臺日茶產業智慧應用趨勢研討會暨第七屆臺茶葉技術交流會

茶樹栽培管理專家診斷系統的建立

中興大學農藝學系 郭寶錚

2025/07/29

地點:臺灣客家茶文化館

Development of Expert Diagnosis System for Tea Cultivation Management

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Topics

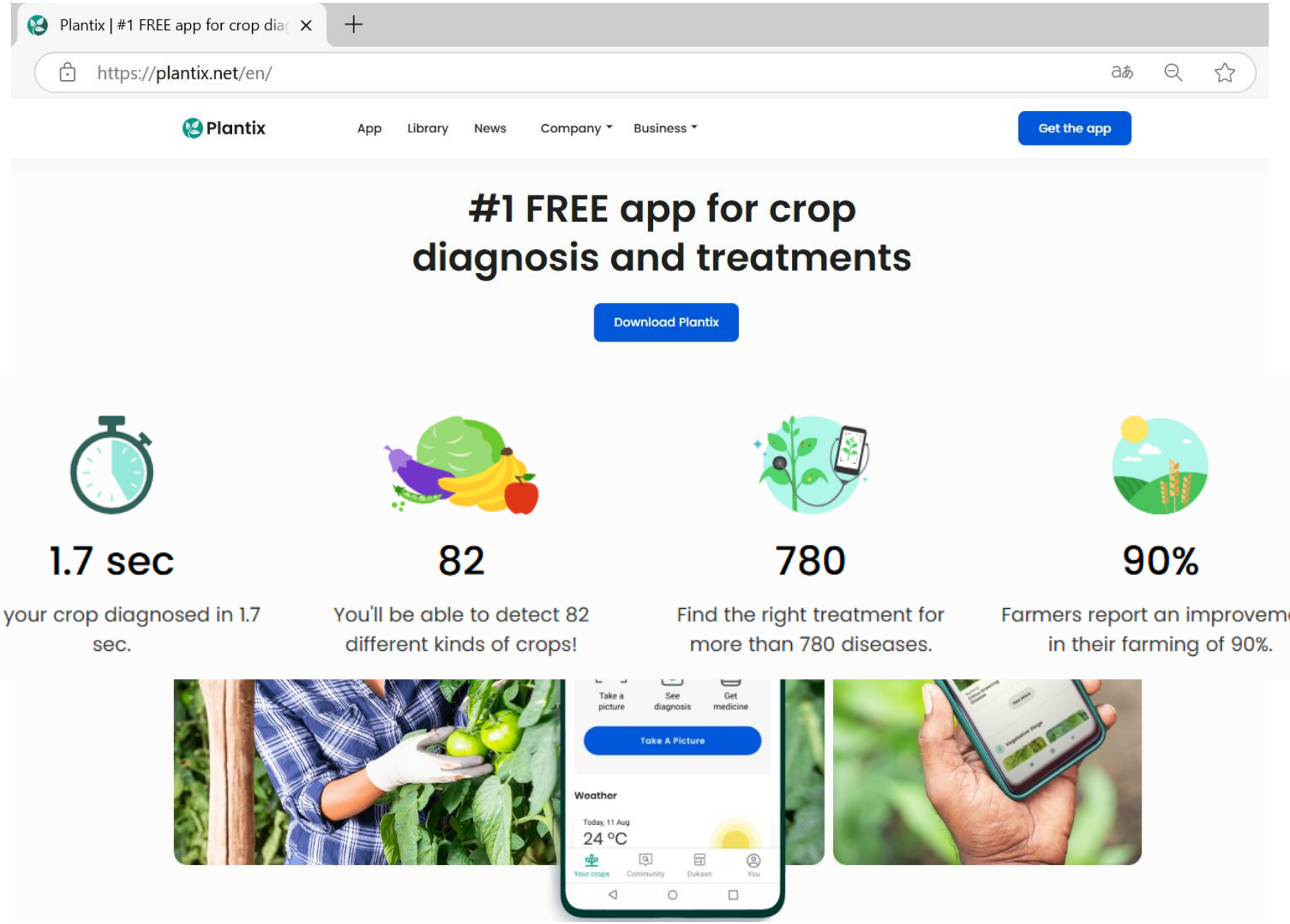
- Related Background
- System Development Goals
- System Architecture and Important Concepts
- Concluding Remarks

Factors Affecting Tea Production

- **Biotic**

  Diseases, Pests, Weeds, …
- **Abiotic**
  - **Soil (pH, compaction, moisture, salinity, …)**
  - **Nutrients (deficiency, overdose/toxicity)**
  - **Climate (light, temperature, humidity, rainfall, …)**
  - **Management (genetic, planting density, fertilization, irrigation & pruning practices, pest management, …)**
  - **…**

Plantix https://plantix.net/en/



https://plantix.net/en/library/plant-diseases/700002/potassium-deficiency/

What caused it?

Root Development?

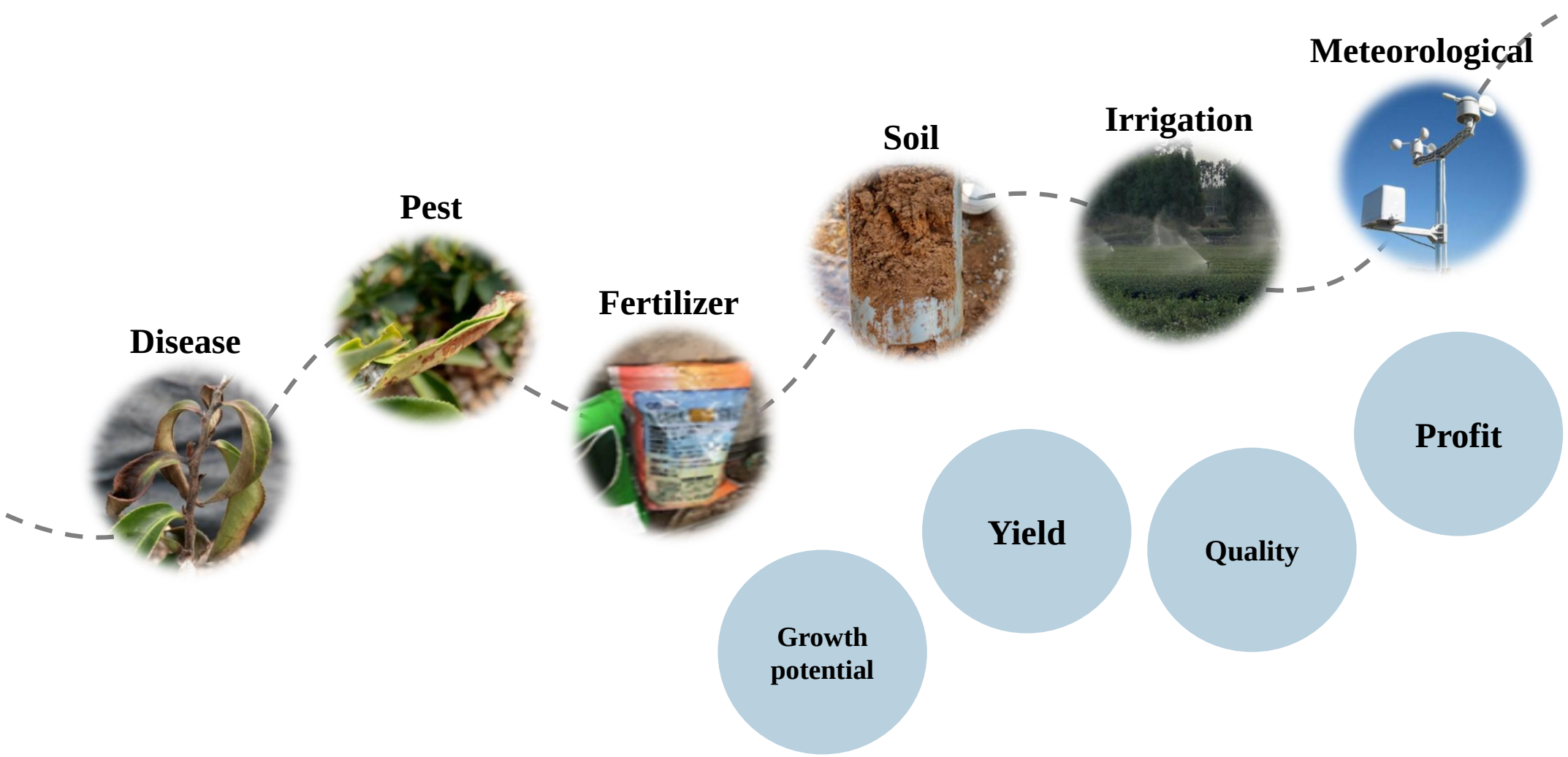
Deficiencies may occur because of low reserves of potassium in the soil or limited availability to the plant. Soils with low pH and sandy or light soils with little organic content are prone to nutrient leaching and drought, and may, therefore, cause problems. Heavy irrigation and high rainfall wash the nutrients from the root zone and can also lead to deficiency. Hot temperatures or drought conditions block the transport of water and nutrients to the plants. High levels of phosphorus, magnesium, and iron can also compete with potassium.

Potassium plays an essential role in the transport of water, the firmness of tissues and the exchange of gases with the atmosphere. The symptoms of potassium deficiency are irreversible, even if potassium is later added to the plants.

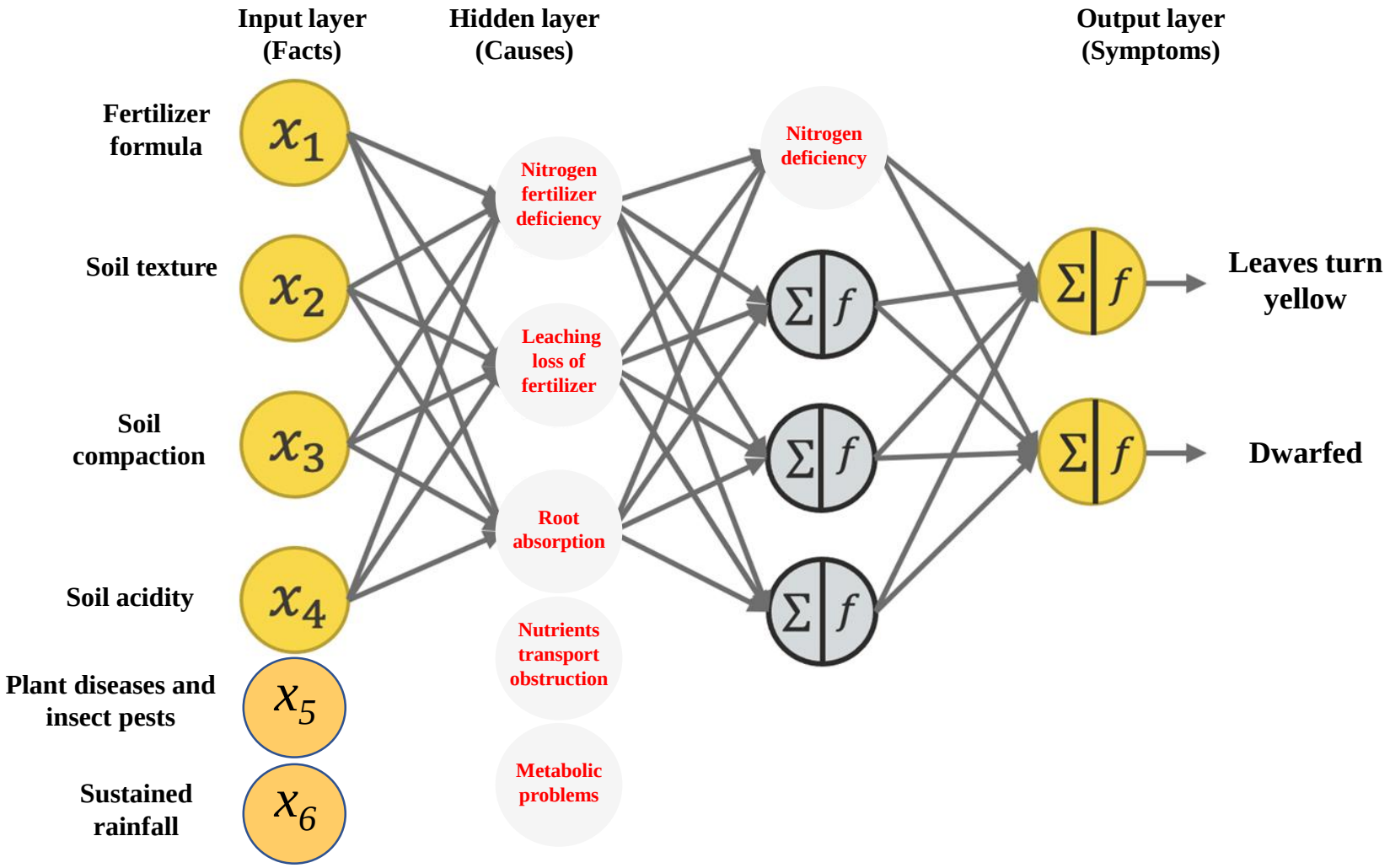
Development Goals

- Expert Expertise?
- Expert Availability?
- Expertise Preservation?
- New Experts Training?

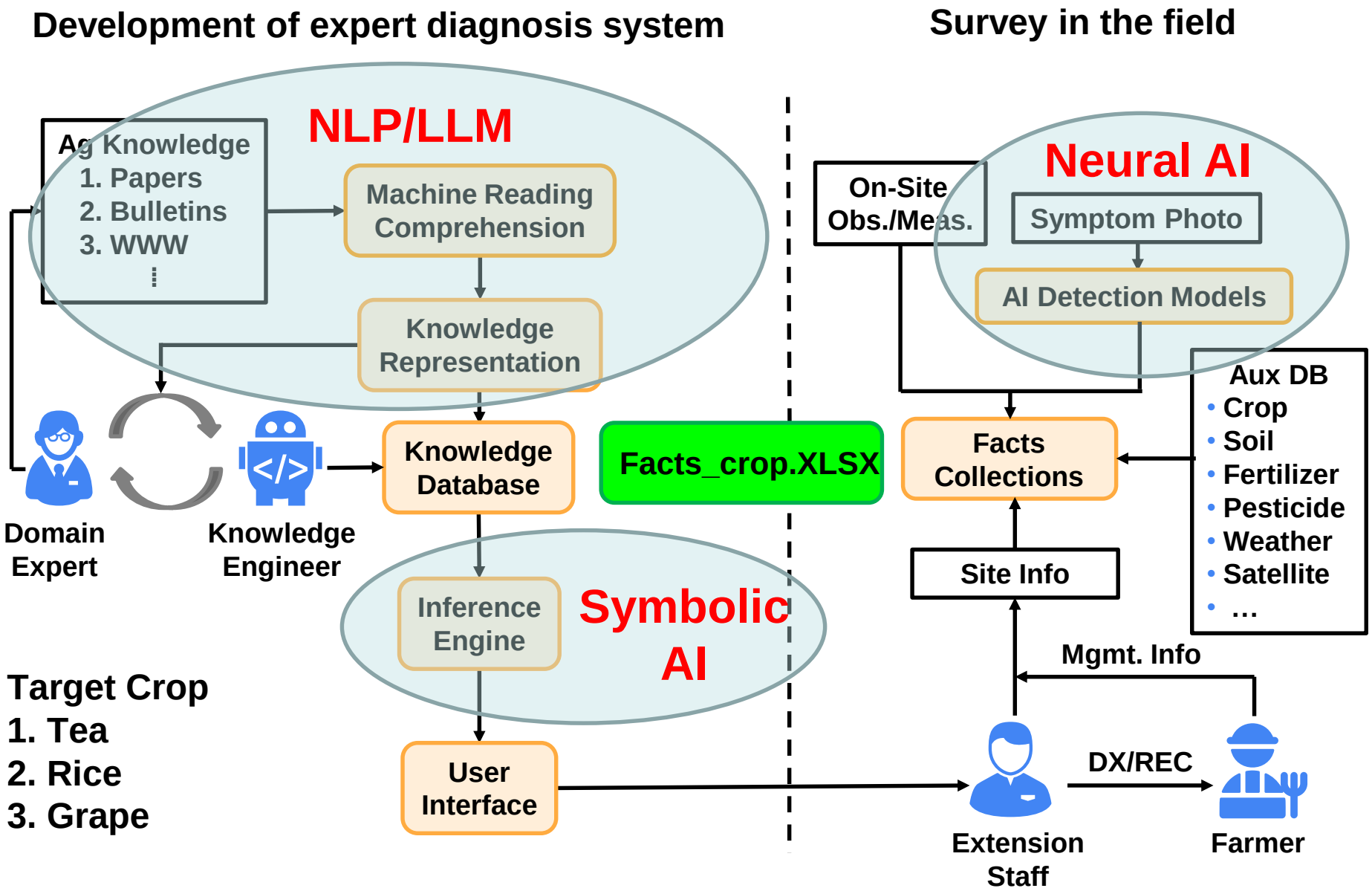
Factors That Affect Tea Growth



Main ideas about our system



System Architecture



Rule Based ES

Diagnosis Rule

IF (Symptom) THEN (Potential Problem), CF

Recommendation Rule

IF (Potential Problem) THEN (Recommendation), CF

Fuzzy Logic

AND : MIN()

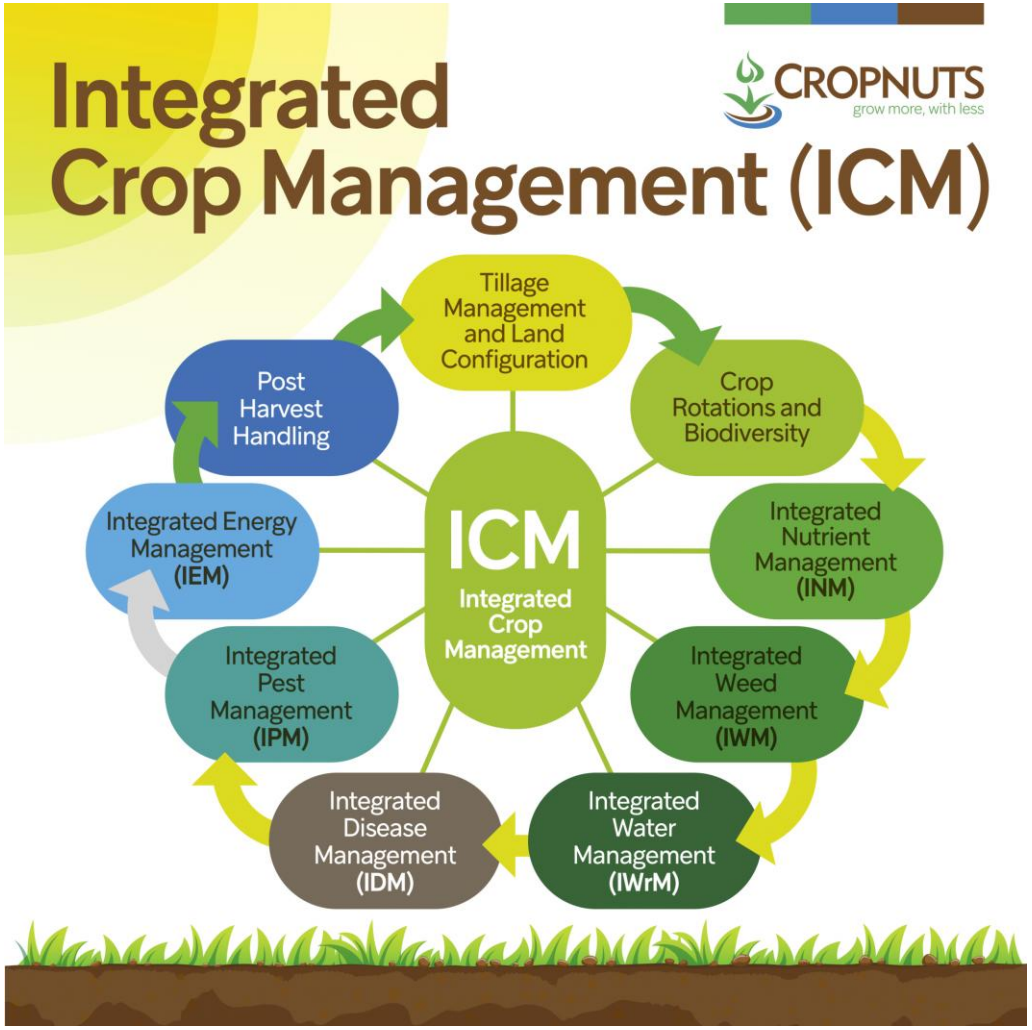
OR : MAX()

Diagnosis Domains

Domain	Source
Variety	Farmer Crop DB
Cultivation	Farmer Surveyor
Weather	Weather DB
Nutrients Diseases Pests Weeds	Neural AI Diag. Keys
Other ● Yield ● Spatial Temporal Variation	Farmer Satellite UAV
Fertilizer Pesticide	Farmer Fertilizer DB Pesticide DB
Soil	Soil Testing Soil DB

Recommendation Domains

- Variety Choice
- Soil Mgmt.
- Fertilization
- Cultivation
- Disease/Pest Mgmt.
  - Chem-Control
  - Phys-Control
  - Bio-Control
- Weed Mgmt.
- Meteorol. Disaster Prot.



https://cropnuts.com/

ES5

Vecteezy.com

uxwing

2021/11-2023/11

2023/12

Abilities Already Possessed

- Powerful computing power and memory capacity

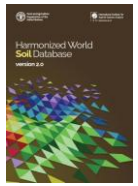
- Visual ability to identify crop symptoms

Plantix
+
AI Models
Developed

- Know crop characteristics

- Know local soil properties

農業部
農業試驗所
Taiwan Agricultural Research Institute, Ministry of Agriculture



Harmonized World Soil Database version 2.0

- Know brands and ingredients of local fertilizers/pesticides

農業部農糧署
AGRICULTURE AND FOOD AGENCY, MINISTRY OF AGRICULTURE

農業部動植物防疫檢疫署
ANIMAL AND PLANT HEALTH INSPECTION AGENCY MINISTRY OF AGRICULTURE

- Know local weather and climate

氣象資料開放平臺
OPEN DATA

OpenMeteo

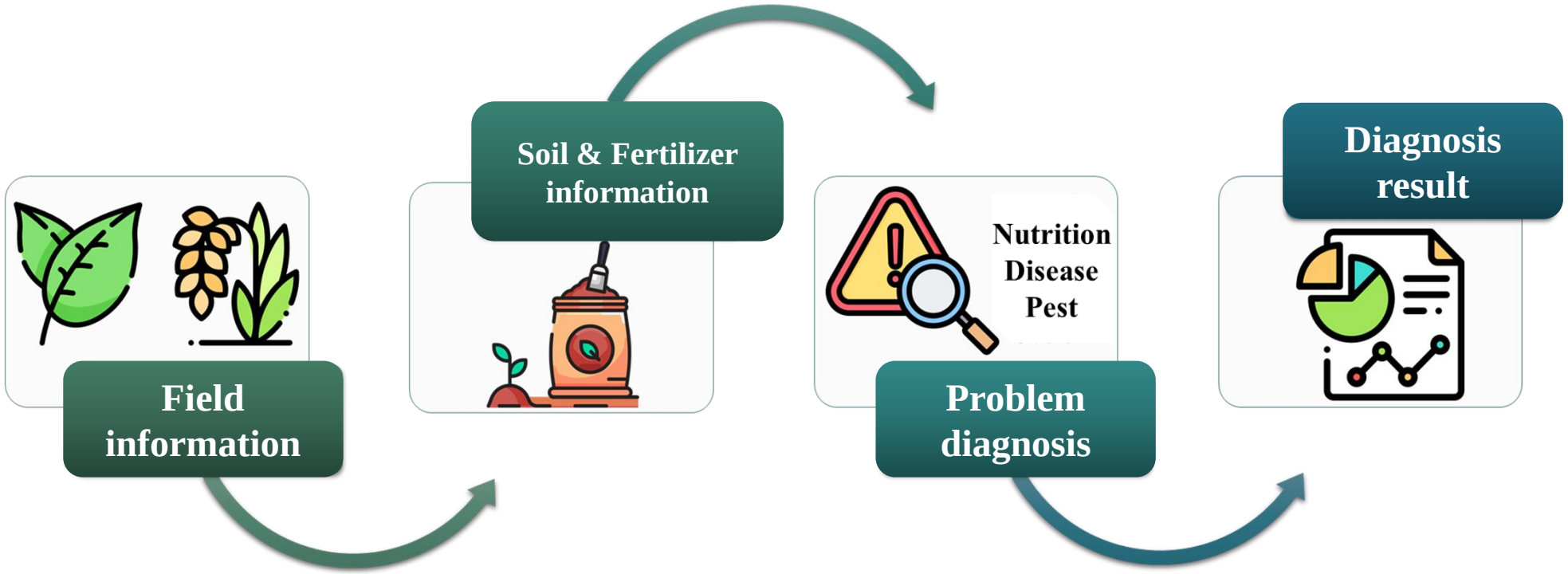
NCEI

Global Historical Climatology Network daily (GHCNd)

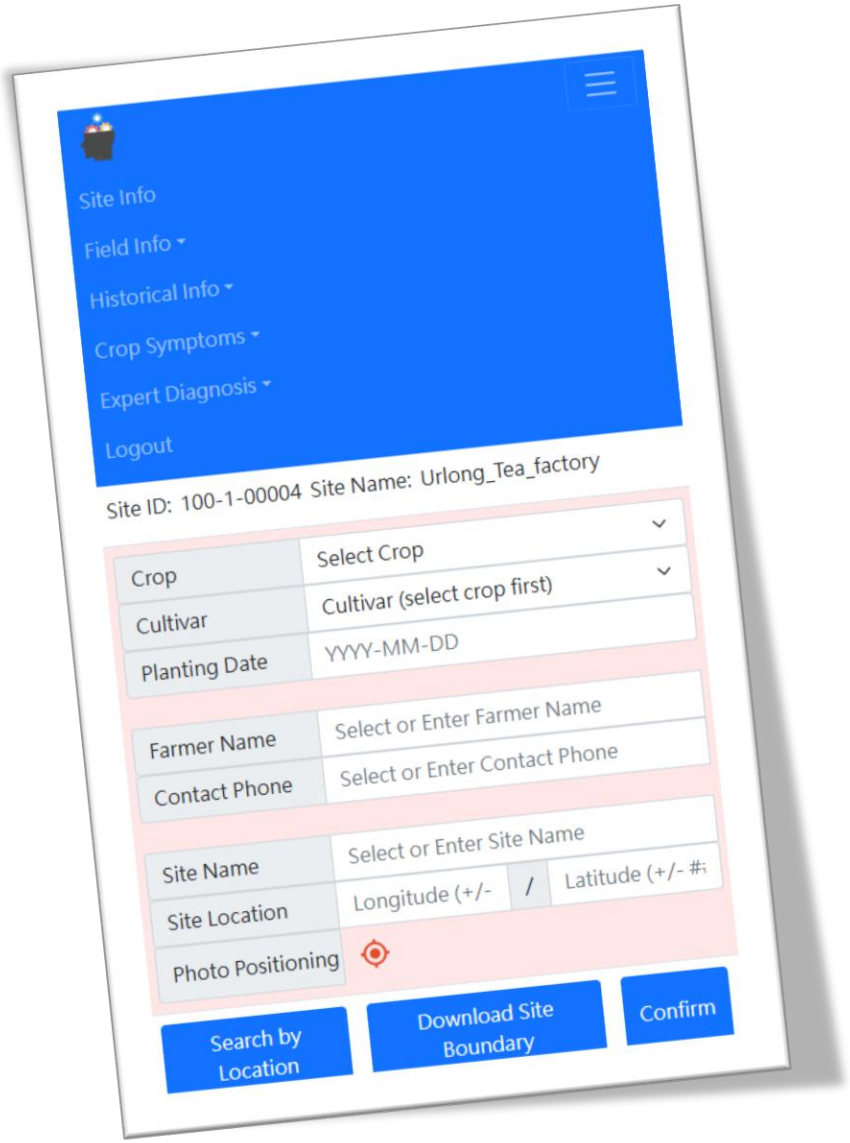
- Know spatial temporal variation of crop status

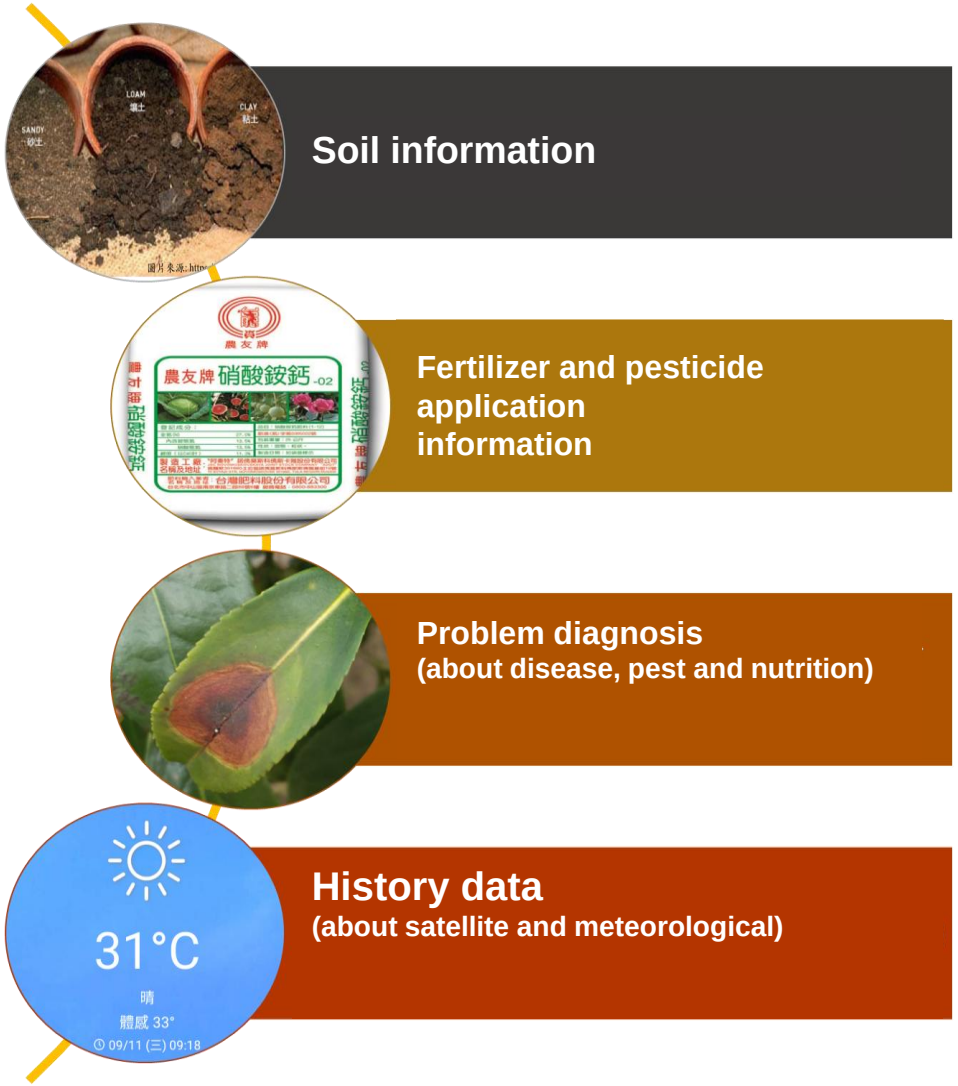
- Can communicate in multiple languages

System Diagnosis Process

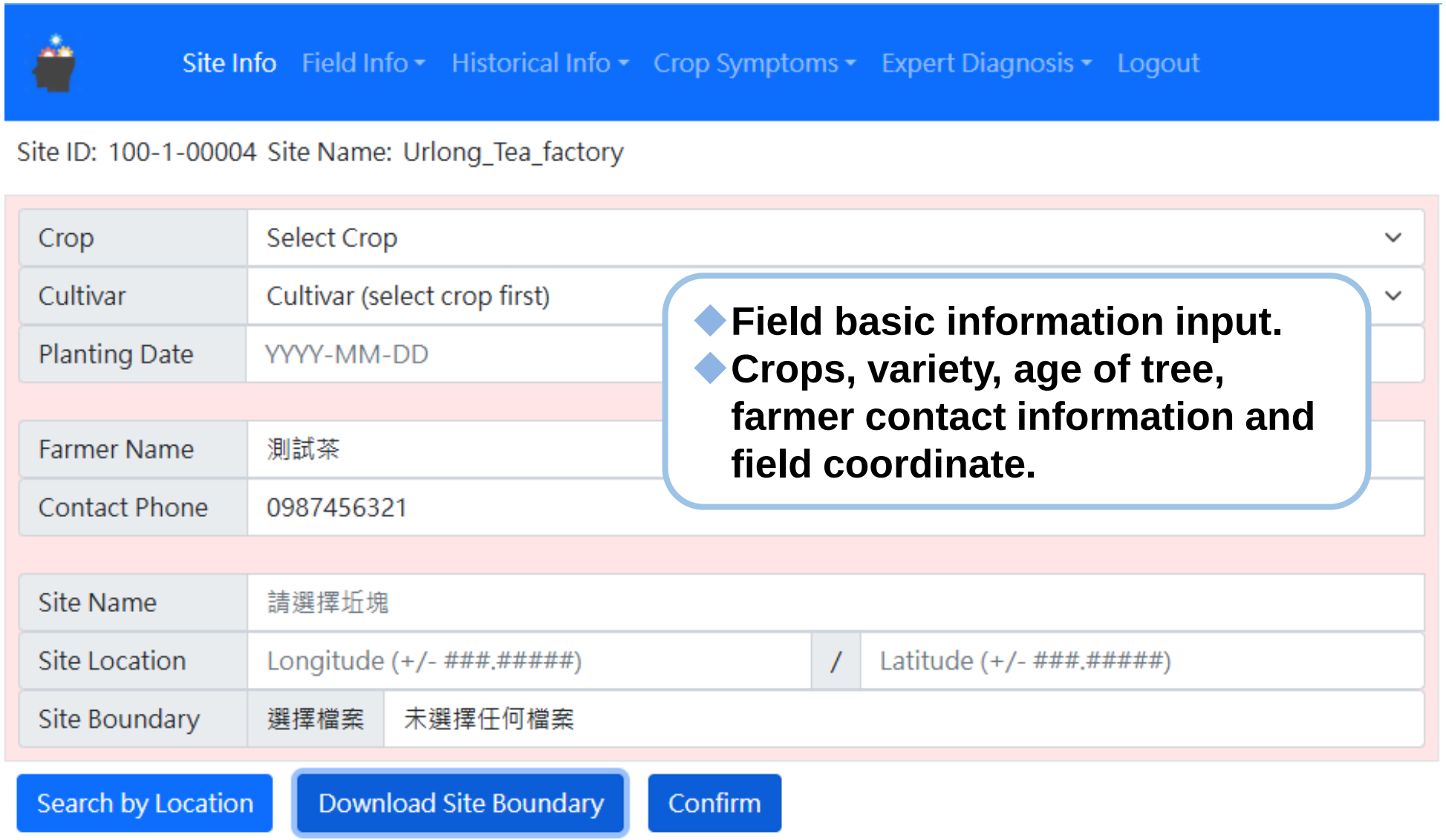


System Display (web page)



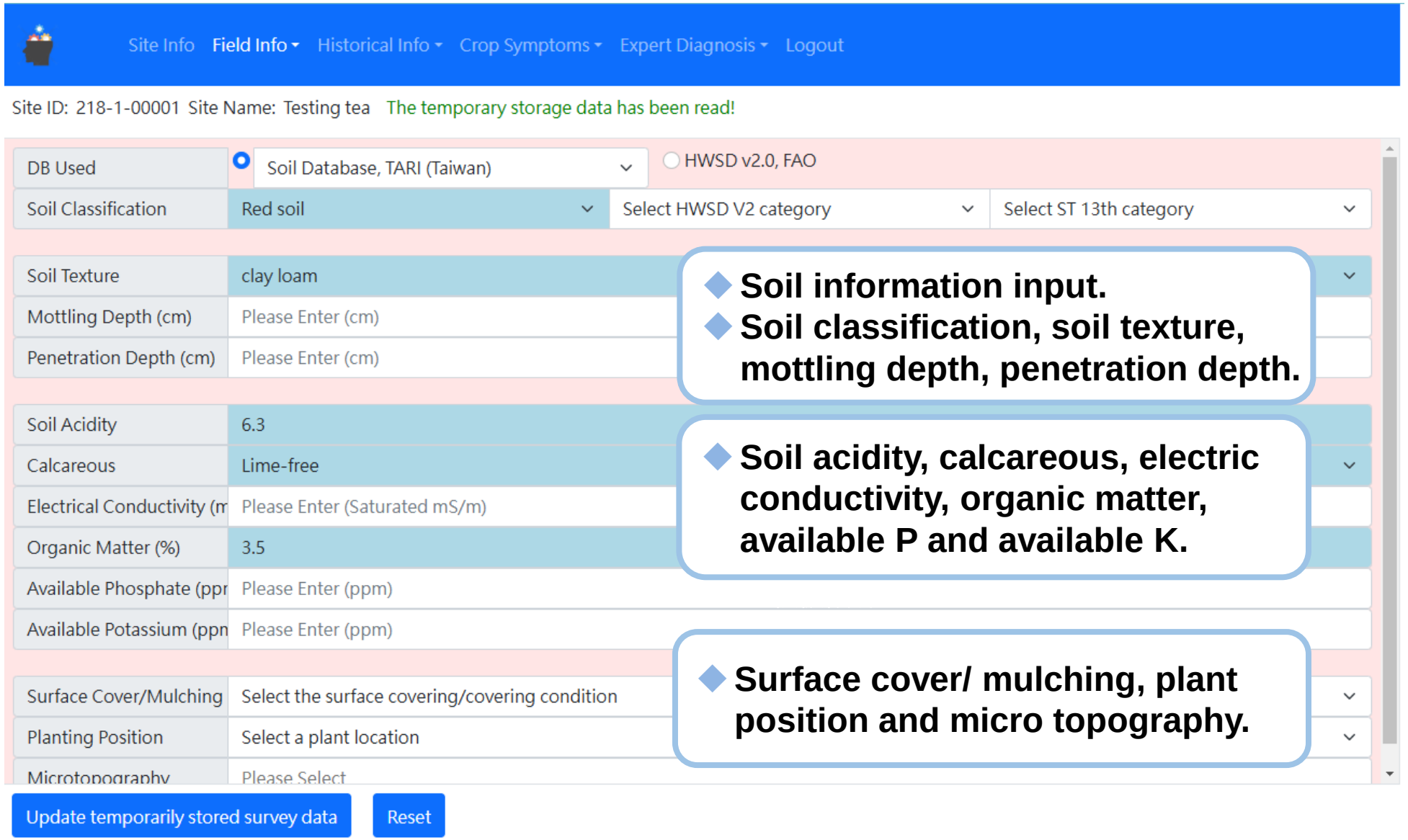


Field Information



- **Field basic information input.**
- **Crops, variety, age of tree, farmer contact information and field coordinate.**

Soil Information



- Soil information input.
- Soil classification, soil texture, mottling depth, penetration depth.

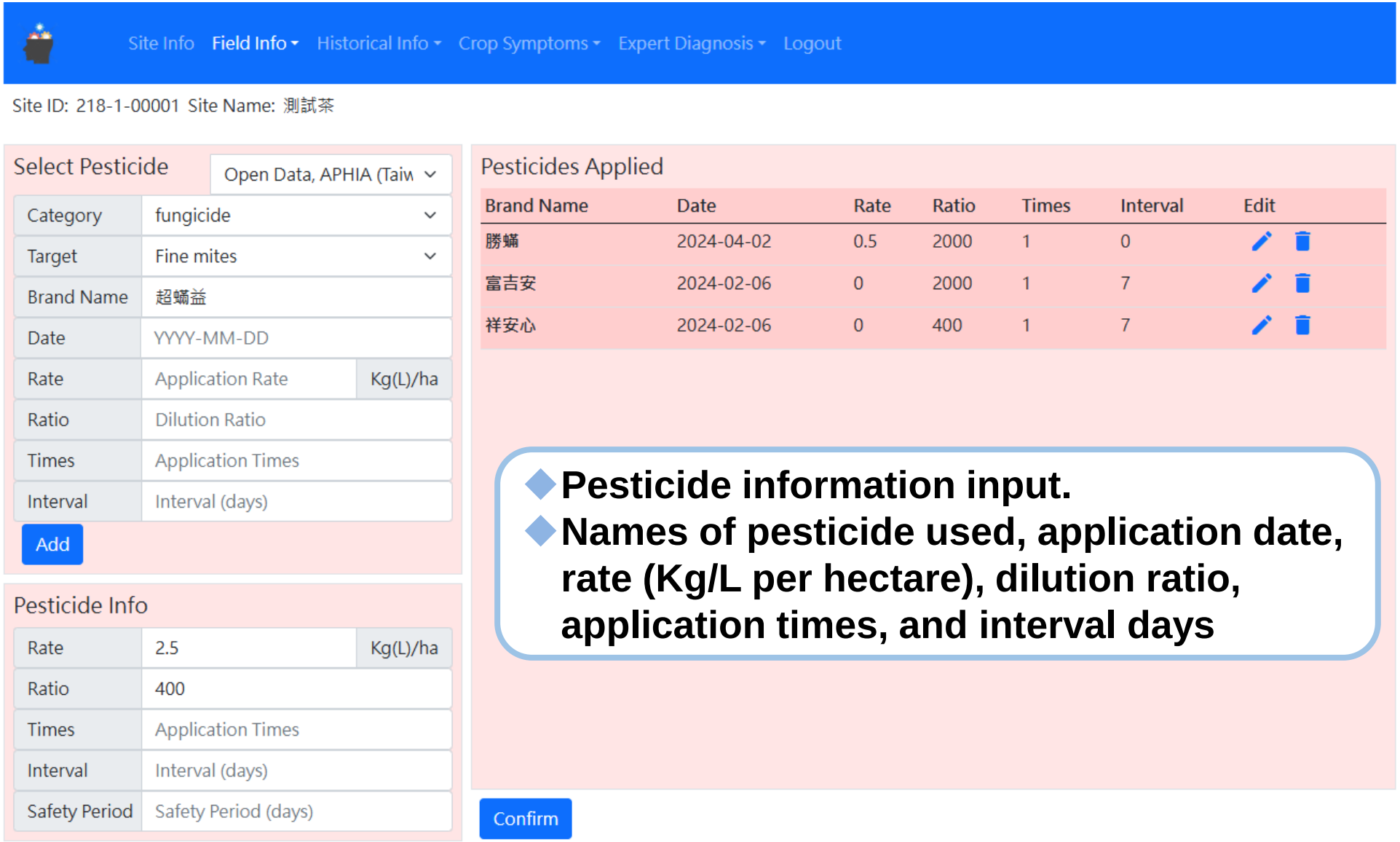
- Soil acidity, calcareous, electric conductivity, organic matter, available P and available K.

- Surface cover/ mulching, plant position and micro topography.

Fertilizer Application Information

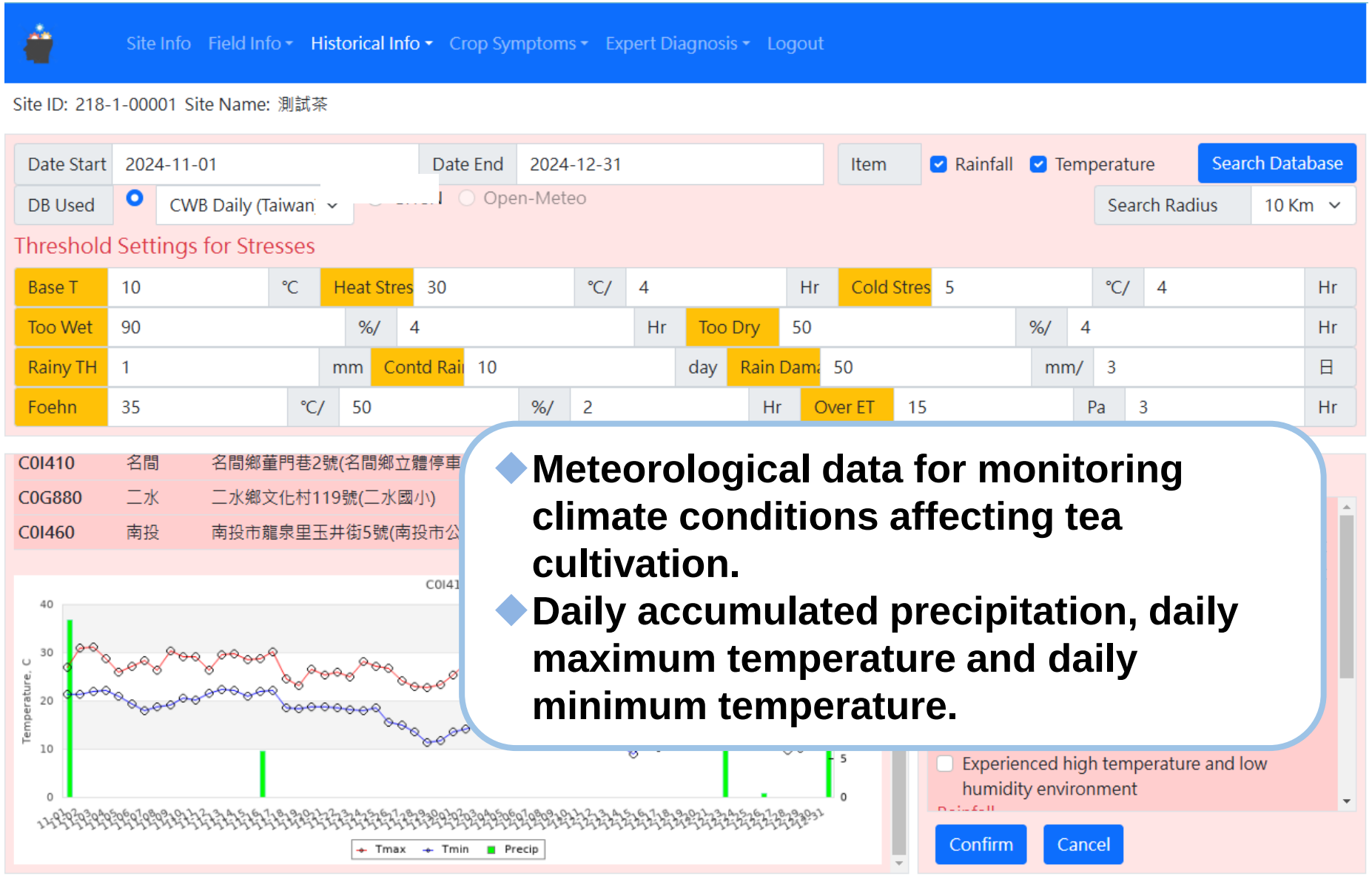
- **Fertilizer information input.**
- **Names of fertilizers used, rate (Kg/ha), timing, and application method**

Pesticide Application Information



- **Pesticide information input.**
- **Names of pesticide used, application date, rate (Kg/L per hectare), dilution ratio, application times, and interval days**

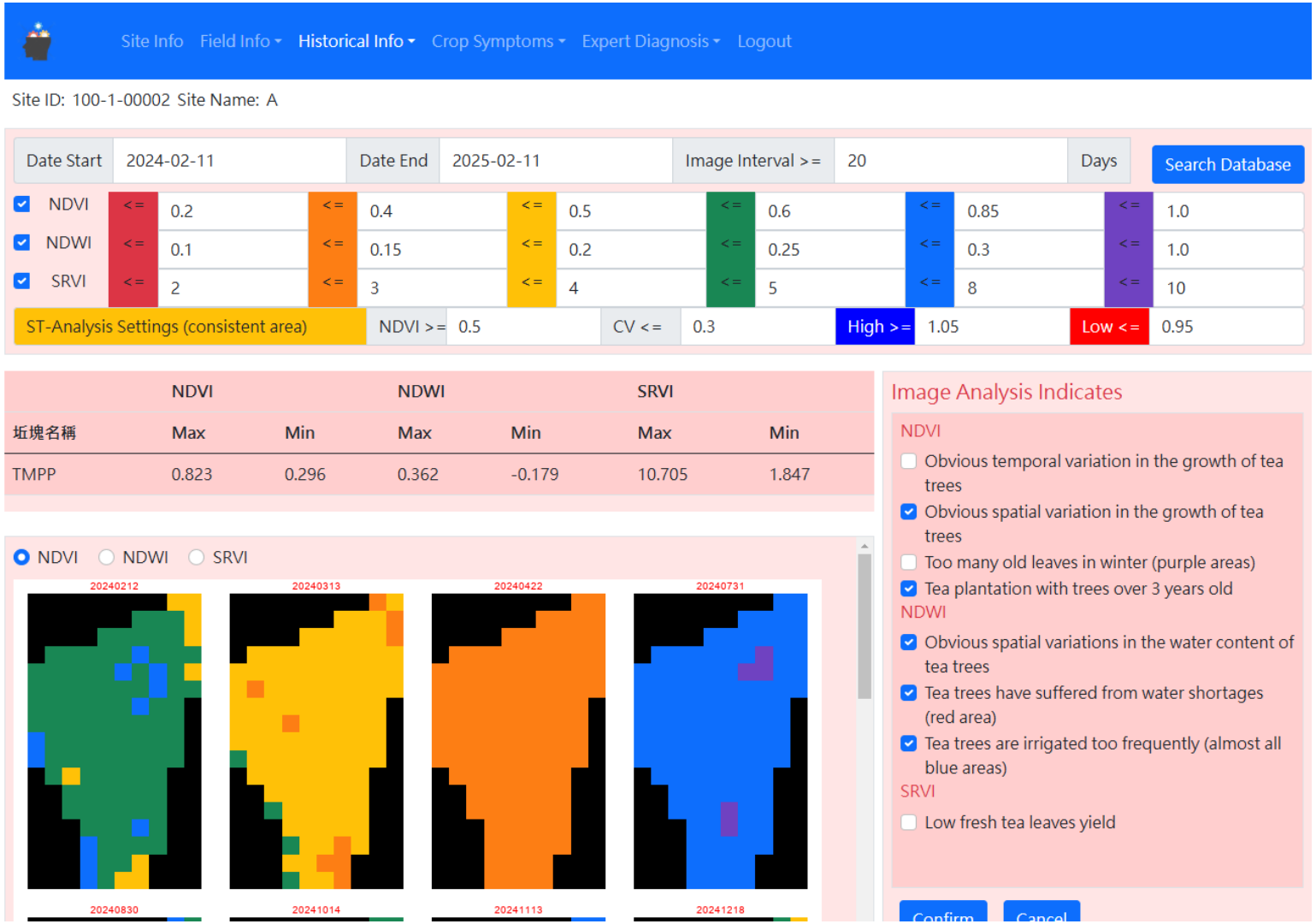
Observation of Meteorological Data



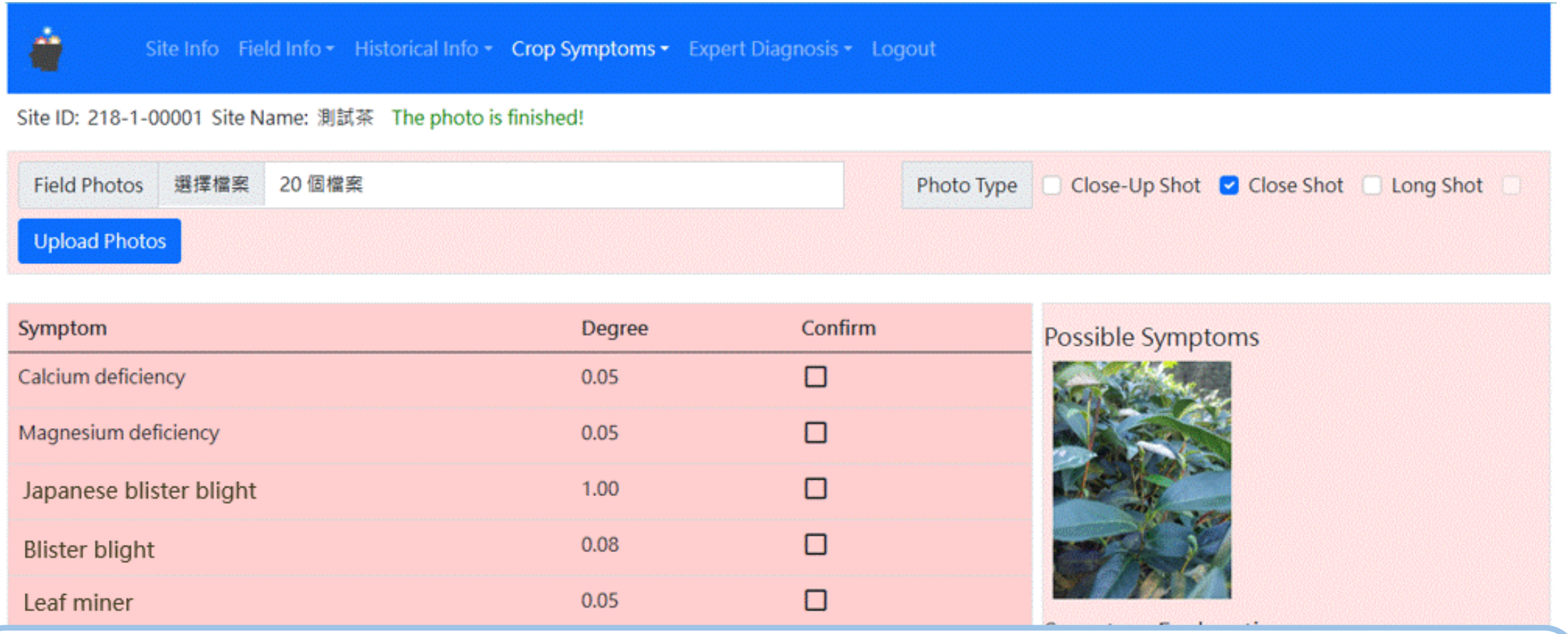
- Meteorological data for monitoring climate conditions affecting tea cultivation.
- Daily accumulated precipitation, daily maximum temperature and daily minimum temperature.

Observation of Satellite Data

- Draw the changes of NDVI and NDWI under different time and space.
- NDVI: Normalized difference vegetation Index
- NDWI: Normalized difference water index

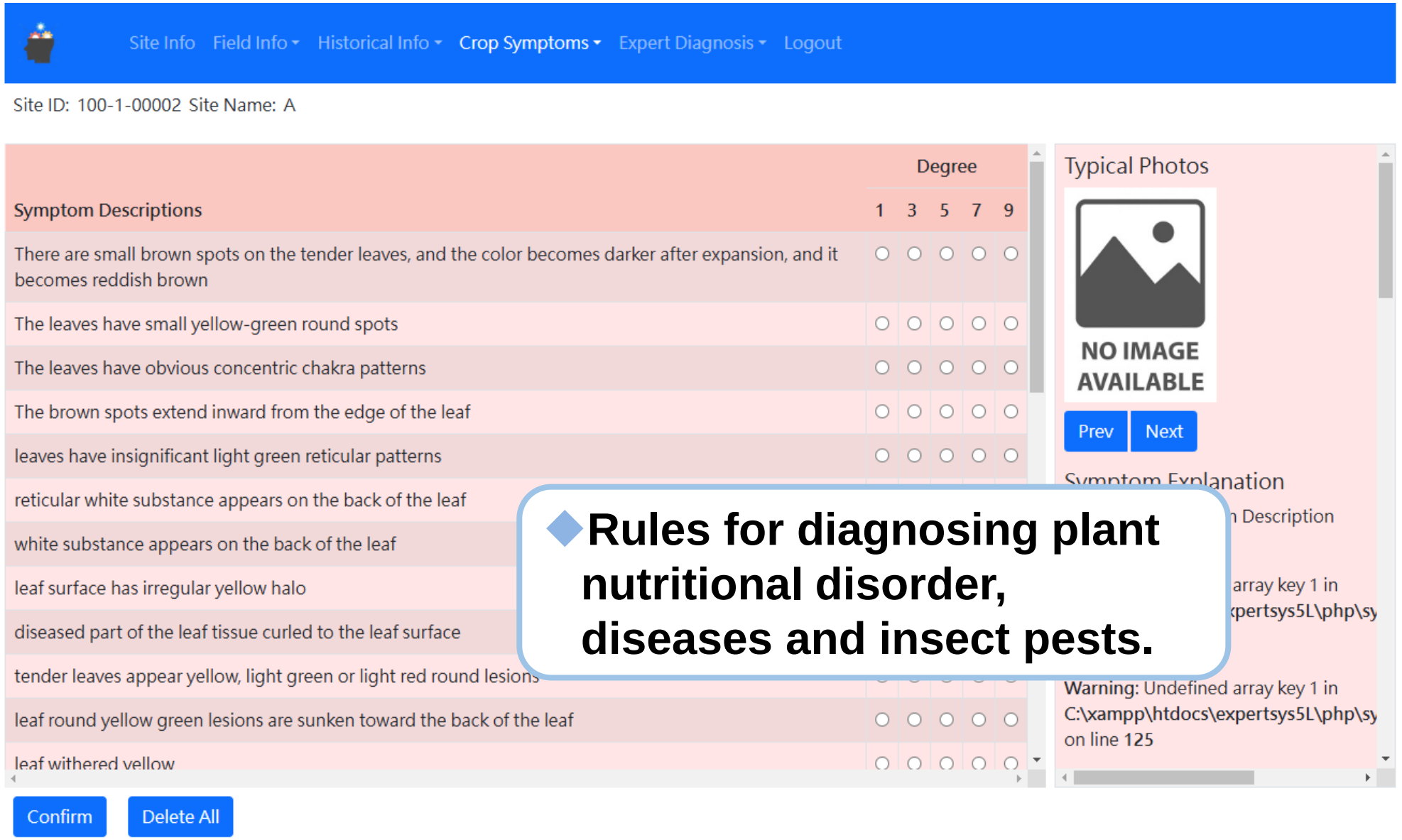


AI Recognition Model



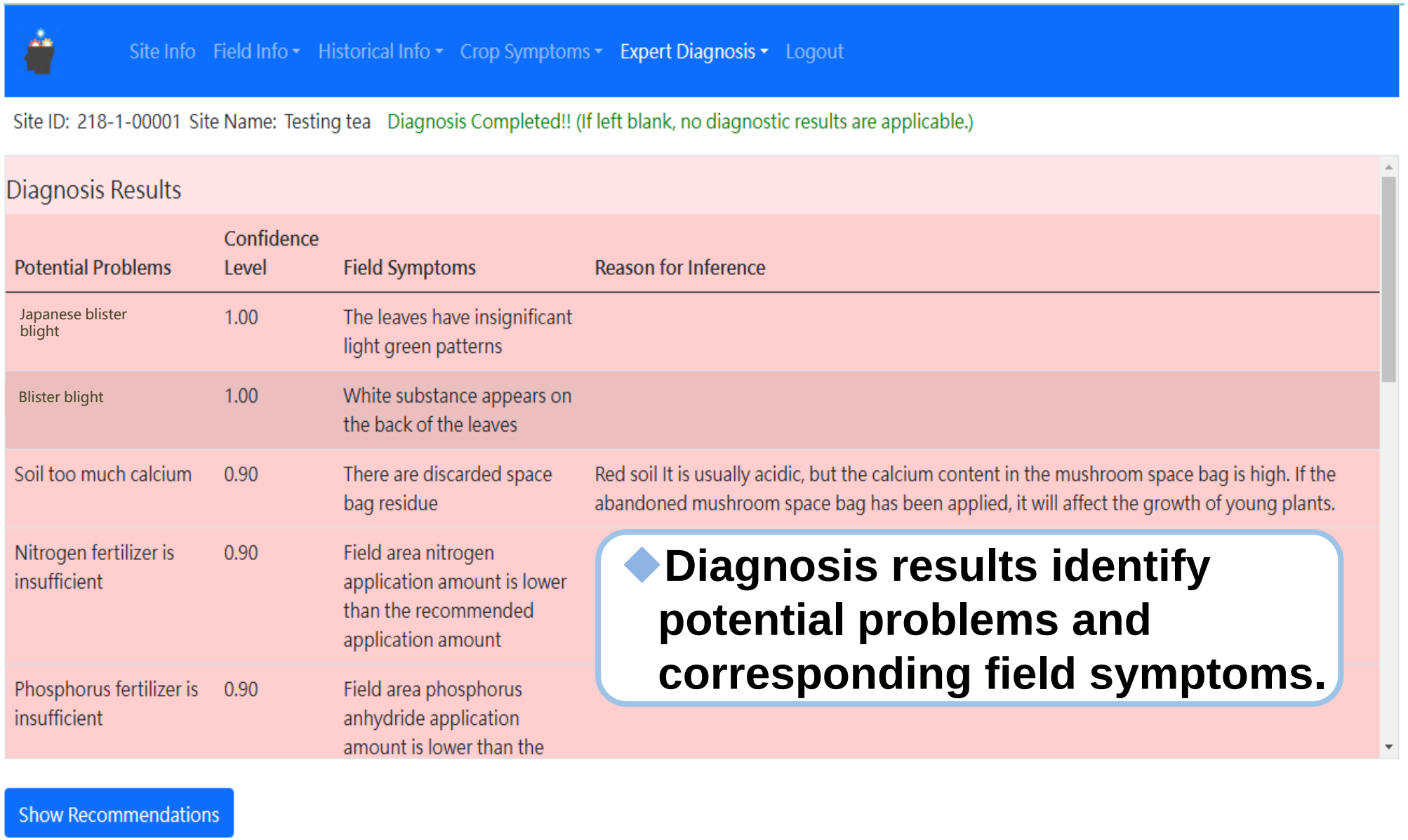
- Uses AI analysis to detect possible symptoms in tea leaves.
- Displays predicted symptoms with confidence scores for user verification

Problem Diagnosis



- **Rules for diagnosing plant nutritional disorder, diseases and insect pests.**

Output Diagnostic Results



- **Diagnosis results identify potential problems and corresponding field symptoms.**

Suggested Actions for Plant Health Improvement

Site Info | Field Info | Historical Info | Crop Symptoms | Expert Diagnosis | Logout

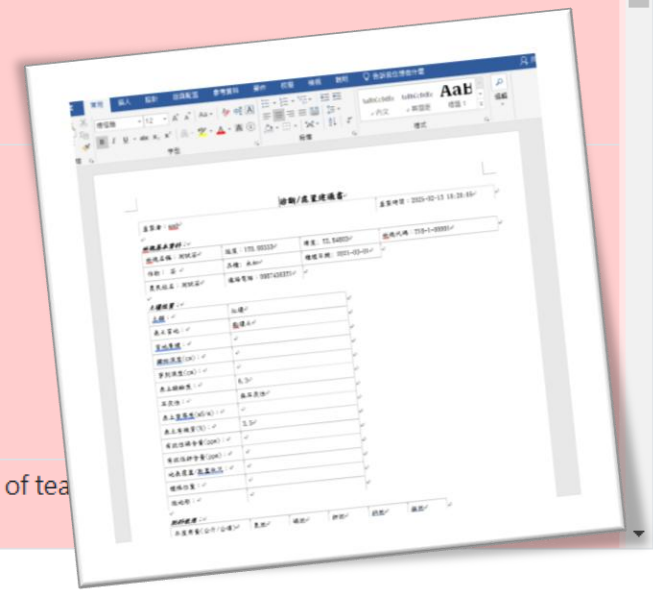
Site ID: 218-1-00001 Site Name: Testing tea

Improvement Recommendations

Problems Dealt	Practices Recommended	Confidence Level
Netcake disease	Plant disease resistant varieties, such as Qingxin Dawu, Taicha No. 13, etc., do not plant the disease-sensitive varieties Qingxin Wulong.	1.00
(Red leaf blight, cake disease, round spot disease, soot disease, algae)	Reduce the humidity in the tea garden.	1.00
(Red leaf blight, cake disease, round spot disease, soot disease, algae spot disease, algae, branch blight)	Cle... ...field.	
(Red leaf blight, cake disease,	Reference Plant Protection Information System (https://otserv2.tactri.gov.tw/PPM/), content of tea... Perform the medicine.	

Download Diagnostic Report

- **After the diagnosis, users can download the report.**



India Field Verification

Location: Shillong, Meghalaya

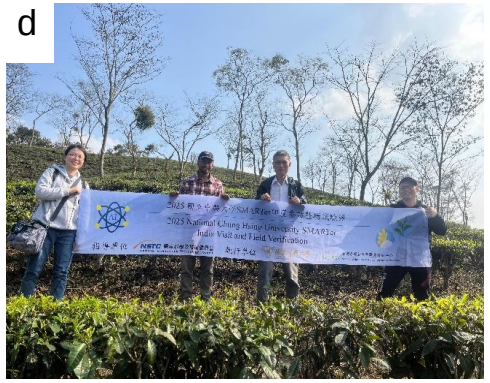
(a,b) Urlong tea estate with two plantations.
(c-e) Anderson tea estate plantation.
(c,f) Introduce and show the Tea Expert System.

a

b

c

d



e

f

Field Validation Result in India

- **Narayanpur Panbarry Tea Estate** is a lowland tea plantation. It mainly grows large-leaf tea for black tea production.
- In the Jorhat region, shade trees are required for tea plants due to the extreme summer heat.
- According to field observation and image data, local tea diseases have been successfully diagnosed.
- About **750 images** of tea pests and diseases from India have been collected and are currently being analyzed with the help of experts in Taiwan.
- This effort contributes to building a localized dataset of tea pests and diseases in India.

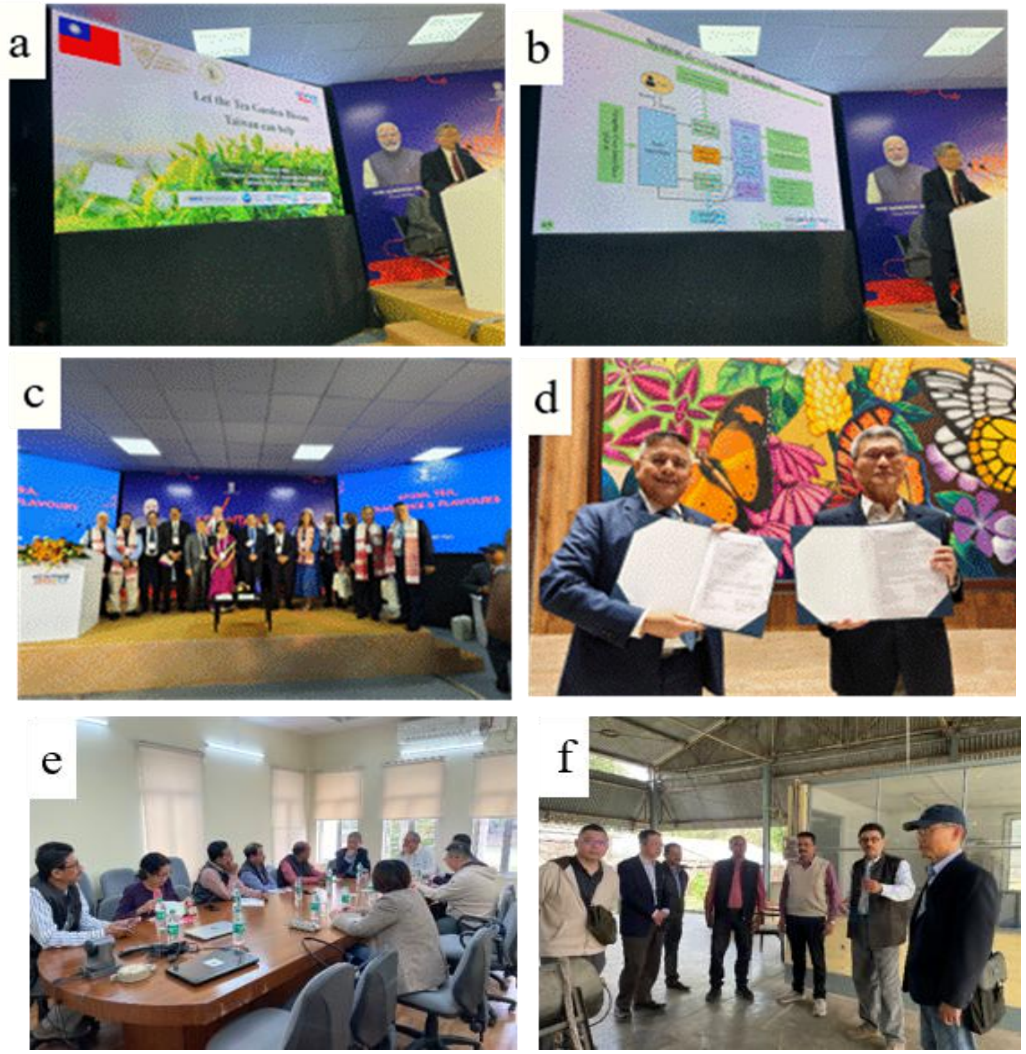
India Field Validation
- Attending Assam 2.0 Summit

Attending India Assam 2.0 Summit at Guwahati

(a-c) Give a speech in Ayush, Tea, Flavour & Fragrance section.

(d) Sign MoU with the Secretary (Dr. Joydeep Phukan) of Tocklai Tea Research Institute.

(e,f) Visit Tocklai Tea Research Institute in Jorhat. (e)Discussion (f) Visiting Tea Factory.



Visiting Assam Agricultural Univ. in Jorhat

(a,b) Photo with Vice Chancellor of AAU、Dean of Agricultural College and Head of Department of Tea Husbandry Technology.

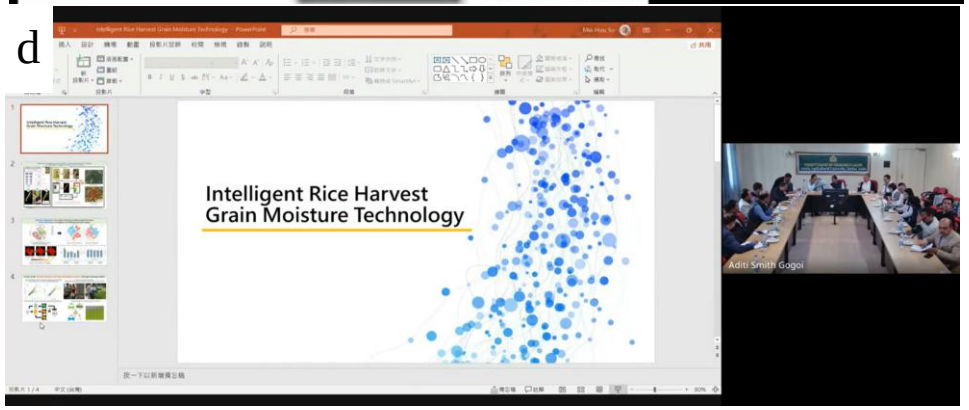
(c,d) Introduce Tea Expert Diagnosis System for Tea Cultivation and Management to the faculties in Assam Agricultural University.

a

b

c

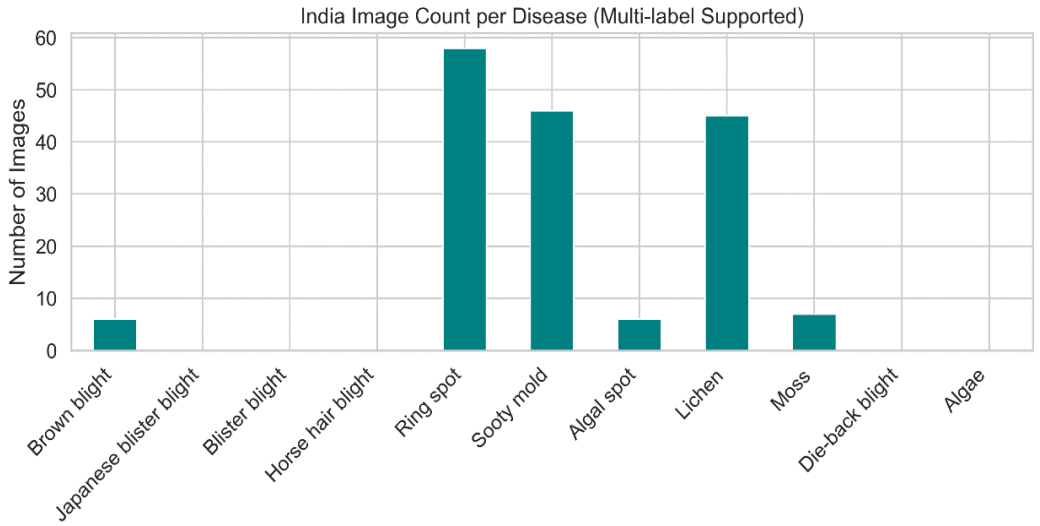
d



Field Validation Result

- As of May 31, 2025, a total of 231 images of tea pest and disease symptoms from Indian have been collected and added to the existing tea symptom dataset.
- After categorizing the images into four major domains -**diseases**, **pests**, **nutrient disorders**, and **others**-the dataset has reached a total of 10,420 images.

Sample Counts of Indian Tea Tree Disease Categories (Data as of May 31, 2025)



The updated tea disease image dataset contains a total of **3,510** images, including **163** images from India. The dataset will undergo quality filtering (n=3,081), and then be split into a training set (n=2,775) and a test set (n=306) in a 9:1 ratio.

Tea Tree Symptom Image Dataset and Number of Collected Categories

Symptom Image Dataset	Dataset size	Number of annotated images	Number of classes
Tea	10,382	14,349	Disease: 11 Pest: 33 Nutrition: 13 Other: 3

Performance metrics of the tea disease image recognition AI model Tea_Disease_v06.pkl, validated using the test set (n=306), across each disease category.

Chinese Name	Name	precision	Recall	F1 score	support
赤葉枯病	Brown blight	0.7857	0.5238	0.6286	21
網餅病	Japanese blister blight	1	1	1	23
餅病	Blister blight	0.9868	0.9868	0.9868	76
茶髪狀病	Horse hair blight	0.98	1	0.9899	49
輪斑病	Ring spot	0.8182	0.75	0.7826	36
煤煙病	Sooty mold	0.9048	0.8636	0.8837	22
藻斑病	Algal spot	0.8654	0.7895	0.8257	57
地衣	Lichen	1	0.7778	0.875	27
苔癬	Moss	1	0.75	0.8571	4
枝枯病	Die-back blight	1	0.5	0.6667	2
藻類	Algae	0.9091	0.7692	0.8333	13

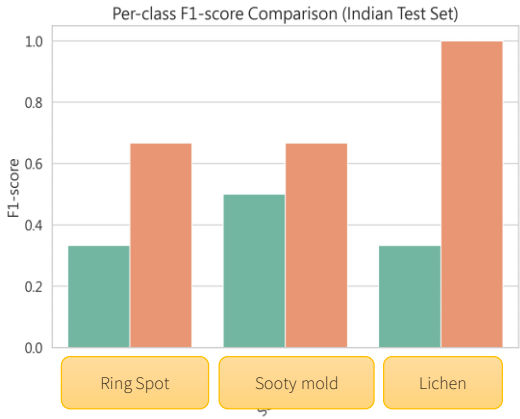
Field Validation Result

AI model Accuracy evaluation

Tea_Disease_v06.pkl	including field images from India and Taiwan
Tea_Disease_v02.pkl	including field images from Taiwan

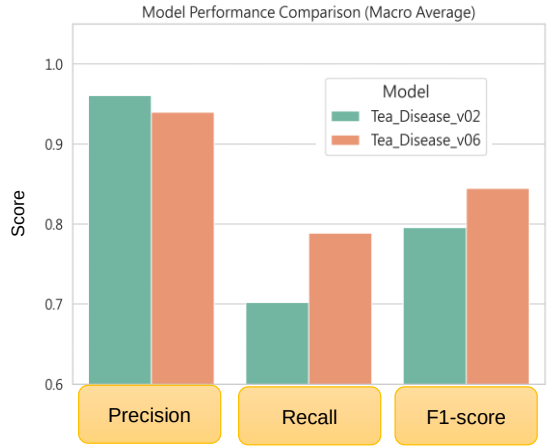
Validation using the test set (n=306) to evaluate two tea disease image recognition AI models.

Comparison of Two Models on Indian Tea Disease Images

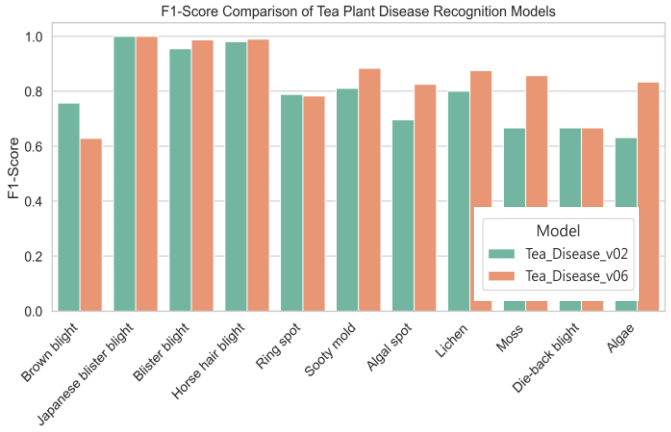


Analysis of the difference in F1 score performance between the two models on images of various tea disease categories from Indian tea trees in the test set (n=3–5 per category).

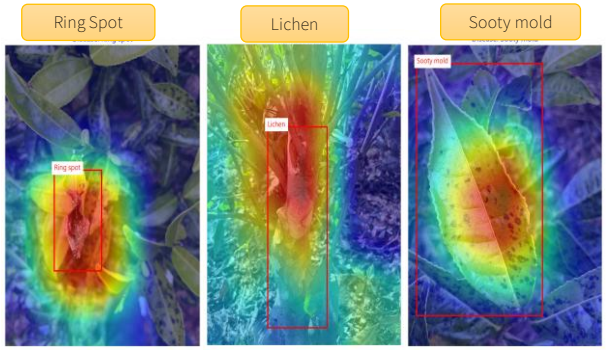
Overall Model Performance Comparison



Per-Class F1-Score Comparison of Tea Disease Recognition Models



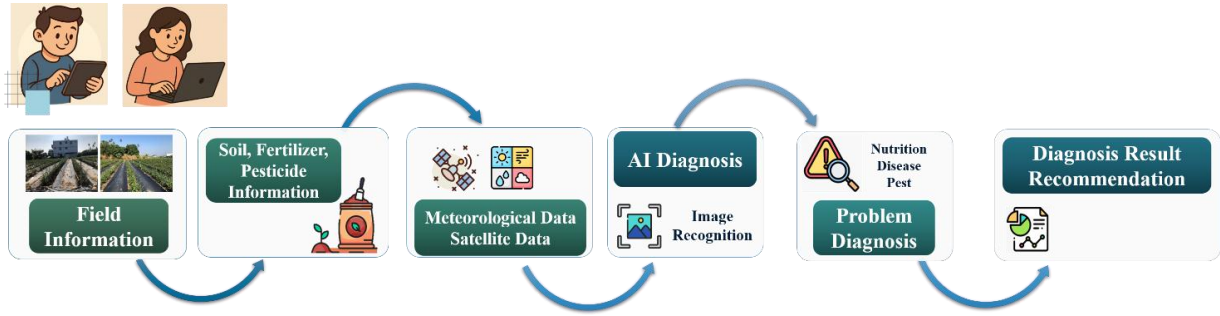
Model Attention Visualization using Grad-CAM



Field Validation Result

User Experience & Feedback

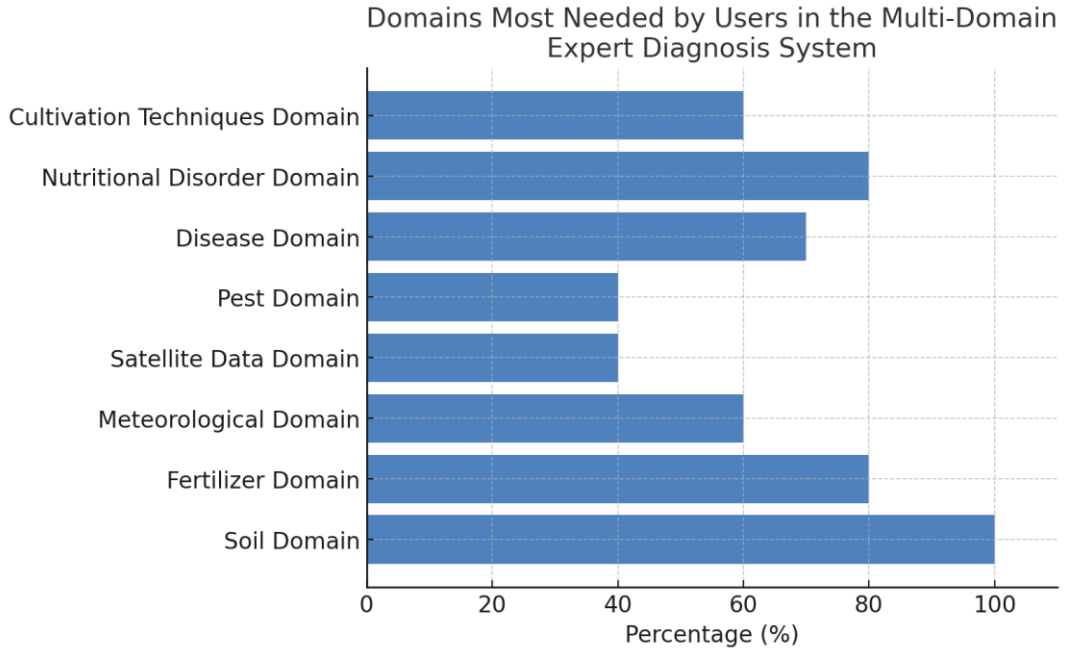
System Diagnosis Process



Survey Respondents and Feedback Summary

- ✓ Target Audience:
  1. Number of second-year Master's students in the Plant Medicine and Good Agricultural Practice program: 11
  2. Number of Reserve Plant Doctors in the Plant Teaching Hospital: 2
- ✓ Number of Responses Collected: 5

➢ *Although the sample size is limited, all respondents possess relevant training or diagnostic experience, providing valuable insights*



Advantages of the User Feedback System

- ✓ Provides expert knowledge across multiple domains.
- ✓ Automatically load soil, weather, climate, and satellite data base on field location.
- ✓ The system has a clear and easy-to-use interface.
- ✓ Allows users to download reports easily for recordkeeping and sharing.

Education
(Learning is endless)

Variety

Cultivation

Weather

Nutrients
Diseases
Pests
Weeds

Other
- Yield
- Spatial
Temporal
Variation

Fertilizer
Pesticide

Soil

Domain

Ways to Train the ES

- **Testing the ES at Various Sites**

  Improvement of UI designs

  Arrangement of questions asked

  Correctness of typical photos displayed

  Accuracy of potential problems diagnosed

  Completeness of recommendations suggested

- **Expand the Existing Knowledges**

  Buildup Case Reports for Diagnosis Rules

  Increase AI Models for Photo Interpretation

Concluding Remarks

- **The stresses encountered by field crops are numerous and complex, but on-site diagnostic personnel are often limited by training and experience, making it difficult for them to conduct a comprehensive diagnosis in order to provide the best treatment recommendations.**

- **An expert diagnosis system can collect and save the knowledge and experience of experts in different fields, thereby assisting on-site diagnostic personnel to conduct a comprehensive diagnosis and provide the best treatment recommendations.**

- **The expert diagnosis system that has been developed is a small step towards the above ideal. Hope we can collaborate together to make the developed expert diagnosis system more perfect.**

Thanks for Your Attention