TARI

ANNUAL REPORT

2023

Taiwan Agricultural Research Institute

Published by Taiwan Agricultural Research Institute
No.189, Zhongzheng Rd., Wufeng Dist., Taichung City 413008,
Taiwan (R.O.C.)
T +886 4 2330 2301
F +886 4 2333 8162
E mwf-doc@tari.gov.tw

https://www.tari.gov.tw/english/

Editor Chang-Tsern Chen

Contributors Ming-Hsin Lai, Keng-Chang Chuang, Che-Wei Chu, San-Tai Wang, Hsiang-I Lee, Yuan-Kai Tu, Chien-Ya Hung, Shou-Horng Huang, Szu-Lun Lai, Yi-Nian Chen, Tsung-Yen Wu, Yun-Sheng Lu, Chien-Hui Syu, Yaw-Jen Dong, Ming-Hwi Yao, Chin-Chih Chen, Ming-Hsuan Tsai, Yu-Shih Hsieh, Yu-Hsuan Yang, Chang-Tsern Chen

Cover photo Jujube 'Tainung No. 13-Shirley' is a variety with an early production period. The fruit's skin is shiny and waxy, free from brown patches, and the quality is consistent.

Published in July, 2024

CONTENTS

Foreword from the Director General

The Taiwan Agricultural Research Institute (TARI) engages in technological R&D work related to agriculture and food products. It develops technical expertise based on the agricultural sciences and the needs of the agricultural sector. Focusing on core bottlenecks in agricultural development, it works to explore problems, undertakes strategic R&D, and develops technical norms for and systematically integrates innovative agricultural technology and techniques. It aims to resolve key issues facing agriculture in Taiwan, acting as a leader in agricultural technology and innovation and a provider of comprehensive technical solutions to agro-industries. In 2023 TARI implemented 268 research projects, and all of our staff worked hard to reach our goals. The Ministry of Agriculture (MOA) affirmed the results of our R&D work, ranking TARI as number one among the MOA's research institutes and agricultural improvement stations, while also presenting TARI with an award for the management and application of its R&D achievements.

Important research achievements made public in 2023 included three new crop varieties (rice 'Tainung No. 88', anthurium 'Tainung No.10- Hong Show', and chili pepper root stock cross-bred to be resistant to bacterial wilt '23-Fengshan chili pepper root stock No. 1') and six new techniques: technology for mass production and application of the fungus *Isaria javanica* FSW1, R&D into the *Beauveria bassiana* fungus, which has the potential to protect against the coffee berry borer, technology for the installation and use of Archimedes micro-hydropower facilities and their energy storage system, R&D into promotion of the growth of tissue-cultured ginger seedlings to replace arbuscular mycorrhiza fungus from ginger planted at high altitudes to reduce soil loss, technology for optimizing growth medium made from waste shiitake mushroom compost with a mixture of insect frass, and technology for a type of longan flower extract preparation that promotes metabolic activity. Research results also included two

new services, which were the use of integrated pest management (IPM) technology to enhance the production of safe fresh passion fruit and an integrated services platform to monitor and control flower fertility and provide information on related production and marketing conditions. Of these, work on the passion fruit technology was conducted by an inter-agency team established to resolve the problem of pesticide residues in passion fruit. With a starting point of ensuring healthy seedlings, they introduced eco-friendly plant protection products during the cultivation period, using non-chemical materials to achieve the goal of controlling insect pests in the fields with reduced use (or no use) of pesticides, thereby ensuring production of safe and high-quality fresh fruit. By solving this critical national problem, the team won an award in the technical innovation group at the MOA's 3rd IPM Awards.

TARI also received variety rights for five plants, including rice 'Tainung No. 85', dianthus 'Tainung No. 2-Summer Pink Cloud', oncidium 'Tainung No. 10-Cleopatra', oncidium 'Tainung No. 11 -Flower Butterfly', and oncidium 'Tainung No. 12-Cardinal'. TARI also added three new patents: the use of a composition containing an extract of mushroom and/or culture substrate thereof for treating depression and emotional regulation, a box carrying device, and a belt conveyor mushroom stem cutting machine. TARI promoted 67 cases of agricultural technology transfer to businesses or farmers, earning N$7.103 million in licensing fee and royalties of NT$511,000.

In terms of international cooperation, TARI jointly held two workshops with the Food and Fertilizer Technology Center for the Asian and Pacific Region. One focused on "Tropical Fruits: Global Status, Value Addition, and Expansion Prospects" in May, while the other addressed "Developing Low Carbon Farming for Smallholders in Asian and Pacific Region: Options, Mitigation Potential, and Challenges" in October. Regarding Taiwan-US cooperation, TARI sponsored several events, including the "Taiwan-US Conference on Carbon Neutral Agriculture" in March, a training class on evaluating natural predators to combat invasive insect pests, the "Taiwan-US Bilateral Cooperation Meeting on Plant Production and Plant Protection" in June, and a meeting on the identification and description of the vibrational signals of leafhopper vectors of Pierce's disease of grapevines in September. Additionally, TARI invited three experts from the Agricultural Research Service of the US Department of Agriculture to attend a conference on sustainable production systems for fruit trees in May. Furthermore, in March, TARI attended a meeting of the Agricultural Innovation Mission (AIM) for Climate, led by the United Arab Emirates and the US, as a "Knowledge Partner" of the organization. TARI also participated in the 28th session of the Conference of the Parties to the United Nations Framework Convention on Climate Change and took part in "4 per 1000 Initiative Day."

I would like to thank all of the staff at TARI for their hard work in 2023. Given the agricultural production environment under conditions of climate change, I hope that everyone will continue to uphold active & innovative AI capabilities to serve the needs of farmers and agricultural industries by conducting technological R&D, building a better agricultural production ecosystem, and creating new value-added for agriculture.

Hsueh-Shih Lin Ph.D. July, 2024

Important Events in 2023

02 FEBRUARY

On 15&16 February, TARI held two meetings to introduce technology and techniques for production and marketing of pineapples.

03 MARCH

The demonstration of reduced pesticide use through integrated pest management for passion fruit was held on 15 March.

TARI organized an exhibition of R&D results and technology matchmaking meetings on 28 March.

04 APRIL

Handed-on activity for the revival of millet cultivation in indigenous peoples communities on 25 April.

05 MAY

On 10 May, handed-on demonstration of reduced-pesticide cultivation techniques for Yuherbau lychees production in facility.

Symposium on sustainable agroecosystem: Genotype, Environment, and Management was held on 30 May.

On 30 May, handed-on demonstration of a cultivation technology package for cherry tomatoes adapted to high temperatures production in facility.

Press conference on multi-layer culture for shiitake mushroom under a pad and fan greenhouse on 31 May.

06 JUNE

On 13 June, hands-on event and lectures for promotion of technology to build a seedling propagation production system for green onions.

On 17 June, Hands-on demonstration for promotion of integrated pest management for passion fruit in Dapingding.

On 20 June, Taiwan-US Bilateral Cooperation Meeting on Plant Production and Plant Protection.

On 30 June, 30th anniversary of the founding of the National Plant Genetic Resources Center.

07 JULY

On 20 July, TARI set the cow market day for microbial agent.

08 AUGUST

On 3 August, ceremony for reopening the Taiwan Agricultural Research Institute under the restructured Ministry of Agriculture.

09 SEPTEMBER

On 8 September, symposium on decision-making support systems for precision management technologies for agricultural water resources.

On 15 September, exhibition of results of research into the processing of pineapples to increase their value-added.

10 OCTOBER

On 24 October, exhibition of results of smart agricultural technology for rice as well as ecosystem template construction.

11 NOVEMBER

on 7 November, seminar for building up contacts and exchanges of information within the avocado industry.

TARI handed-on demonstration of an integrated technology package for Oncidium orchids on 9 November.

On 14 November, TARI held a meeting to introduce the real-time services network for management of diseases and insect pests in crops.

12 DECEMBER

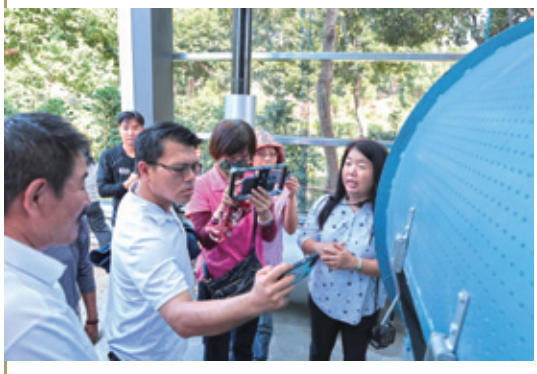
On 6 December, review meeting for naming of the new rice line, Tainung-yu 105041 was held and this new rice variety formally named 'Tainung No.88'.

Press conference on new varieties of potted Oncidium orchids was held on 7 December.

On 10 December, handed-on demonstration of an integrated production technology package for Taiwan jujube production in facility.

Handed-on demonstration of a streamlined production operations system for coffee on 13 December.

Opening of a demonstration venue for automated coffee operations and handed-on demonstration event were held on 15 December.



Selected New Varieties in 2023

Rice 'Tainung No. 88'

'Tainung No. 88' rice variety was hybridized from 'Tainung No. 74' (known for its good taste and excellent appearance) as the mother parent and 'Tainan No. 11' (known for its wide adaptability). This rice variety has good resistance to high temperatures in terms of both grain production and quality. Its grain production is stable and can be stored for four months without any change of its rice taste. The grains have few chalkiness and good transparency, while the cooked rice has a taro fragrance and excellent texture. 'Tainung No. 88' also shows strong resistance to major diseases in the field.

Anthurium 'Tainung No. 10- Hong Show'

The anthurium 'Tainung No. 10' originates from the natural pollination of the TARI-481 mother plant, which was selectively bred through open pollination and chosen named TARI-1188 in 2016. In 2018, tissue culture from young leaves, and trial cultivation was conducted in Kaohsiung, Tainan, and Nantou to select a superior variety. The anthurium 'Tainung No. 10' is a cut-flower variety of medium to large size, characterized by a bright red subtending spathe, a green spadix, as well as tapering towards the top spathe slightly. The stems are straight, long, and green, and the flowers have excellent vase life.

Dianthus 'Tainung No.3-Summer Jade'

This variety of Dianthus, selected through tests of its nutritional system and regional trial cultivation, has been named Dianthus 'Tainung No.3-Summer Jade'. It has deep purplish-red single-lobe flowers, with cut flowers reaching over 40 centimeters in length and emitting a pleasant fragrance. The leaves have a coriaceous texture. The cut flowers can last for more than 15 days, and the cultivation management for this variety is very easy. It is heat-resistant, and the long cut flowers in the summertime do not fade in color under high temperatures and retain their fragrance.

Green onion 'Tainung Select No. 1'

The green onion variety 'Tainung Select No. 1' features erect foliage with strong tillering and early maturation. This variety has a tender texture and rich taste. It is a heat-tolerant Szu Chi Tsung type, making it suitable for production in the spring and summer in central and southern Taiwan. Cultivation in the summer takes 80 to 90 days from planting to harvest. With 6 to 12 tillers per plant in summer production and 10 to 14 tillers per plant in winter production, the yield ranges from 26 to 35 metric tons per hectare in summer and 28 to 45 metric tons per hectare in winter. It is not susceptible to bolting in the winter in the lowlands of central and southern Taiwan.

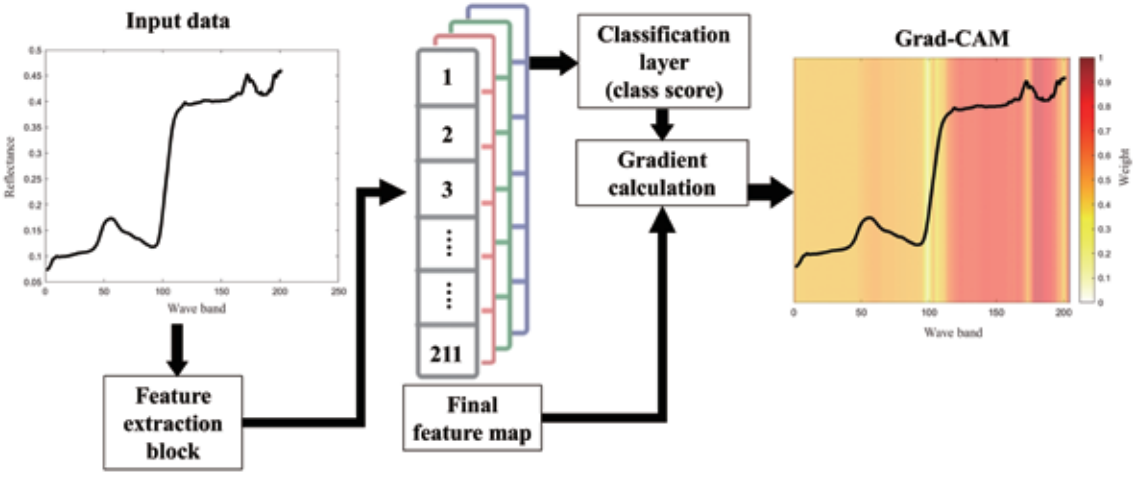
Hybridized rootstock line for chili pepper resistant to bacterial wilt '23-Fengshan Chili Pepper Rootstock No 1'

The newly bred chili pepper hybridized rootstock line '23-Fengshan Chili Pepper Rootstock No. 1' has been confirmed for its resistance to bacterial wilt through seedling stage inoculation. When grafted with the Korean-type sweet pepper '307', it achieved an 88.6% survival rate in fields infected with bacterial wilt, compared to only 48.8% for ungrafted plants, resulting in a 78% increase in yield for grafted vs. ungrafted plants. In April, it was grafted with the 'Andalus' sweet pepper, achieving a survival rate of 93.8% for grafted plants compared to 61.3% for ungrafted plants, and a 96.9% increase in yield for grafted vs. ungrafted plants. In July, it was grafted with the 'Buffy' upright fruit-setting hot pepper, reducing the incidence of anthracnose from 66.7% in ungrafted plants to 40.6% in grafted plants. Not only has the grafted '23-Fengshan Chili Pepper Rootstock No. 1' proven resistant to bacterial wilt, but it has also shown an increase in yield, particularly in early-stage yield.

Outstanding New Agricultural Technologies for 2023

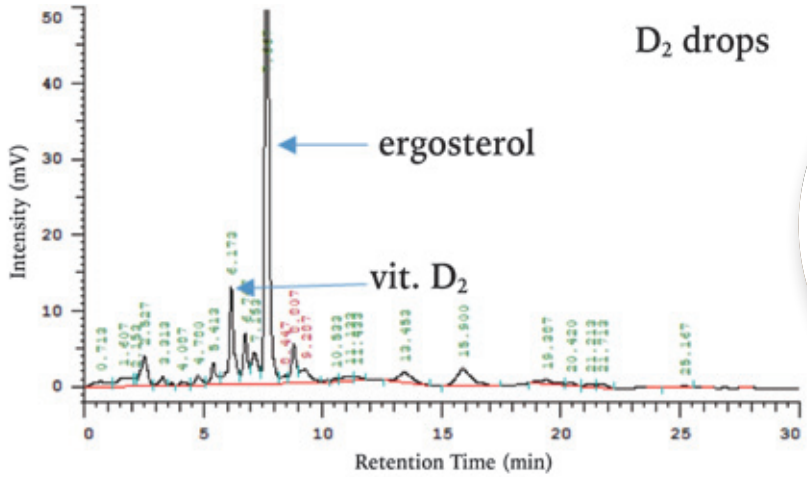
1 Application of explainable artificial intelligence models for feature band selection

Using gradient-weighted class activation mapping (Grad-CAM) for convolutional neural networks to analyze spectroscopy data, it is possible to determine the weight of each band within the neural network. This weighting process enables the understanding of each band's contribution to the model's predictive ability, facilitating the extraction of important feature bands. This technology is already being applied to select feature bands for adversity-resistant biological states, such as early drought detection in tomatoes, and for developing a simple and cost-effective spectrum detection prototype.



2 Production technology for Vitamin D_2 drops from mushrooms

Using mushrooms with high conversion efficiency as raw material, TARI exposed specified mushrooms to light irradiation to produce Vitamin D_2. TARI then used appropriate extraction equipment and edible oils, employing oil extraction technology to produce liquid Vitamin D_2. The extraction efficiency varied from 18.4% to 27.6% depending on the oils used, with the same extraction equipment. The Vitamin D_2 content ranged from roughly 780 to 1,100 IU mL^{-1}. The total yield of liquid Vitamin D_2 produced was about 52% to 54%, with Vitamin D_2 content between 1,000 to 1,500 IU mL^{-1}, as well as the functional ingredient ergosterol. When stored at room temperature for 12 months, the changes in indicator ingredients of the liquid Vitamin D_2 were less than 20%.



3 New breakthroughs in critical disease and pest prevention technology for exported pineapples

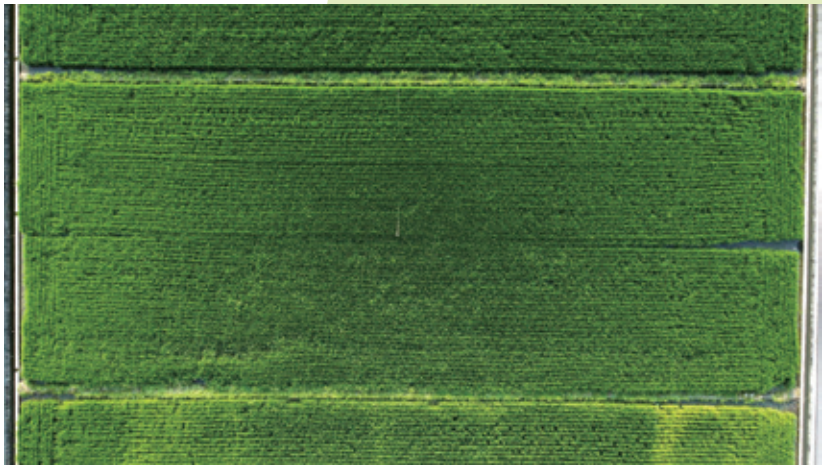
In order to reduce the incidence of disease and insect pests in exported pineapples, ensure the safe use of agricultural chemicals, and meet permissible pesticide residue standards in export markets, TARI conducted comprehensive trials and research to test pesticide effectiveness and residue levels. These trials gathered data on effective chemicals, application methods, and safe harvest times. TARI identified that pineapples are most vulnerable to critical diseases and pests (such as the moth [Lepidoptera: Cosmopterigidae] and fruitlet core rot) during their flowering period, making this the key time for prevention. This led to a strategic shift in pesticide application schedules to better align with the pineapple's vulnerability during flowering. Additionally, TARI established standard operating procedures for cleaning venues where export pineapples are concentrated and packaged. These procedures guide venues in strengthening insect cleaning and preventing secondary contamination, thereby reducing the rate of export pineapples failing to meet inspection standards.

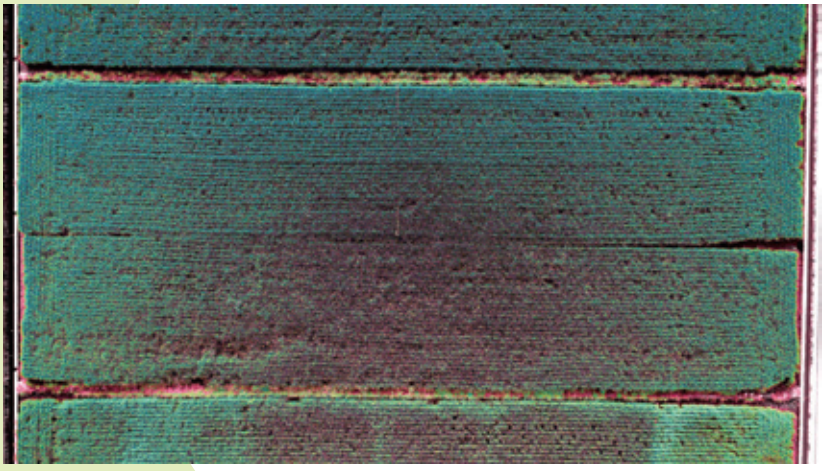
4 Technology for horizontal packaging of *Eustoma* for shipment to Japan by air

When Eustoma cut flowers are placed horizontally, they usually lose their commercial value due to bending flower buds (resulting from negative gravitropism) and broken necks. However, by strengthening bud grading and improving post-harvest handling operations, Eustoma can maintain saleable quality for up to eight days within the current air transport temperature chain. Over 10,000 stems have already been exported to Japan using horizontal packaging, without any customer complaints. This waterless transport method saves about NT$50 in liquid packaging costs per unit (ten boxes per unit).

5 Early warning technology for rice leaf blast

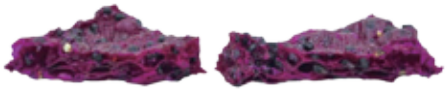
Through spectroscopic data collected on rice plants in the field, after image processing, specific vegetation index could be extracted. And we are able to using the model with these vegetation index to predict whether the rice is infected by leaf blast fungus or not, and tell us the safety rate of rice in the field. With this result, farmer could decide to operate the field management strategy or not, achieving the goals of early warning and preventing rice leaf blast.





6 Pressure-differential puffer drying technology for fruits and vegetables

Use of the hot compression effects of gas and phase change, coupled with pressure-differential and infrared drying technology, creates a new crispy texture to dried fruit while reducing its fibrous feel. This method offers several advantages, including shorter drying times, lower water activity, and preservation of the fruit's natural fragrance. Moreover, it has broader applications beyond fruit, extending to vegetables and other dried products. Notably, this technology significantly reduces production costs and enhances the competitiveness of related products. Production costs are 30% to 50% lower than vacuum-frying or freeze-drying processing methods. Because this form of processing does not employ high temperatures, it can better preserve the nutritional value and taste of fruits and vegetables, and creates product differentiation in the current dried fruit market.

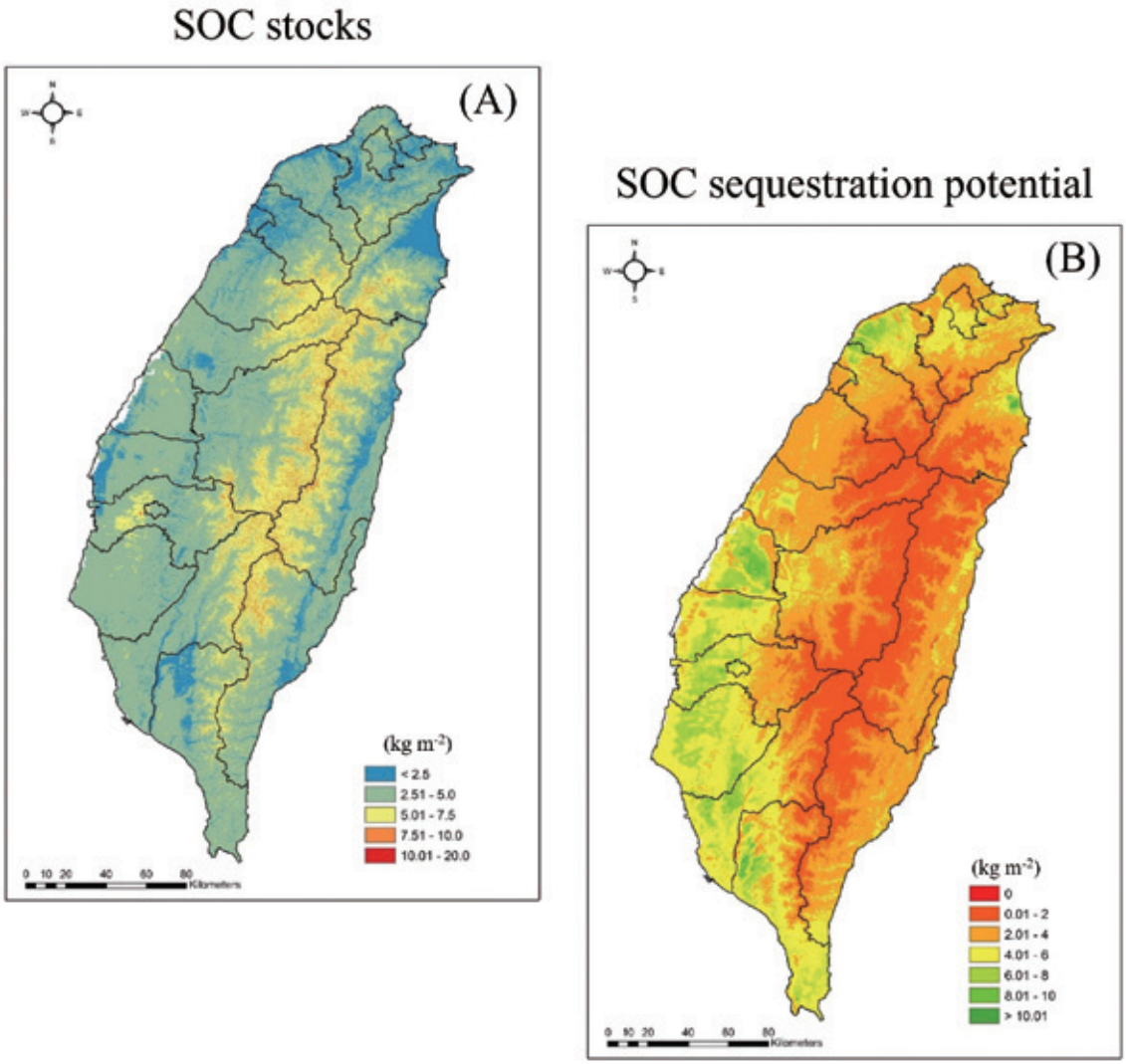


7 The application of multi-layer culture for mushroom under fan and wetted pad greenhouse in the shiitake industry

Through using of greenhouse materials and a pad and fan system, conditions of cooling in the summer and heating in the winter can be achieved, so that an environment can be created in which the temperature in summer never exceeds 28°C while that in winter never falls below 15°C, and moreover relative humidity can be controlled at 80% to 90%. This enables year-round cultivation of shiitake. It also raises the success growth rate of shiitake mycelium in sawdust bag to 95%, raising yield by 25% to 30% over traditional facilities. Cultivation of shiitake sawdust bags on vertical shelves allows for a six-fold increase in cultivation volume per unit of area, while using a separate track configuration for the mycelium -growing area and the fruiting-body formation area means the space efficiency in the fruiting area can be increased four times over, making it possible to have a ten-fold increase in the cultivation volume per unit of area.

8 AI-assisted digital soil mapping

Digital soil mapping is an approach that utilizes various soil-forming factors, including climate, parent material, topography, organisms, and time, to predict soil properties. By employing machine learning or deep learning algorithms, predictive models are established to generate maps of these soil properties. This process also allows for the representation of spatial distribution of predictive uncertainty, enabling users to clearly understand the predicted results.



9 Technology for the mass production and value-added use of mealworms

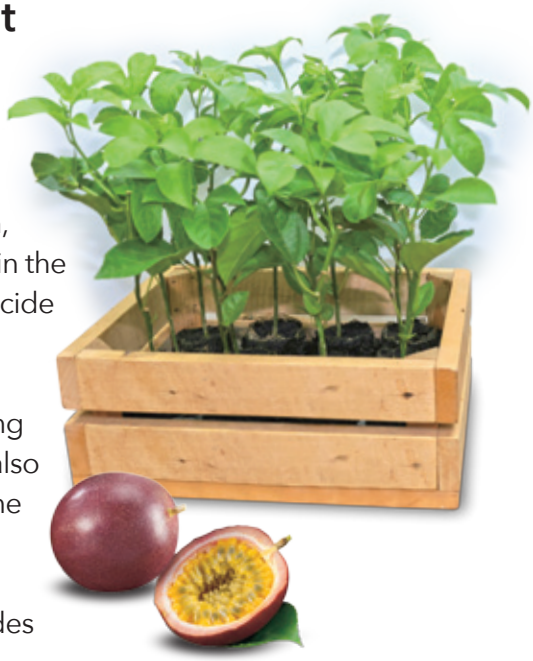
This technology plays a crucial role in minimizing variations between different batches of mealworms by controlling key parameters in mass production. It enhances the efficiency of mealworms in consuming food and converting it into protein, thereby addressing issues related to poor growth potential. Additionally, it optimizes the use of production resources and enables diversification of end products through primary and refined processing techniques. Furthermore, it facilitates the analysis of the physical and chemical characteristics of mealworm fecal matter, ultimately leading to zero waste production in insect farming.

10 Development of smart greenhouse environmental control systems using AI technology

Using the vast amount of highly accurate weather data from agricultural meteorological stations, hourly weather forecasting can be generated by AI technology from forecasting data with three-hour intervals. In combination with crop physiology and greenhouse environmental control systems, this technology puts calculations and decision-making into the cloud and uses them to develop smart greenhouse environmental control systems with AI technology. At the same time, accessing a custom-tailored grid weather forecasting data from the Central Weather Administration, it uses LSTM models to estimate the greenhouse microclimate. This model is validated with meteorological instruments in the greenhouse. The greenhouse microclimate forecasting passes through a crop photosynthesis rate model developed by a team at TARI, using the crop status as the fundamental basis of greenhouse environmental control. As a result, it serves as an example of AI applications in smart greenhouse environmental control systems.

New Services

Enhancing the production of safe fresh passion fruit by integrated pest management



Passion fruit is an important economic fruit tree in Taiwan, with about 940 hectares of land cultivated area. The production values of fresh fruit and seedlings are about NT$1.2 billion and NT$50 million, respectively. In order to address the problems arised in the continuous harvest of fresh passion fruit, such as pesticide residues, as well as emerging diseases and insect threats caused by climate change, TARI has adopted an integrated pest management (IPM) strategy. Starting from ensuring the health of seedlings, this approach also introduces eco-friendly prevention products during the cultivation period in the fields and uses non-chemical synthetic pesticides, in order to achieve the following goals: (1) Reducing (or eliminating) the use of pesticides while effectively managing diseases and pests in the fields; (2) Ensuring the production of safe and high-quality fresh fruit and making value-added use of the entire passion fruit; (3) Promoting the sustainable development of Taiwan's passion fruit industry.

An integrated services platform for flower growth monitoring and control and production-and-marketing information

In order to enhance the competitiveness of Taiwan's export flower industry, TARI has developed various data systems to establish an integrated production-and-marketing intelligence network. This network provides information on crucial flower diseases, records of cultivation environments, and statistical data on flower production and marketing. Integrated with an industrial application model, the system ensures that companies have comprehensive insights into data spanning from production to sales, thereby strengthening their planning capabilities. Within this platform, the production-and-marketing information systems automatically collect data from Taiwan's most important flower export market—Japan—including the announced prices and sales volumes of wholesale flower markets in that country. Furthermore, the platform transforms complex production-and-marketing data into graphs and images. It also gathers data on the sales volume and prices of flower exports from Taiwan to Japan and the US and also offers analysis of the composition and trends in Japan's flower import market. The construction of this production-and-marketing intelligence service transforms vast amounts of data into easily comprehensible forms, enabling the entire flower industry to have a firm grasp of commercial conditions and adapt to changes in international markets as rapidly as possible.

Feature Story

Cultivation with Constant Moisture Maintaining and Dr. Geng-Peng Chang

Nutrients and moisture play crucial roles in plant growth, with both being essential management considerations in crop cultivation. When it comes to soil moisture management, it is important to maintain sufficient levels of dissolved oxygen in crop root systems. By providing sufficient moisture to crop root systems and ensuring the appropriate nutrient content and element ratio, higher production volumes can be achieved. Dr. Geng-Peng Chang, a crop nutrition management expert at TARI, refers to this approach as "cultivation with constant moisture maintenance."

After graduating from the Graduate Institute of Agricultural Chemistry at National Taiwan University in 1982, Dr. Chang joined TARI's Agricultural Chemistry Division in 1984. He specialized in plant nutrition and fertilized cultivation management, conducting experimental research in nutrient solution cultivation and fertilized cultivation management for various economic crops. Concurrently, he frequently visited production areas to understand the challenges faced by farmers in crop nutritional management. Through observation, visits, and field trials, he built a strong foundation in practical crop nutritional management. Dr. Chang's pragmatic personality, coupled with his research passion, enabled him to lead teams in solving practical problems

for farmers on-site, assisting with crops ranging from fruit trees and vegetables to flowers and specialty crops, wherever farmers required assistance.

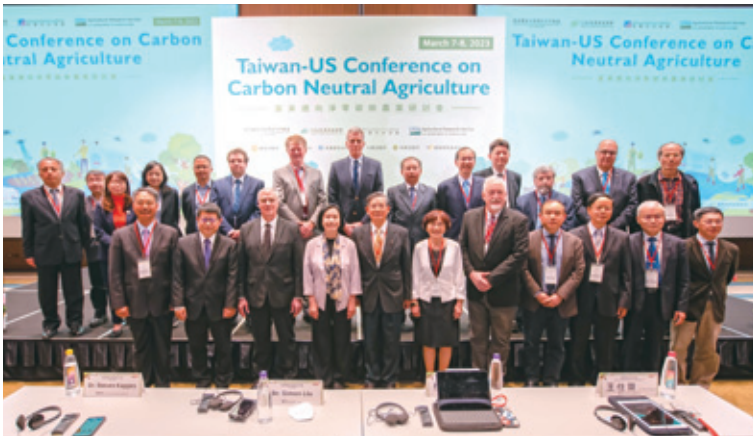
The main objective of the "cultivation with constant moisture maintenance" technology is to enhance the root systems' ability to efficiently absorb water and optimize nutrient utilization under consistently moist conditions. This approach aims to improve both the quantity and quality of crop production. A sufficient dissolved oxygen level is an important prerequisite to constant moisture management. For example, hydroponic cultivation requires various power-driven methods to dissolve oxygen in the air into the water. Cultivators use peat moss as a medium and limit the depth of the planting trough to 10 centimeters or less. They drain excess water by gravity to sustain stable moisture levels and a high dissolved oxygen content within the medium. For those who cultivate in soil, qualitative and quantitative standards of moisture content have been established for adjustment.

Based on Dr. Chang's field cultivation experience, the incidence of soil diseases is less severe when using cultivation with constant moisture maintenance compared to those with drastic changes in moisture management. However, when the spatial environment is very humid, such as in the evening or when transpiration conditions are poor, cultivators should reduce or halt watering altogether to avoid severe aboveground diseases that can be caused by highly humid environments.

Before retiring, Dr. Chang compiled his practical experiences and what he had learned from nearly 40 years of experimental research into a book. This book can serve as a valuable reference for farmers and is a gratifying record of his career in public service.

International and Academic Cooperation

TARI's international cooperation work involves collaborating with the Ministry of Agriculture to hold bilateral conferences or sign cooperation agreements in order to conduct technical exchanges and cooperation with overseas academic and research institutions. In 2023 TARI also worked with the Food and Fertilizer Technology Center for the Asian and Pacific Region to hold two conferences, one on tropical fruit and the other on low-carbon agricultural development for small farmers in the Asia-Pacific region. TARI also sent 15 researchers to France in August to attend the 12th International Congress of Plant Pathology, where they gave one talk and presented 15 posters; worked with the US Department of Agriculture to hold three conferences and one training class; and joined the AIM for Climate initiative, led by the US and the United Arab Emirates, as a "knowledge partner" in March, attending the AIM for Climate Summit in the US in May. TARI also participated in the 28th Conference of the Parties to the United Nations Framework Convention on Climate Change (UNFCCC COP28) and "4 per 1000 Initiative Day."

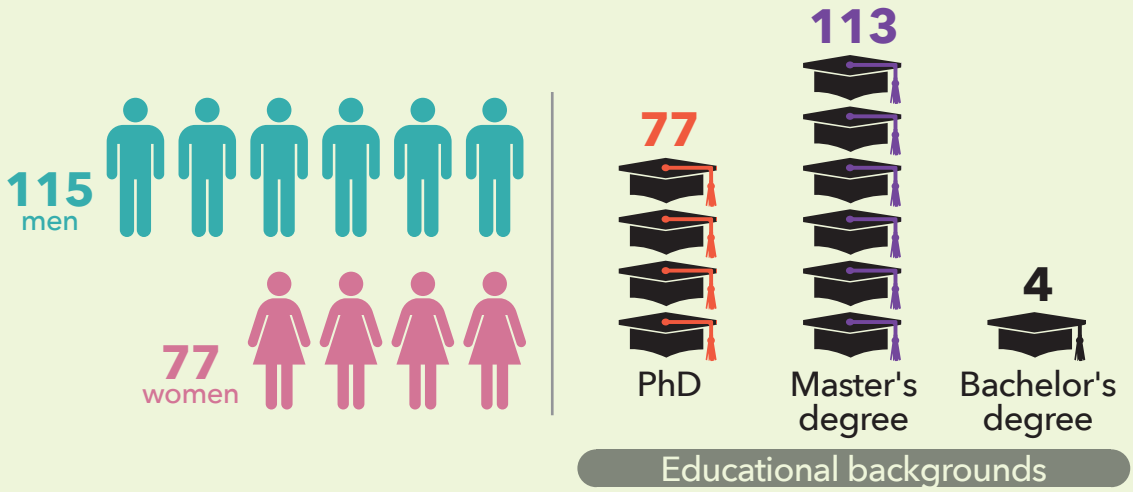


TARI also engages in academic cooperation with universities in Taiwan, including National Taiwan University, National Chung Hsing University, and National Yang Ming Chiao Tung University. Researchers from collaborating parties do joint R&D work on issues of agricultural or forward-looking concern. Examples include analysis of tricetin in brown planthopper-resistant rice germplasm the population parameter of white pupal strains for the melon fly at different temperatures, use of portable surface plasmon resonance technology to undertake rapid and accurate testing for the pesticides chlorfenapyr and difenoconazole, and a study of a pre-processing procedure for establishing tea leaf sample quality through field testing. These collaborative projects have yielded significant findings.

Resource Introduction of TARI

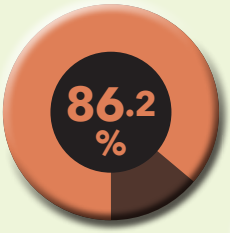
Human Resources

In 2023, our research and development team consisted of 192 persons.

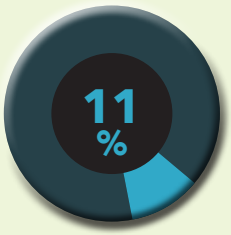


$ Budget

In 2023, the total amount was NT$1.45 billion.



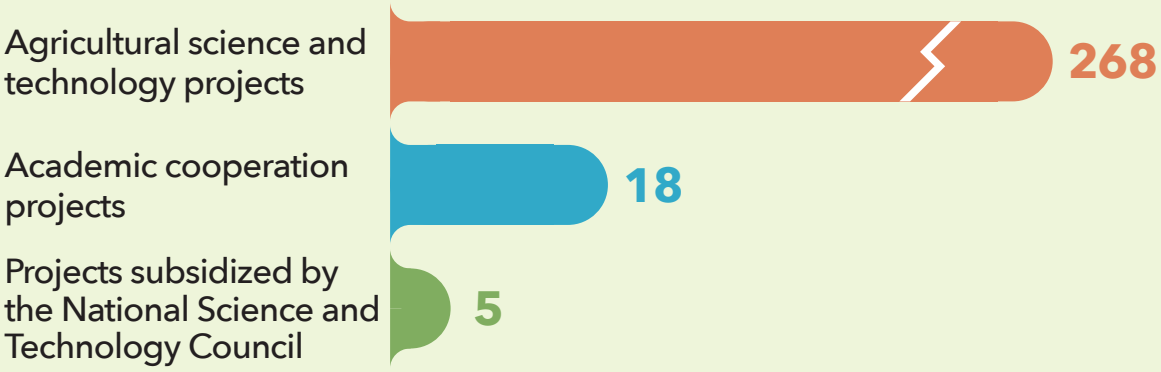
NT$1.25 billion from the government budget



NT$160 million from commissioned experimental research

NT$40 million for subsidized projects from the National Science and Technology Council

Number of Research Projects



Performance of the Innovation Incubation Center

- **4** Newly signed enterprises
- Guiding **9** enterprises
- Facilitated **2** companies to invest over $4 million
- Increased employment to 16 people at **15** enterprises

Important Academic Publications