiment Branch, Fengshan Tropical Horticultural Experiment Branch, and Floricultural Experiment Branch, have been set up.



# Important Annual Activities of TARI

## 01 JANUARY

On 26 January, TARI collaborated with the Central Weather Bureau to publish the first online cherry blossom forecast system.



## 02 FEBRUARY

On 25 February, Chiayi Agricultural Experiment Branch held a press conference to observe the new variety of potato 'Tainung No.4' suitable for processing and fresh eating.

## 03 MARCH

On 22 March, TARI held the groundbreaking ceremony of the National Plant Phenomic Center.



On 23 March, the 2022 R&D Achievement Matchmaking Conference was held with agricultural net-zero emissions as the theme.

On 29 March, TARI conducted the conference of agricultural water resource programs and the inter-ministerial cooperation, and the exhibition of agricultural research achievements.

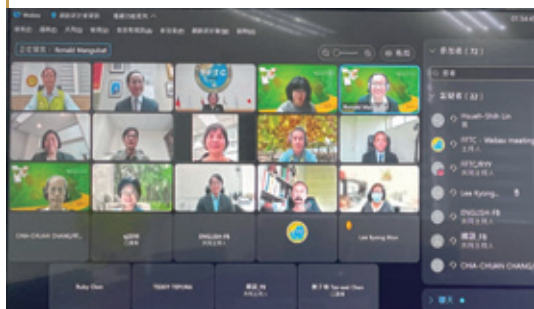
## 04 APRIL

The construction of the multi-environmental stresses simulation greenhouse started on 13 April.



## 05 MAY

TARI worked with FFTC to organize the e-commerce workshop regarding enhancement international collaboration on tropical fruit value chain for global market on 5 May.



On 6 May, TARI promoted the temporary protection of Japanese plant variety rights for pineapple 'Tainung No.23'.

On 18 May, the Fengshan Branch held an observation meeting about using special spectral light control to prevent *Conopomorpha sinensis* at night.

## 06 JUNE

On 10 June, the research results of the weedy rice cooperation with Nicaragua were published in the Pest Manag Sci Journal.



## 07 JULY

On 26 July, TARI set the cow market day for microbial agent to enable businesses to participate in research and development to meet market demands.

## 08 AUGUST

Director General Hsueh-Shih Lin led the team at the 2022 Bilateral Cooperation Meeting on Agricultural Science and Technology between AIT/USDA ARS and TECRO/COA on 2 August.

Secretary General Yi-Tan, Fang led 19 colleagues at the International Horticultural Society Conference (IHC 2022) in France from 14 to 20 August.

On 17 August, TARI held the 2022 Seminar on the Application of Plant Pest Classification and Identification in Plant Prevention and Quarantine with the Plant Protection Society of Republic of China.

On 30 August, TARI organized a demonstration and prevention and control meeting for integrated pest management of melon flies in Penghu with the Bureau of Animal and Plant Health Inspection and Quarantine.

## 09 SEPTEMBER

TARI collaborated with the Department of Agronomy at National Chung Hsing University to hold a seminar on development trends in smart agriculture and the achievements of the intelligent rice farming industry on 13 September.

## 10 OCTOBER

A presentation on the results of bilateral cooperation programs with universities was given on 5 October. TARI co-published with National Taiwan University, National Yang Ming Chiao Tung University, and National Chung Hsing University.

On 13 October, the 2022 Smart Agriculture International Seminar was held.

On 25 October, TARI collaborated with the Taiwan Space Union to organize the 2022 Earth Observation and Food Security, Smart Agriculture, and Sustainable Environment Forum.

On 25 October, TARI published the new variety, Papaya 'Tainung No. 11-Little Baby' and held the IPM Technology Demonstration Observation Meeting.



## 11 NOVEMBER

An event was held to mark the 127<sup>th</sup> anniversary of the establishment of TARI on 22 November.

On 28 November, the Floriculture Research Center held a new variety (series) observation event for flamingo lily, Oncidium, and a new variety of Dianthus, showcasing a total of 75 varieties/series.



Muji Signed Sales Intention Letters with New Farmers to create a new agricultural marketing model on 30 November.

## 12 DECEMBER

On 7 December, the Fengshan Tropical Horticultural Experiment Branch and Maejo University, Thailand signed a cooperation agreement in Chiang Mai, Thailand.

On 8 December, TARI held a demonstration and observation meeting on the integration of mechanized potato production.

On 20 December, TARI held a demonstration and observation meeting for multi-line operation with a flat-belt mushroom stem removal machine.

# Selected New Varieties in 2022

## Papaya 'Tainung No.11-Little Baby'

The fruit shape is long ellipsoid, with an orange-yellow pulp and vibrant taste. The average fruit weight is 800-900 grams, making it suitable for small family consumption. The fruit setting is uniform, with low malformed rate and good storageability, giving it great potential for future promotion.



## Tomato 'Tainung No.2'

As a new hybrid variety, it is a cherry tomato (*Solanum lycopersicum* L.) with a yellow ellipsoid shape and indeterminate growth habit. It has the ability to set fruit and turn color naturally during spring season, making it a new tomato variety with high economic value potential. The fruit is with high sugar content, good flavor, and its appearance has a clear distinction, making it highly recognizable by consumers.







## New Variety of Bitter Gourd 'Fengshi-2405'

A single fruit weighs about 650 grams, and has a long spindle shape and green flesh. The fruit has a glossy appearance, delicate taste, and excellent cold resistance. It can bloom and bear fruit normally in a low temperature environment of 12-15°C. The rate of deformed fruit is low, and the yield per unit area can reach 2,200 kilograms/0.1 hectares.

## Dianthus 'Tainung No.2-Summer Pink Cloud'

It has heat-resistant characteristics and bright colors, and grows well in the hot summer in Taiwan. It is highly ornamental and can increase the richness of summer flowers.



Oncidium

'Tainung No.10'

'Tainung No.11'

'Tainung No.12'



## **Oncidium 'Tainung No.10-Cleopatra'**



It is a large flower variety in a red-violet color with a pinkish-purple lip petal.

The plant is 91 cm tall, with an inflorescence length of about 67 cm, a pseudobulb length of 7.5 cm, and width of 4.6 cm. Each pseudobulb grows one to two flower stems, with a flowering period of about one month. The vase life of cut flowers is about seven to ten days. The flowers are 3.1 cm long and 2.5 cm wide, with a large number of flowers (about 97) arranged neatly and fragrant. It is an excellent potted flower variety and can also be sold as cut flowers. The ideal temperature for cultivation is 20-30°C.

## **Oncidium 'Tainung No.11-Flowery Butterfly'**



It is a medium-flower variety in a red-violet color with purple dots on its white lip petal. The plant is 74 cm tall, with an inflorescence length of about 55 cm, a pseudobulb length of 7.3 cm, and width of 2.8 cm. Each pseudobulb grows one to two flower stems, with a flowering period of about one month. The vase life of cut flowers is about eight to ten days. The flowers are 2.8 cm long and 2.5 cm wide, with a large number of flowers (about 68) and a fragrance. It has strong growth potential and is an excellent potted flower variety, but can also be sold as cut flowers.

## **Oncidium 'Tainung No.12-Cardinal'**



It is a medium-sized flower variety with purple red flowers and green stripes. The lip petal is white with purple red patches. The plant is 58 cm in height. The flower stalks are upright. The differentiation and growth of small flower buds are resistant to high temperatures. The inflorescence is about 45 cm long, with a pseudobulb stem length of 8.1 cm and width of 3.3 cm. Each pseudobulb stem grows one to two flower stalks, with a flowering period of about one month. The vase life of cut flowers is about seven days. The flowers are 2.7 cm long and 2 cm wide, and there are many flowers (about 110) with a fragrance. The plant has strong growth potential, and the flower spikes are located above the plant, which is ideal for the height of the plant, making it the best potted flower variety.

# R&D of New Technologies

## Process Technology for Frozen Food Ingredients

### Process Technology for Frozen Potato French Fries

This technology provides a method for producing high-quality frozen potato French fries, and is divided into two stages: post-harvest processing and sugar content adjustment, and efficient potato French fries production. It has the following characteristics: quality control from the source of origin, monitoring sugar content and solanine; simplifying the manufacturing process, and providing precise parameters to save 30% of costs and reduce finished reddish French fries by over 90%. Additionally, rapid detection technology for solanine has been developed, allowing for real-time feed control without the need for expensive instruments.





## Process Technology for Frozen Pre-cooked Green Banana Ingredients

When the cultivar "Pei-Chiao" banana (Giant Cavendish, AAA) was used as raw materials, green bananas were heated at different temperatures (70-100°C) for different periods of time. As the heating temperature and time increased, the maximum hardness, average hardness, and chewiness of banana flesh texture gradually decreased. After heating at 100°C for 0-20 minutes, the contents of resistance starch decreased from 64.67% to 8.34-12.27% (dry basis). Frozen pre-cooked semi-finished products of green bananas were developed by establishing the manufacturing processes of green banana preparation and freezing. The qualities have been analyzed and the microbial detection has met sanitation standards. The textural taste of pre-cooked green bananas without sweetness, is similar to potatoes, taros, and sweet potatoes. It can replace potatoes and taros in cooking.

## Processing Technology for Directly-consumed Frozen Fresh Pineapple

The technology provides a method for producing directly-consumed frozen fresh pineapple, including raw material pre-treatment technology, flavoring formula and process, and rapid freezing process.

This technology preserves the better pineapple flavor and increases palatability, reduces quality deterioration during frozen storage, and hence improves the overall quality of frozen fruits. Generally, frozen fresh-cut pineapples are prone to a high level of microorganisms and flavor loss during frozen storage, which is not conducive to direct consumption as frozen fresh fruits. The directly-consumed frozen pineapple made by this technology retains the nutrition and flavor of the original pineapple, has good palatability, and can be directly eaten after slightly thawing, or can be used to make pineapple sorbet. This highlighted product conforms to the consumption trend of being nutritious and natural with fewer food additives, which is different from the highly processed frozen products commonly sold in the market. Therefore, it has considerable competitiveness and is conducive to the development of the frozen fresh fruit market.



## Processing Technology for New Frozen Guava Fruit Ice Product

The technology provides a method for producing a new type of frozen guava ice product, including raw material selection, multiple processing methods, flavoring formulas and processes, and rapid freezing processing. It reduces the gritty taste and improves the palatability of frozen guava. The creative processed guava product made by this technology - the new-style frozen guava ice product - retains the fruit flesh appearance and nutrients, has a novel taste and a good flavor, and can be eaten directly after slight thawing or used to make sorbet products. Because of the increased health awareness of the public, frozen fresh fruit ice products with fruit flesh appearance and nutrients become a key market trend. This new-style frozen guava product is aligned with the consumption trend of being nutritious and natural with fewer food additives. This highlighted product is different from the highly processed ice products commonly sold in the market and will be competitive in the frozen dessert market.

## Research and Development of Plant-based Products

### Technology for Producing Tempeh Using Whole Soybean Fermentation

The traditional tempeh making process requires removing the soybean seed coat, and therefore the mycelium can be fully coated. This new technology uses whole soybean seeds, since it is unnecessary to remove the seed coat before fermentation, thereby simplifying the process, reducing waste, improving raw material utilization, and reducing processing cost. In addition, the dietary fiber content of tempeh is increased, retaining more nutrients.



# Technology for Producing Plant-based Chicken Essence from Fermented Soybeans





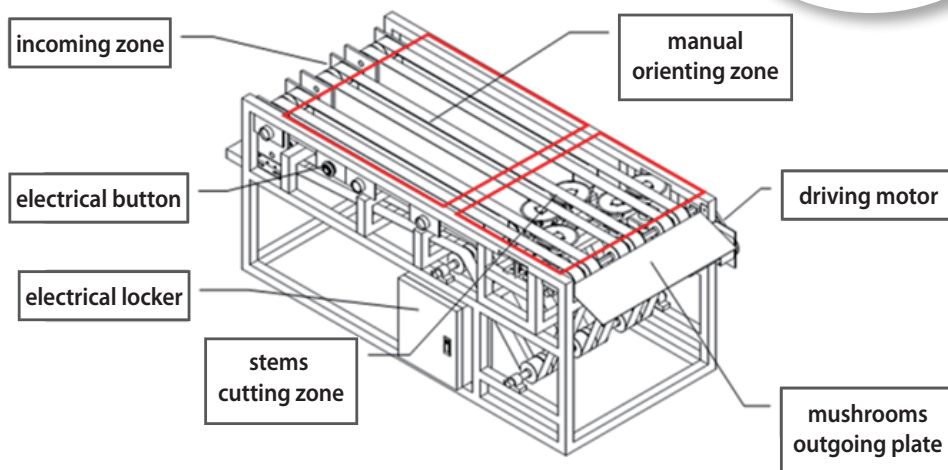
Most of the vegetarian chicken essence on the market is made from mushrooms and Chinese herbal medicine, lacking the traditional healthy ingredient of chicken essence: BCAA (branched-chain amino acids). Soybeans are rich in protein. Through fermentation and post-ripening processes, the content of free BCAA increases significantly, providing a natural umami taste and mushroom-like aroma. The plant-based chicken essence has a golden color, which is similar to traditional chicken essence, making it suitable for consumers who are sensitive to the flavor of chicken essence and require nutrition supplementation for sport purposes.

## Mushroom Essence Production Technology

By using a combination of different mushrooms and hydrolyzing the original essence of mushrooms under high pressure, various high-quality functional amino acids such as GABA, tyrosine, and arginine, are extracted from mushrooms without excessive purine. This is ideal for consumers who are concerned about gout but still want to acquire nutrition from mushrooms. This is also a plant-based product that replaces animal chicken essence and therefore is suitable for vegetarians.

## Batch Processing and Multi-line Operation Technology for Mushroom Stem Cutting

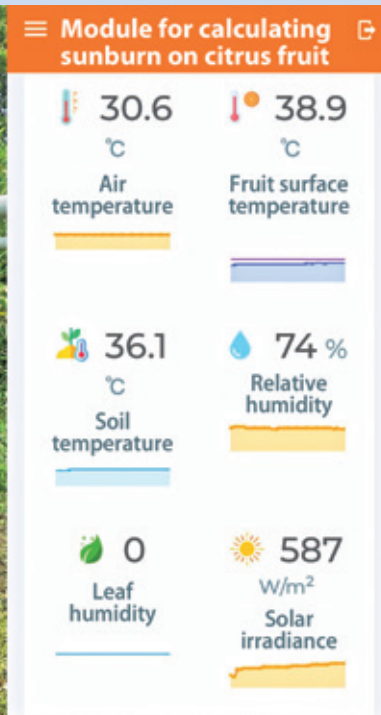
By combining existing food-grade transmission belts with mechatronics integration technology, multiple intermittent transmission mechanisms that conform to ergonomics are formed. Belt-support plates are used to maintain the stability of the long belt, and after the mushroom stem is oriented manually in batches, the stems are removed using a cutting mechanism directly driven by an electric motor to reduce multiple collision damage of the mushroom during processing. The machine assembled using this technology can operate stably, and with the cooperation of operators, the operating capacity can reach over 6,000 mushrooms per hour, and the error rate of cutting mushrooms is less than 2%. There is also no concern about mechanical oil pollution during the operation process, making it a suitable machine for mushroom farmers.



# New Services

## Module for Calculating Sunburn on Citrus Fruit

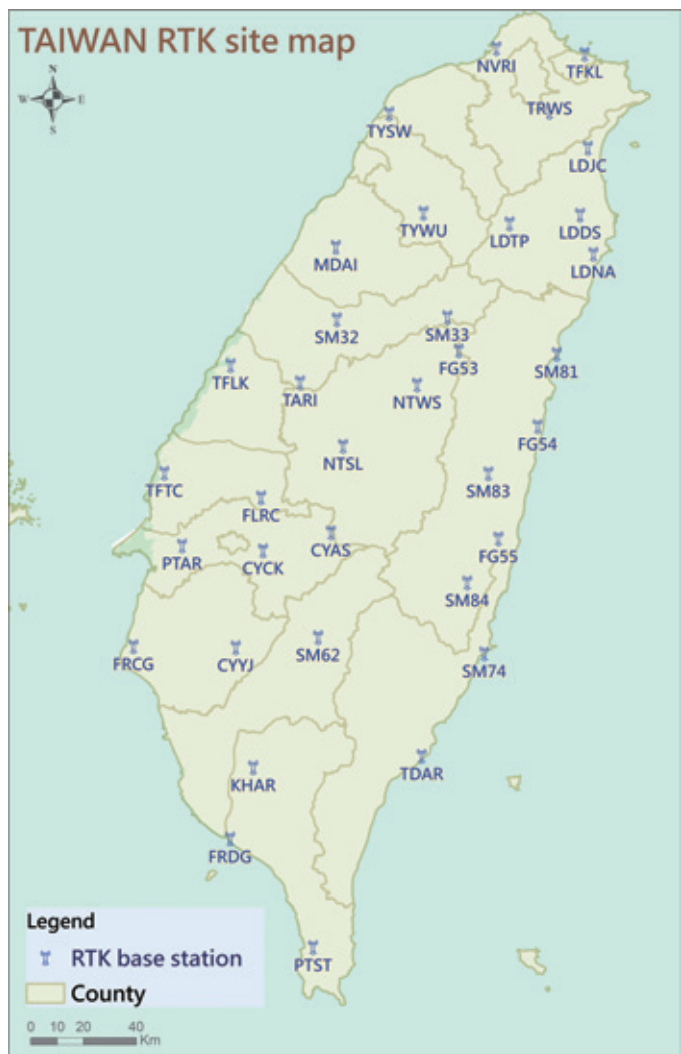
Because of its intelligence and accuracy, this technology can give farmers early warnings and help them avoid sunburn damage on citrus fruit. Operators can accurately forecast the occurrence of sunburn disease by combining data from the Open Platform of Meteorological Data of the Central Meteorological Bureau with the parameter of the "Citrus Fruit Sunburn Threshold" and importing it into the executable files of the Citrus Fruit Surface Temperature Model program. Farmers can



receive the real-time warning information right away by SMS, email, or an app, which has tremendous commercial values. With the use of this technology, farmers may implement accurate protection at the appropriate time, which helps to decrease the needless application of pesticides by two to three times and saving NT\$20,000-30,000 per hectare in labor and pesticide cost. It is anticipated to reduce damages by 10% to 15% when paired with the sunburn prevention materials developed by TARI, resulting in a cost reduction of NT\$100,000-150,000 per hectare.

## Agricultural RTK Positioning Assistance Network Assists the Smart Agriculture and Agricultural Service Management Platform

TARI installed 35 RTK base stations (18 stations on flat land and 17 stations in mountains) throughout Taiwan in 2021, which can be used for pesticide spraying on farmlands and slopes, paddy field leveling, rice harvest yield maps, and other applications. TARI has also connected RTK for no-load and vehicular light transmission. Currently, we can provide precise RTK positioning services covering agriculture across Taiwan. In addition to installing stations, our institute has also completed the development and design of a shared RTK core module, and has



expanded the development of low-end and high-end precise positioning control platforms for various agricultural machinery. In addition, in conjunction with the platform operations of the Civil Aeronautics Administration and the Bureau of Animal and Plant Health Inspection and Quarantine, a unified management platform for unmanned spraying machines has been planned to bring the platform closer to user needs. Through precise positioning and tracking of agricultural machinery, RTK precision positioning technology and agricultural machinery has been integrated to improve farmer field management efficiency.



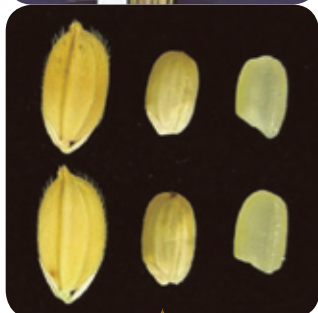
# Rice Research and Dr. Yong-Pei, Wu

When TARI was established in 1895, rice research was initiated to address the issue of poor taste of rice in Taiwan at that time. TARI's logo, which features rice, shows the emphasis on and the investment in rice research.

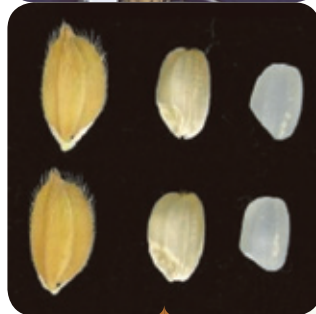
The head office and Chiayi branch are engaged in rice research. The Chiayi branch is located in the center of the Chianan Plain Taiwan granary, and the natural conditions of the rice test fields are very suitable for screening germplasm resistant to rice blast, and also have facilities for breeding resistance to brown planthoppers and insect resistance testing. Therefore, the resistance breeding of paddy rice is the key direction of the branch; many rice varieties resistant to diseases and pests have been bred, such as Guangfu No.1, Jianong No.242, Tainung No.68 and Tainung No.70. With the progressing of time and social changes, the westernization of the Taiwanese diet and the decline in the consumption of rice have led to adjustments in the rice breeding goals of the Chiayi branch; it now focuses more on improving rice quality and functionality. In recent years, climate change has also been taken into account by an important leader, Dr. Yong-Pei, Wu (1965-2023).



After graduating from the Department of Agronomy at National Chung Hsing University, Dr. Wu joined the Chiayi branch in 1991 and obtained a PhD in Agronomy from Taiwan University in his spare time. He devoted his whole life to rice breeding and used the accumulated mutation pool of chemical mutagenesis to screen out many distinctive rice varieties. He successively bred 'Tainung No.76', which is rich in nutrients and has a pale yellow appearance. It is known as "Golden Rice". The embryo of 'Tainung No.78- Giant Embryo Rice' is two to three times more than that of ordinary varieties, which can provide more nutrients than starch and has the potential to develop health supplements. The crude protein content of 'Tainung No.82- Low-Protein Rice' ranges from 4.5 to 5.2%, and the rice has a good taste with a soft and bouncy texture. 'Tainung No.81' and 'Tainung No.86' have a greater resistance to rice blast, making them more suitable for cultivation by farmers. Ten years ago, Dr. Wu started to become concerned about climate change and believed that rice breeding



'Tainung No.76'  
Golden Rice



'Tainung No.78'  
Giant Embryo Rice



'Tainung No.81'



'Tainung No.82'  
Low-Protein Rice



'Tainung No.86'

should focus on stress resistance breeding. He therefore conducted many breeding programs concerning salt tolerance, drought tolerance, and multi-resistance to abiotic stress. As rice is a water-consuming crop, the drought tolerance of current hybrid rice varieties is insufficient. He attempted "inter-genus hybridization" with maize from the millet genus, sorghum from the sorghum genus, and rice from the rice genus, which was difficult. He kept working on his research, nevertheless.

Dr. Wu's greatest effort during his lifetime was to devote in the cross-species hybridization of rice and determined that most rice and poaceae crops could be crossbred; he found that new genetic variations could be created through cross-species hybridization, and that new strains with cultivation and utilization values could be produced. In the future, this approach can be used in rice breeding in Taiwan to develop a variety of traits which it lacks, including disease and insect resistance, drought resistance, other adversity characteristics, and quality characteristics, and to raise Taiwan's research standard in the rice industry.

Here is our gratitude to Dr. Wu for his contributions to TARI and the rice industry.

# Achievements of International and Academic Cooperation

The international cooperation business involves technical exchange and cooperation with foreign research institutions through bilateral meetings organized by the Council of Agriculture (COA) and under the framework of cooperation agreements. Additionally, two online international symposia have been co-organized with the FFTC. Five oral presentations were given and 12 posters were published by 15 researchers assigned to attend the IHC 2022 in France and the other three researchers attended virtually. Director General Hsueh-Shih Lin Ph.D. led the team to attend the 2022 Bilateral Cooperation Meeting on Agricultural Science and Technology between AIT/ USDA ARS and TECRO/COA in the United States, where future cooperation with the Agricultural



Research Service, USDA was discussed. TARI continues to implement the projects for New Southbound Policy, and helped the demonstration zone in Long An Province of Vietnam to purify the Vietnamese rice variety 'Dragon Blood' and to set up the facility production system of lemon seedlings. TARI has also remotely assisted the Baguio button mushroom demonstration farm of the Bureau of Plant Industry, the Philippines to solve the problems of pests and diseases in button mushroom cultivation, and has held three mushroom cultivation training courses, with a total of 58 trainees participating in the Philippines.

TARI continues academic cooperation with domestic universities, including National Taiwan University, National Chung Hsing University, and National Yang Ming Chiao Tung University, as researchers jointly devote in research and development regarding agricultural concerns and future issues, such as expanding and establishing a soil hydraulic characteristics database in Taiwan with limited data, developing and applying artificial intelligence in the growth model of *Phalaenopsis*, and studying the eQTL and physiological expression of resistance to bacterial wilt disease in rice mutant AZ1310.

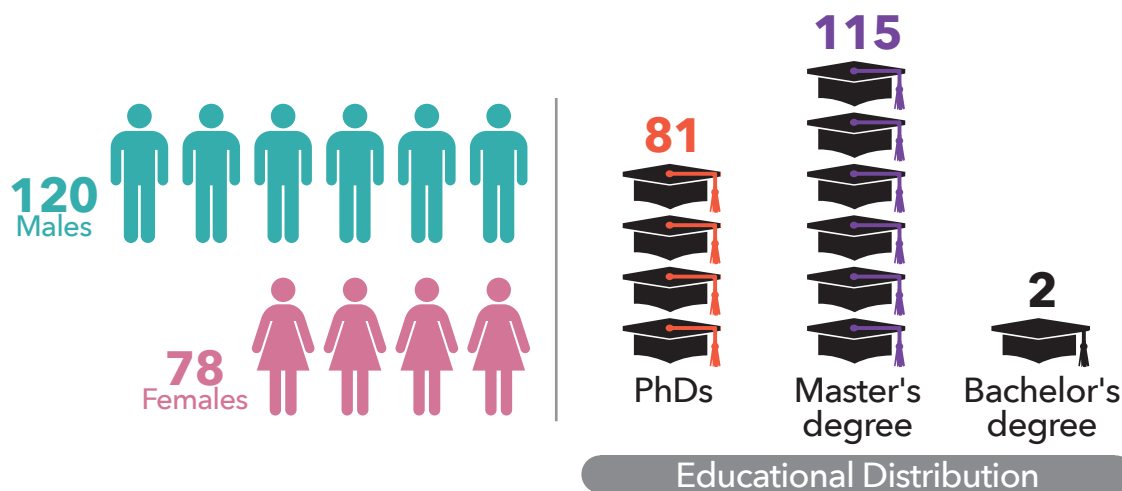


# Resource

## Introduction of TARI

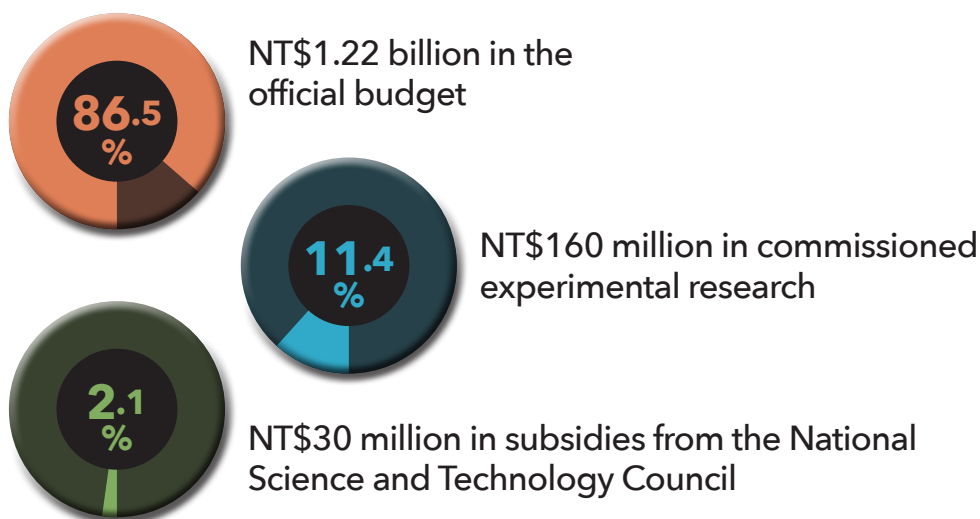
### Human Resources

In 2022, our research and development team consisted of **198** people.



### Budget

In 2022, the total amount was **NT\$1.41 billion**.



## Number of Research Projects



## Cultivation Center Performance



- 3** Newly signed enterprises
- Guiding **13** enterprises
- Facilitated **4** companies to invest over \$25 million in additional capital
- Increased employment to 31 people in **5** enterprises

## Important Academic Publications



TARI



