# TRAINING MODULE ON

## Training of Trainers on Smart Farming on Greenhouse Production for Fruit Crops and Leafy Vegetables

Bukid Amara,
Lucban, Quezon

2024

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Published by:

**Department of Agriculture**
**AGRICULTURAL TRAINING INSTITUTE REGION IV-A**
Brgy. Lapidario, Trece Martires City, Cavite 4901

ISBN: _______
Printed in the Philippines

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# FOREWORD

It is with great pleasure and gratitude that I present the "*Training Manual for Training of Trainers on Smart Farming on Greenhouse Production for Fruit Crops and Leafy Vegetables"* by Bukid Amara. This invaluable resource is not just a product of a collaborative effort between Bukid Amara, a pioneering vegetable and flower farm in Lucban, Quezon, and the Department of Agriculture - Agricultural Training Institute (DA-ATI) CALABARZON that serves as the capacity builder, knowledge bank, and catalyst of a harmonized Philippine Agriculture and Fisheries Extension (AFE) system. It also attests to the commitment to revolutionizing the agriculture sector by responding to the needs of the time.

Together, we aim to redefine what farming can be—transforming it into a sustainable and innovative practice that blends tradition with modern technologies.

The DA-ATI CALABARZON and Bukid Amara have long been promoting sustainable farming methods, and with this manual, we take another step towards our goal for agriculture. This comprehensive training module introduces participants to the core principles of smart farming, focusing on the greenhouse production of fruit crops and leafy vegetables. At the heart of this program is the integration of precision farming technology, which empowers farmers to make data-driven decisions and optimize production. From greenhouse automation and intelligent lighting systems to the Internet of Things (IoT) and data analytics, this manual provides the knowledge necessary for managing crops efficiently and sustainably.

I am firmly convinced that this manual will mark a significant milestone in our ongoing effort to equip agricultural professionals with the tools and knowledge they need to succeed in the modern farming landscape. By embracing cutting-edge technologies, we can minimize resource wastage, increase crop yields, and ensure that the agricultural industry remains competitive and resilient in the face of climate change and other global challenges.

As we move forward, let us continue to push the boundaries of what is possible in agriculture, striving for innovation and sustainability every step of the way. The future of farming is smart, sustainable, and driven by technology. I hope this manual will inspire you to embrace these changes and become part of a new era of farming.

**DR. ROLANDO V. MANINGAS**
*Center Director,*
DA ATI CALABARZON

The agricultural production system is facing unprecedented challenges due to the increasing demand for food and the growing global population. With dwindling natural resources, less arable land to farm, emerging pests and diseases, and the increasing impacts of climate change, growing crops to feed the world must embrace a technological transformation to produce more with less input.

Smart farming and precision agriculture hold the key to addressing the future of sustainable food security. New technological advancements such as drone technology, robotics, Internet of Things (IoT), cloud computing, artificial intelligence, and automation provide innovative systems and sustainable solutions to optimize crop management and maximize productivity.

As an agricultural nation, the Philippines is also one of the most disaster-prone areas in the world. Adapting smart farming technologies under protected greenhouse cultivation could help address the challenges facing Philippine agriculture and revolutionize farming toward a more food-secure future.

**MICHAEL S. CABALLES**
*Chief Farmer/Owner*
Bukid Amara Agri Farm

# MESSAGE

Agriculture is evolving rapidly, with smart farming and precision agriculture reshaping traditional practices through automation, artificial intelligence (AI), and the Internet of Things (IoT). These innovations allow farmers to optimize crop production, reduce resource wastage, and enhance climate resilience. However, despite the global shift toward technology-driven agriculture, the Philippines remains slow in adopting these advancements due to limited access, lack of technical knowledge, and the high cost of implementation. To address these barriers, the Department of Agriculture - Agricultural Training Institute (DA-ATI) CALABARZON, in collaboration with Bukid Amara, is launching a Training of Trainers (ToT) on Smart Farming in Greenhouse Production for fruit crops and leafy vegetables.

This ToT program is necessary as many Filipino farmers and agricultural professionals still rely on conventional methods that often result in low yields, inefficient water and fertilizer use, and vulnerability to climate change. Unlike countries such as the Netherlands, where greenhouse crop production reaches 25-30 kg per plant, Philippine greenhouse farms only achieve 3-6 kg per plant due to outdated techniques and limited automation. By introducing IoT-based climate control, smart irrigation, and AI-driven pest management, this training aims to equip agricultural trainers, Learning Sites for Agriculture (LSAs), and State Universities and Colleges (SUCs) with advanced farming knowledge to bridge this gap.

One of the key challenges in the Philippines is the increasing impact of climate change, which disrupts traditional farming practices and reduces agricultural productivity. Smart greenhouse farming offers a solution by providing a controlled environment, protecting crops from extreme weather conditions, and ensuring year-round production. Through automated fertigation, climate monitoring sensors, and precision lighting, farmers can maximize crop yield and resource efficiency while minimizing environmental impact. Training agricultural trainers on these climate-smart technologies will empower them to transfer this knowledge to farmers nationwide, helping them adapt to a changing climate.

Aside from environmental benefits, Smart Farming and Precision Agriculture significantly improve resource management. Traditional farming methods often lead to overuse of water, fertilizers, and pesticides, which not only increases costs but also harms the environment. With smart farming technologies such as AI-powered nutrient formulation, drone-assisted pest monitoring, and automated irrigation systems, farmers can apply inputs more efficiently. This will provide hands-on training on how to implement these technologies in greenhouse production, ensuring that Filipino farmers can optimize their farming practices without unnecessary waste.

# BACKGROUND

Another important aspect of this training is addressing the knowledge gap in agricultural professionals and extension workers. Many of them lack formal training on advanced greenhouse automation and data-driven farming, making it difficult for them to assist farmers effectively. This ToT will create a network of well-equipped trainers who can serve as resource persons in their respective regions, teaching farmers how to integrate smart farming into their operations. By strengthening this knowledge base, the program ensures that the benefits of modern greenhouse farming reach a wider audience and have a long-term impact.

Furthermore, smart greenhouse farming presents new economic opportunities for Filipino farmers. The rising demand for high-quality, pesticide-free vegetables in local and international markets highlights the need for improved production systems. Countries with advanced greenhouse technology are already capitalizing on high-value crops, and the Philippines must follow suit to remain competitive. This training will not only focus on technical skills but also provide insights into business models, market access, and investment strategies that will enable farmers to scale their greenhouse operations profitably.

This program will be conducted through a blended learning approach, combining online discussions on smart farming principles with hands-on training at Bukid Amara, a recognized Learning Site for Agriculture specializing in greenhouse automation. Participants will learn how to set up smart greenhouses, monitor climate conditions, and apply AI-based farm management strategies. They will also develop a Smart Greenhouse Business Plan that can be implemented in their respective regions, ensuring that their training translates into real-world agricultural improvements.

By equipping agricultural trainers, LSAs, and SUCs with the latest advancements in smart farming, this ToT will catalyze the modernization of Philippine agriculture. With a strong network of trained professionals, the widespread adoption of precision greenhouse technology will lead to higher farm productivity, increased food security, and more sustainable agricultural practices. This initiative aligns with the government's push for agricultural innovation, ensuring that Filipino farmers remain competitive in the global market while embracing a climate-resilient and tech-driven future.

| Lesson Objective | Topic | Estimated No. of Hours | Strategy/ Method/ Technique | Instructional Material | Expected Output (Tangible) |
|---|---|---|---|---|---|
| **MODULE 1** *(page 8)* | | | | | |
| Participants will be able to utilize precision farming technology, greenhouse automation, lighting, internet of things (IOT), and data analytics in managing crops. | Smart Farming and Precision Agriculture *(page 9)* | 2 hours | Lecture Discussion | Powerpoint | |
| Participants will be able to have insights on the greenhouse vegetable industry and an overview of the business of growing high value crop under protected cultivation. | Market and Business Opportunities on Greenhouse Vegetable Production *(page 25)* | 3 hours | Lecture Discussion | Powerpoint | Market Goal |
| Participants will be able to explain the different cultivars and variety preferences and market specifications of both domestic and international market. | Greenhouse Crop Typology Overview *(page 37)* | 2 hours | Lecture Discussion | Powerpoint | |
| Participants will be able to have an in depth understanding on Greenhouse nursery operation and management. | Nursery Operation and Management | 2 hours | Hands-on Demonstration | Actual Greenhouse Nursery Facility and Materials | |
| Participants will be familiarized with drip irrigation setup, tank and water pump specification, flow rate calculations and drip irrigation layout. | Drip Irrigation System Installation | 4 hours | Hands-on Activity (3 groups) Nursery, Facility, Drip Irrigation Tour | Drip Irrigation Facility and Materials | |
| Participants will be able to create a masterplan and faming system design for the greenhouse business. | Greenhouse Farming System | 3 hours | Lecture Discussion | Powerpoint | |
| Participants will be able to explain the technical details of the greenhouse. | Greenhouse Components | 1 hour | Lecture Discussion | Powerpoint | |

| Lesson Objective | Topic | Estimated No. of Hours | Strategy/ Method/ Technique | Instructional Material | Expected Output (Tangible) |
|---|---|---|---|---|---|
| Participants will be able to craft the specific farm design and layout for their planned greenhouse business. | Farm Lay Out | 1 hour<br>5 hours<br>8 hours | Lecture<br>Discussion<br>Workshop and Presentation | | Farming System Layout per region group |
| | End of Module Assessment | | Examination | | |
| **MODULE 2** | | | | | |
| Participants will be able to learn the basics of greenhouse crop nutrition for fruit crops and nutrition management, understand nutrient deficiencies, it's symptoms and mitigation strategies. | Introduction to Greenhouse Plant Nutrition | 4 hours | Lecture<br>Discussion (Online) | Powerpoint | |
| Participants will be able recognize single element nutrients and calculate the specific nutritional crop requirement | Nutrient Calculation Workshop | 8 hours | Workshop | | Nutrient Formula for Target Crops |
| | End of Module Assessment | 4 hours | Examination | | |
| **MODULE 3** *(page 57)* | | | | | |
| Participants will be able to explains the major pest and disease in the greenhouse and how to create mitigation strategies to manage its population and prevent significant crop loss. | Introduction to Greenhouse Pests and Diseases *(page 59)* | 4 hours<br>2 hours | Lecture-Discussion<br>Workshop | Powerpoint | Pest and Disease Database |
| Participants will be able to establish integrated pest and disease management strategies, scouting and monitoring protocols, and identify important pest and disease for the fruit crops. | Greenhouse Pests and Diseases Management *(page 60)* | 2 hours | Lecture-Discussion | Powerpoint | |

| Lesson Objective | Topic | Estimated No. of Hours | Strategy/ Method/ Technique | Instructional Material | Expected Output (Tangible) |
|---|---|---|---|---|---|
| Participants will be able to explain the importance of bio-security protocol on the farm operation and greenhouse management. | Greenhouse Bio security Protocol *(page 61)* | 1 hour | Lecture-Discussion | Powerpoint | |
| Participants will be able to explain how scouting and monitoring can help prevents uncontrollable disease and pest infection and infestation. | Scouting and Monitoring *(page 62)* | 1 hour | Field work | | |
| Participants will be able to identify greenhouse pest and disease and to create mitigation control and management of pests. | Workshop on Pest and Disease Identification, Strategy and Recommendation *(page 63)* | 2 hours | Workshop | | Pest and Diseases Strategy and Recommendation |
| | End of Module Assessment | 4 hours | Examination | | |
| **MODULE 4** | | | | | |
| Participants will be able to apply routine care and maintenance and calibration of greenhouse equipment and tools. | Greenhouse Maintenance and Equipment Calibration | 3 hours | Workshop | | Accomplished Job Instruction Sheet |
| | Greenhouse Leafy Crops Cultivation and Cultural Management | 8 hours | Lecture-Discussion Field Work | | Accomplished Job Instruction Sheet |
| Participants will be able to apply actual tomato and pepper, leaf pruning, vine training, trellising and other pertinent cultural management practice for fruit crops | Greenhouse Bell pepper, Eggplant and Tomato Cultivation and Cultural Management | 4 hours | Online | Powerpoint | |

| Lesson Objective | Topic | Estimated No. of Hours | Strategy/ Method/ Technique | Instructional Material | Expected Output (Tangible) |
|---|---|---|---|---|---|
| Participants will be able to apply actual melon pollination, fruit selection for cucumber and pepper, leaf pruning, vine training, trellising and other pertinent cultural management practice for fruit crops | Melon and Cucumber Cultivation and Cultural Management | 4 hours | Online | Powerpoint | |
| Participants will be able to explain Harvesting Post-Harvest Handling, Marketing and Packaging of Fruit Crops based on the market set preference | Harvesting Post-Harvest Handling, Marketing and Packaging of Fruit Crops | 4 hours | Online | Powerpoint | *Every participants are required to bring and present their own harvested fruits for evaluation and their proposed packaging.* |
| | End of Module Assessment | 8 hours | Examination | | |
| Participants will be able to familiarize greenhouse farm operation and management. | Greenhouse Farm Operation Management | 4 hours | Lecture | Powerpoint | |
| Participants will be able to apply actual farm operation and management. | Workshop on Farm Operation and Management | 4 hours | Workshop | | |
| Participants will be able to apply actual farm operation and management. | Workshop on Farm Operation and Management | 4 hours | Workshop | | Crop production schedule Job Instruction Sheet |
| Participants will be able to present farm operation plan. | Presentation of Farm Operation Plan | 4 hours | | | |
| Participants will be able to present farm operation plan. | Presentation of Farm Operation Plan | 4 hours | | | Farm Operation Plan |
| **Post Test and Overall Evaluation<br>Re-entry Plan** | | | | | |

# MODULE 1

Greenhouse Farming System

# MODULE OVERVIEW:

Greenhouse farming is an innovative agricultural method that involves growing plants in controlled environments. Greenhouses are structures designed to provide an optimal growing condition by regulating environmental factors such as temperature, humidity, light, and air circulation. By isolating crops from external weather conditions, greenhouse farming ensures consistent growth, enhanced productivity, and year-round production. This farming system is increasingly adopted to meet the global demand for fresh, high-quality produce, especially in areas with challenging climates or limited arable land.

This module will cover key topics related to the concepts of smart farming and precision agriculture as well as the market and business opportunities of greenhouse farming system. It will also tackle topics on the design, operation, and management of greenhouse systems, highlighting their benefits and challenges, as well as their growing significance in sustainable agriculture.

# Lesson 1: Smart Farming and Precision Agriculture

**OBJECTIVES:**

At the end of this lesson, the participants will be able to utilize precision farming technology, greenhouse automation, lighting, internet of things (IOT), and data analytics in managing crops.

**COVERAGE:**

This lesson covers the following topics:

1. Overview on Smart Farming and Precision Agriculture
2. Automation and the Internet of Things (IoT)
3. Fundamentals of Artificial Lighting in Greenhouse
4. Future Farms - how technology is shaping the future of farming

**TIME ALLOTMENT:** 2 hours

**METHODOLOGIES:** Lecture-participatory discussion

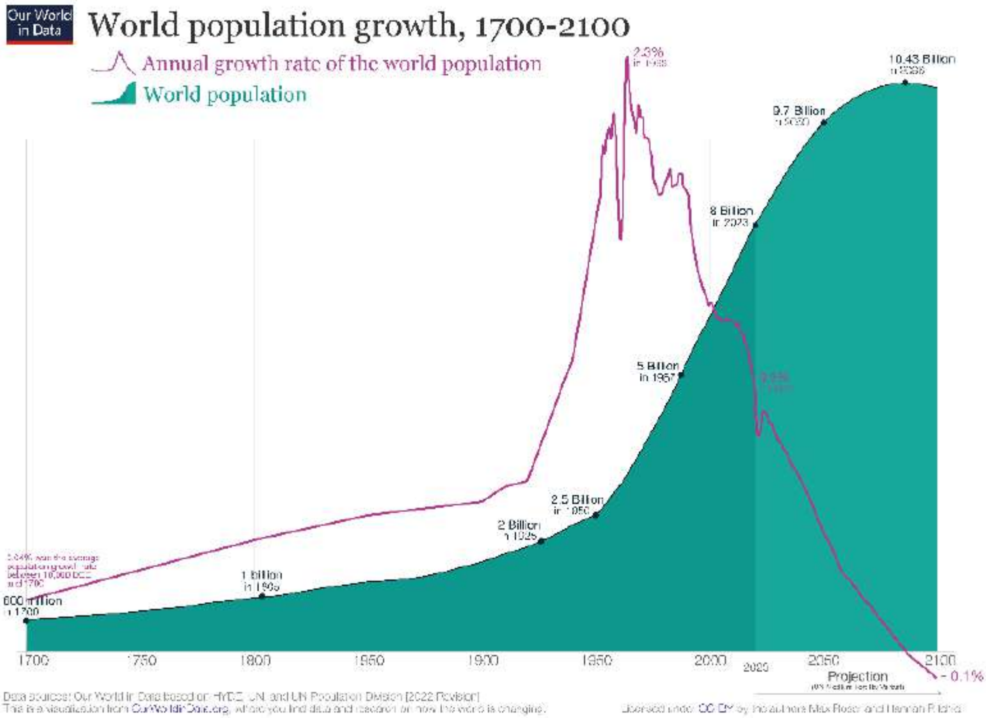
**INSTRUCTIONAL MATERIALS:** PowerPoint presentation

## OVERVIEW

According to United Nations calculations, by 2050 there will be 9.7 billion people in the world, creating around 2 billion more mouths to feed than in 2020. This increase, needs to be met through a 70 % rise in agricultural production (FAO, 2020).

Smart Farming and Precision Agriculture are interrelated concepts that is based on technology and data-driven methods to transform conventional farming practices to improve agricultural production. Smart farming is an approach that involves the latest technologies and data such as using sensors, robotics, drones, artificial intelligence (AI), and other Internet of Things (IoT) devices to monitor crops, livestock, soil conditions, weather patterns, and more. Precision Agriculture, on the other hand, is a subset of smart farming focusing specifically on the technical aspects of crop and resource management at a specific level.

This lesson emphasizes Smart Farming and Precision Agriculture potentials in boosting agricultural resilience, improve resource allocation, and improve food security by utilizing technology, data-driven insights, and sustainable practices that in redefines global food systems and paving the way for a sustainable future.




## A. OVERVIEW ON SMART FARMING AND PRECISION AGRICULTURE

The global human population has doubled from 1960 to 2010 and is projected to reach about 9.7 billion by 2050, and 10.9 billion by the 2100, presenting significant challenges for global food security due to a significant increase in the global demand for food. With global populations rising rapidly, agriculture faces the challenge of producing enough food to meet increasing demand in conditions of changing climate, increasing production costs and natural resources depletion.

To meet the increasing demand for food together with the environmental challenges, it is critical to modernize traditional farming methods and prepare for a technological revolution to establish eco-friendly crop production systems. Smart farming concepts like precision agriculture can be aptly deployed to achieve this goal. This farming method utilizes technologies to improve crop production as well as the environment. Technology took the agriculture domain to a higher level where it not only made the often-tedious tasks easier but also provided many solutions to various complications of conventional farming. Smart farming and precision agriculture are two such technology-driven farming concepts that focuses on managing and preparing the agricultural industry with frameworks to include advanced technologies such as big data, the Internet of Things and Machine Learning for tracking, monitoring, analyzing, automating, and executing operations.

## Smart Farming

Smart Farming focuses on the implementation of data and information technologies to utilize human labor more effectively and enhance crop quality and quantity. This approach is what drives smart farming industry players to enable agribusinesses to grow more with less.

Today, most farmers, especially in rural areas, rely on learnings passed down through generations and approximate estimations to carry out seeding, applying fertilizers and crop protection products, and harvesting.

Smart farming improves these processes and enhances their efficiency with the help of agricultural technology tools and software solutions. It helps producers make more informed, data-driven decisions and achieve economic efficiency by reducing workforce requirements.

What differentiates smart farming from precision agriculture is that it does not focus on precise measurements. Instead, smart farming focuses on capturing data and interpreting them using computing technologies to make farm operations more predictable and efficient. Some of the smart farming tools are the following:

- **Machine learning.** Self-learning technologies give you the power to predict changes in climate, soil and water parameters, carbon content, disease and pest spreading, and more.

- **Big data.** Without them, it is impossible to imagine the possibility of accurate forecasts, activity planning, and designing more efficient business models. Smart farming and big data allow you to make long-term decisions and act right now.

- **Internet of Things (IoT)** - gives you the opportunity to combine all the tools and solutions into a single system. All devices and software can exchange data and perform specific actions based on patterns.

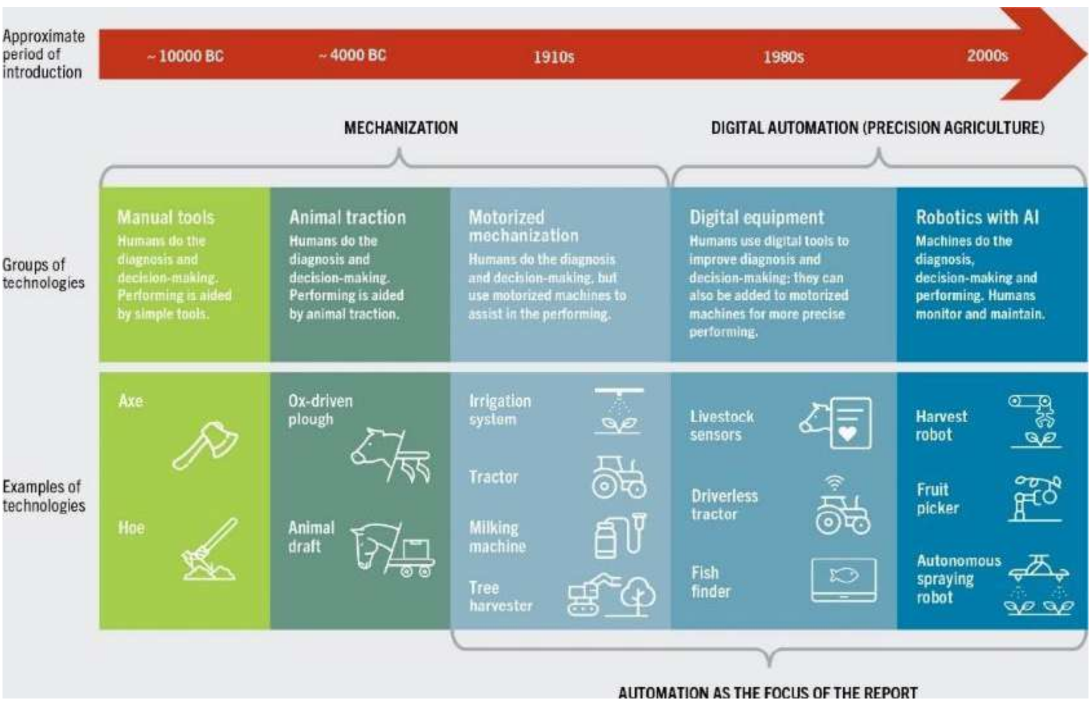
- **Artificial Intelligence (AI)** - Artificial intelligence, or AI, is technology that enables computers and machines to simulate human intelligence and problem-solving capabilities.

- **Robotics**

- **Unmanned Aircraft Systems (UAS)**

- **Sensors and Actuators** - Sensitive sensors help farmers to monitor the slightest changes in the state of the environment and fields in real-time.

- **Drones in Agriculture** - With their help, growers can create regularly updated maps and monitor the territory remotely without the need to go to the field.



## Precision Agriculture

As the name suggests, precision farming or precision agriculture involves highly controlled, accurate, and optimized agricultural production. It facilitates more efficient resource utilization, better yield, and reduced environmental impact, all at the same time. An ideal example of the precision farming practice is a focused agro-chemical application with AI-aided analysis, targeting only areas that need attention instead of the blanket application.

This farming practice involves the implementation of modern information and communication technologies (ICT). Producers also incorporate a combination of devices and machinery that help capture vital field data, including:

- Remote sensors
- Automated hardware and software
- Telematics
- Drones
- Autonomous vehicles
- GPS soil sampling
- Robotics

Despite all the advantages of smart farming and the use of advanced technologies, this concept faces some challenges:

1. **Lack of Internet.** To implement smart agricultural technologies, you need a stable Internet connection. Unfortunately, it is not available in all regions of the world.

2. **Low awareness.** Modern systems require fine-tuning and knowing the features of their operation. Some farmers do not fully understand the benefits of using smart farming technologies or do not know how to work effectively with them.

3. **Lack of unification.** Many suppliers and machinery manufacturers make it difficult to arrange a single system since the equipment may not be compatible. Smooth integration of equipment and software requires standardization of the technologies used.

4. **Lack of scalability.** Both small farmers and large

corporations should be able to use the same technologies, just at different scales. Easily scalable solutions would mean easier and faster production expansion.

## B. AUTOMATION AND THE INTERNET OF THINGS (IoT)

### Smart Farming

Food and Agriculture (FAO) defines agricultural automation as: the use of machinery and equipment in agricultural operations to improve their diagnosis, decision-making or performing, reducing the drudgery of agricultural work and/or improving the timeliness, and potentially the precision, of agricultural operations. The definition derives from the technological evolution or progression of agricultural technologies, from those that assist solely the physical performing of operations to those that assist diagnosis and decision-making. By this definition, agricultural automation includes precision agriculture, which is a management strategy that gathers, processes and analyses data to improve management decisions.

Automation can involve any one or a combination of the three connected phases cycle of an automation system: diagnosis, decision-making and performing. For example, diagnosis may be carried out by sensors while decision-making and performing depend totally on humans. Alternatively, both diagnosis and decision-making may be executed by digital technologies while performing is done by humans. An example of a fully automated system where all three phases are automated is the autonomous spraying robot: the system first obtains data on soil fertility, then decides on the operation area and application rate, and finally applies fertilizer based on that variable rate.

### Internet of Things

Internet of Things (IoT) is a recent technology that creates a global network of machines and devices that can communicate and exchanging data with each other through the Internet. There is a difference between the Internet of Things and the Internet. Internet of Things can create information about the connected objects, analyze it, and make decisions; in other words, one can tell that the

Internet of Things is smarter than the Internet. Security cameras, sensors, vehicles, buildings, and software are examples of things that can exchange data among each other.

Since the term "Internet of Things" was coined in 1999, its adoption has penetrated every aspect of people's life, from health and fitness, automotive and logistics, home, and industries. Thus, it is only logical that IoT and automation would find its application in agriculture and as such improving nearly every of its aspects. Namely, these are some of the potential ways that IoT can transform agriculture:

- Data, tons of data, collected by smart agriculture sensors, e.g. weather conditions, soil quality, crop's growth progress or cattle's health. This data can be used to track the state of your business in general as well as staff performance, equipment efficiency, etc.

- Better control over the internal processes and, as a result, lower production risks. The ability to foresee the output of your production allows you to plan for better product distribution. If you know exactly how much crops you are going to harvest, you can make sure your product will not lie around unsold.

- Cost management and waste reduction thanks to the increased control over the production. Being able to see any anomalies in the crop growth or livestock health, you will be able to mitigate the risks of losing your yield.

- Increased business efficiency through process automation. By using smart devices, you can automate multiple processes across your production cycle, e.g. irrigation, fertilizing, or pest control.

- Enhanced product quality and volumes. Achieve better control over the production process and maintain higher standards of crop quality and growth capacity through automation.

- Reduced environmental footprint. Automation also carries environmental benefits. Smart farming technologies can cut down on the use of pesticides and fertilizer by offering more precise coverage, and thus, reduce greenhouse gas emissions.

As a result, all of these factors can eventually lead to higher revenue.

## C. FUNDAMENTALS OF ARTIFICIAL LIGHTING IN GREENHOUSE

The new generation of greenhouse technology has gone from simple covered greenhouses to sophisticated factories that guide agricultural production at the lowest possible cost. Combined with automated cultivation systems, the architecture and structures of green-houses make crops profitable for year-round cultivation. However, controlling the climate inside greenhouses requires a high use of primary energy.

Natural and artificial lighting are the most critical factors for photosynthesis and plant development. This variable's low density or excess directly affects growth, and the optimal amount varies for each species. However, this dependence is lower in plants developed under shading conditions and protected cultivation. According to Teixeira et al. (2022), artificial lighting applied in precision agriculture aims to provide or supplement photosynthetically active radiation to optimize the production of cultivars and obtain a level of maximum productivity, good product quality, and production capacity regardless of the season.

A plant grow light is a source of artificial light which has been designed to grow plants in spaces where there is little or no natural light available or when the natural day length is artificially extended. Light for cultivation has traditionally tried to resemble sunlight in terms of the composition of the light spectrum, but it was not until the appearance of LEDs (Light Emitting Diode) that it was possible to produce customized spectra. The most used greenhouse lights, the high-pressure sodium (HPS) lamps, irradiate mainly in the yellow and red area of the visible spectrum, while fluorescent lights, which have traditionally been used in growth chambers have more blue light in their spectrum.

Artificial lighting applied to greenhouses has historically been linked to areas that receive few hours of sunshine during winter, or to the modification of the photoperiod to induce flowering of ornamental crops at times of the year in which they have greater commercial value. The use of artificial light in horticultural applications results in better growth and larger yields due to photoperiod extension and increase in the daily light integral. Artificial light can also bring benefits to the growers via the manipulation of flowering induction by giving short/long day treatments or night interruption. In closed environments artificial light is of course the only supply of light for photosynthesis and plays therefore a more critical role than artificial light in greenhouse applications. The artificial light in horticulture allows a better growth by extending the photoperiod when there are only few hours of natural daylight available and thus increases the daily light integral. Artificial light is also used to control or inhibit flowering in long-day/short-day treatments and can supply natural light in closed growth chambers.

In recent years, great development has been made in lighting technology, including the reduction of operating costs thanks to the introduction of LEDs. LEDs have been introduced already into facilities which produce flowers, vegetables, fruits, grafted seedlings, microgreens, algae, and medicinal plants, etc. Due to its environmental and productive efficiency advantages, LED lighting has been described as the most revolutionary invention in horticultural lighting in recent decades. In early 1966, Hardh suggested that the artificial lighting used for plants should adapt to the spectrum of photosynthetic function sensitivity, and in 1970 McCree offered a proposal for a generalized spectrum for photosynthesis action. The parameters to be considered in artificial lighting are:

- light spectrum
- light intensity
- Photoperiod

## D. FUTURE FARMS - HOW TECHNOLOGY IS SHAPING THE FUTURE OF FARMING

We use technology in almost every aspect of our lives. It helps us accomplish tasks at work and home, stay up to date with current events and provides countless hours of entertainment.

From a business perspective, technology is helping across all industries as well. It aids in production, customer service, talent acquisition, security and much more but what impact is it having on the planet?

Some might argue outdated devices are contributing to the ever-growing pollution problem or that our data is at risk by using these technologies and while that may be true, several innovations are aiding in land and water sustainability.

We are in the midst of the world population growth so we must continue to adopt more efficient and sustainable production methods while also adapting to climate change. Many farmers are utilizing technology to help achieve those goals, reduce water consumption, improve operations and increase profits.

### ☑ Better Pest Management

Farmers can calculate the best combination of water irrigation, fertilizer, and pesticides, combined with soil type, to improve insect tolerance and protect crops. Scientists have even discovered the most efficient methods of pesticide application to minimize product use. These innovations have agritech to thank for money saved and crops' ability to resist infestation.

### ☑ More Genetically Productive Crops & Livestock

There is a popular picture comparing the average chicken size in the 1950s and today. If you have not seen it, it shows how we have tripled the amount of muscle mass in chickens in just a few decades.

Smart farming techniques have created better fertilizers, seeds, and genetically modified livestock that produce more meat, wool, or whatever the desired product is.

### ☑ Increase Output with Agriculture Automation

Automated farming refers to incorporating automation in agriculture via devices and machines such as: autonomous tractors, automatic watering, robot seeders/harvesters and drones.

Automation can reduce labor costs and increase yields by minimizing human error, plus saves time and money by providing more efficient and accurate farming practices. It also can reduce the need for pesticides and chemical fertilizers, resulting in a more sustainable and environmentally-friendly way of farming.

## Higher-Precision Use of Field Equipment

Precision agriculture technology gives farmers the tools to use crop inputs more efficiently. Things like water, fertilizer, and pesticides are large farmer expenses. Using less is good for the farmer as well as the planet.

To do this, farmers and farmer groups invest in new agriculture technology like drones and GPS systems that gather data and perform their functions accordingly.

## Facilitate Specialization

Modern large-scale farming facilities are specialized, producing only a few different products. This has driven the development of improved logistics solutions and creative supply chain practices. Specialization doesn't just mean sticking to one product; it could also mean niching down to one phase of growth. For example, some farms specialize in creating seeds while others produce fruiting crops. Some farms raise sheep for wool, others for dairy.

Thanks to new agrotechnological research, farmers can predict possible problems like input or commodity price changes or weather events that affect their niche and make informed, strategic plans.

## Climate-Proof Agriculture

Scientists of today have known about climate change's looming threats for years now, and have developed some "climate-proof crop varieties" that have traits to withstand climate change's impacts. These plants aren't necessarily guaranteed to survive it all, but they're resilient to location-specific climate shocks that are more adaptable to changing environments. The goal is to ensure food security in the case of extreme climate change, and make agricultural practices more environmentally sustainable. New developments in agritech make this goal more possible every day.

## AI in Agriculture

AI is revolutionizing the way farmers scale and optimize operations. Using computer models more powerful and high-speed than human cognition, AI can maximize output and minimize inputs at a more exact level than before possible.

### Crop and Soil Monitoring

Farmers can use AI to predict seasonal soil moisture given specific soil parameters like soil type, acidity, permeability, temperature, and more, to inform their decisions on irrigation needs, crop selection, quality control, and field operations. Not only does this prevent water waste, but it allows farmers to make long-term plans ahead of time and take better care of existing crops.

### Insect and Plant Disease Detection

AI can predict and prevent crop damage from pests and diseases using image recognition, machine learning, big data, and historical trends. By detecting and recognizing patterns by plant type, location, and weather, AI in agriculture can identify potential threats before they do serious harm.

Preventing outbreaks saves farmers money on damaged products, but it also diminishes food waste, contributing to global sustainability goals.

### Livestock Health Monitoring

AI can be used to streamline livestock health monitoring by providing farmers with real-time data on the animals' food and water intake, behavior, and body temperature. This data can identify potential health issues and inform preventative actions. AI-enabled monitoring systems can be used to track the animals' habits and alert farmers when an animal has not eaten for a certain period of time or if their body temperature is abnormal.

Farmers can also compare the health of individual animals or herds, preventing outbreaks, sequestering carbon in rangeland, and minimizing waste. AI makes the future of farming a brighter one.

### Automatic Weeding

Automated weeding removes all weeds in proximity to the seedline to protect seedlings from exterior challenges and crowding. It typically involves a robot able to distinguish the crop from the weed and administer a small amount of herbicide. This optimizes human labor hours and the amount of pesticide applied. Here is yet another example of AI in agriculture being cost-effective and eco-friendly.

### Aerial Survey and Imaging

AI aerial imaging helps farmers monitor crops and herds by providing high-resolution images of their farms from a bird's eye view. This agritechnology imagery can be used to identify potential pest infestations, diseases, or irregular growth patterns, alerting farmers before problems get out of hand. AI aerial imaging can also help farmers with other tasks like mapping irrigation lines, determining soil quality, identifying pesticide-needy areas, and assessing the health of their herds.

### Intelligent spraying

AI robots optimize pesticide and fertilizer use by using sensors and analytics to intelligently identify areas that need to be sprayed.

These machines can detect areas with higher concentrations of pests or disease-carrying organisms and target those areas for spraying. The robots can also use past data to identify likely areas for future infestations, allowing for proactive spraying. Using imaging and analysis, AI in agriculture can determine the most effective way to spray and the optimal amount of pesticide to use, helping to reduce overspraying, waste, and potential runoff.

## Biotechnology in Agriculture

Biotechnology in agriculture is the application of scientific techniques and engineering principles to the manipulation of living organisms and biological systems. Though its techniques often attract skeptical publicity, advanced agriculture technology has numerous benefits:

1. Increase crop yields
2. Disease and pest resistance
3. Nutrient enhancement
4. Reduced water requirements
5. Improved soil fertility
6. Reduced chemical use
7. Improved storage life/waste reduction

### Gene Editing

One of the most important agricultural advancements of our time has been the ability to create crops that are more resilient to weather changes, more resistant to diseases, easier to transport, and produce a more edible product.

The breakthroughs increase output by enlarging crops and preventing pest-related food waste. Farmers can also use fewer chemicals because their plants reject diseases and use nutrients more efficiently.

### Pesticide-Resistant Crops

Pesticide-resistant crops were created to tolerate herbicides while they kill surrounding weeds. The majority of corn, soybeans, and cotton planted are pesticide-resistant which keeps prices affordable and supply stable.

Though there are a few issues with the environmental and human impacts of these crops, they have no doubt transformed and paved the way for agrotechnological science. Continued innovations could improve upon existing plant genes to enhance their sustainability and eco-friendliness in cultivation.

### Synthetic Chemistry

Synthetic chemistry in agriculture refers to the science behind herbicides, fertilizers and other chemicals used to grow plants. Over time, scientists have developed more effective, less toxic formulas that control pathogens and increase the fertility of the soil.

Although the health effects of synthetic chemicals concern many, they've been essential in maintaining food supply levels for our ever-growing population. The agritech-science can improve both the quality and quantity of the crop while fighting off pests and diseases.

### Plant and Animal Breeding

When it comes to genetic interference, we're already living in the future of farming. Advances in genetic engineering have enabled scientists to develop new varieties of plants and breeds of animals that produce higher yields, resist disease and pests, and tolerate extreme climates. DNA-based technologies have allowed scientists to identify the most beneficial traits in animals and plants, such as those that make them better suited to climates or soil types, and breed these seeds much more quickly. Reproductive technologies such as artificial insemination, make it possible to produce animals with desirable traits more efficiently than ever before.

### Blockchain in agriculture

Blockchain in agriculture means employing a tamper-proof food tracing system that encourages traceability and eliminates concerns of unknown unethical practices. By making the flow of food products public, consumers can feel confident in their buying decisions and institutions can more easily track down the origin of contaminants. One of the newest technologies in agriculture, blockchain promises many benefits including increased administrative efficiency and improved food safety and transparency.

These are just a few of the technologies and ways they are influencing the future of farming. As we look toward the future and the growing food demand, farmers continue to seek better ways to produce crops by embracing innovation.

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# Lesson 2:
# Market and Business Opportunities on Greenhouse Vegetable Production

**OBJECTIVES:**

At the end of this lesson, participants should be to have insights on the greenhouse vegetable industry and an overview of the business of growing high value crop under protected cultivation.

**COVERAGE:**

This lesson covers the following topics:

1. Commercial Greenhouse in Europe and in Asia
2. The Philippine Greenhouse Vegetable Industry
3. Opportunities and Challenges in the Philippine Greenhouse Vegetable Business

**TIME ALLOTMENT:** 3 hours

**METHODOLOGIES:** Lecture-participatory discussion

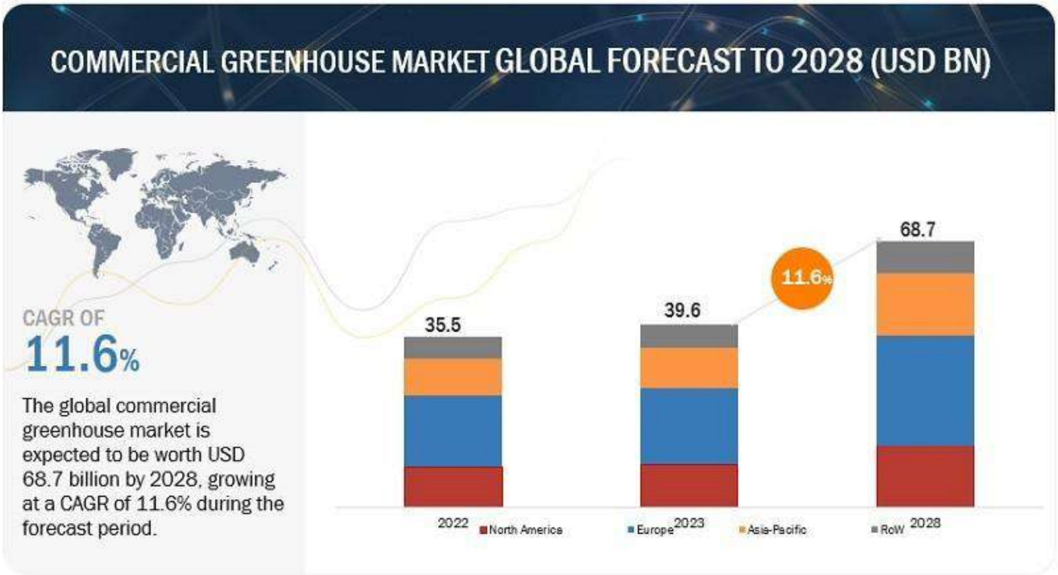
**INSTRUCTIONAL MATERIALS:** PowerPoint presentation

**WORKSHOP OUTPUT:** Market Goal

## A. COMMERCIAL GREENHOUSE IN EUROPE AND ASIA

The global commercial greenhouse market size is projected to reach USD 68.7 billion by 2028 from an estimated USD 39.6 billion in 2023, at a CAGR of 11.6% during the forecast period in terms of value. The global expansion of the commercial greenhouse market is fueled by a confluence of factors that are reshaping the agricultural landscape. Commercial greenhouses provide controlled environments that enable year-round production of crops regardless of external weather conditions. This steady supply of fresh produce aligns with consumer demand for consistent availability of crops year-round, thus augmenting the market of commercial green-houses. Moreover, rising climate variability, including extreme weather events, has led to disruptions in traditional agriculture. Greenhouses offer a way to mitigate these challenges by creating stable and protected growing conditions. These are some of the factors influencing commercial greenhouse market growth.

The global commercial greenhouse market has been experiencing significant growth, driven by several key




factors. Here are some of the main growth drivers:

- **Increasing Demand for Food Production:** As the global population continues to rise, there is an increasing need for sustainable and efficient food production methods. Commercial greenhouses offer controlled environments that enhance crop yields and quality, making them a vital solution to meet this demand.

- **Advancements in Greenhouse Technology:** Innovations in greenhouse design, materials, and climate control systems have made commercial greenhouses more efficient and cost-effective. Technologies such as automated irrigation systems, LED lighting, and advanced climate control systems help optimize growing conditions, leading to better crop yields and reduced operational costs.

- **Growing Popularity of Organic Farming:** There is a rising consumer preference for organic and locally grown produce. Commercial greenhouses provide the perfect environment for organic farming by allowing better control over pests, diseases, and environmental conditions without the use of synthetic chemicals.

- **Government Support and Incentives:** Many governments around the world are promoting sustainable agricultural practices and providing incentives for greenhouse farming. Subsidies, grants, and favorable policies encourage farmers to invest in commercial greenhouse operations.

- **Climate Change and Weather Uncertainty:** Unpredictable weather patterns and climate change are posing significant challenges to traditional farming. Commercial greenhouses offer a controlled environment that mitigates the risks associated with adverse weather conditions, ensuring consistent crop production year-round.

- **Urbanization and Limited Arable Land:** As urban areas expand, the availability of arable land for traditional farming is decreasing. Commercial greenhouses can be set up in urban and peri-urban areas, making efficient use of limited space and bringing food production closer to consumers.

- **High-Value Crops and Specialty Plants:** Commercial greenhouses are particularly beneficial for growing high-value crops and specialty plants, such as flowers, herbs, and exotic fruits, which require specific environmental conditions that can be precisely controlled in a greenhouse setting.

The Netherlands has a worldwide leading position in agriculture technology. According to the World Bank, 53.9 percent of the land area is agricultural in the Netherlands. Despite being small and having a rainy climate, the Netherlands has learned to utilize its land and production systems in an effective and creative way to maximize yields. Due to this, the Netherlands now has a particularly high concentration of specialist greenhouse businesses. According to the official data provided by the Government of the Netherlands, over 90 square kilometers of greenhouses are available in the country. Based on the surface area, this is nearly 3.5 times larger than the greenhouses in Canada. Further, Government's efficient land regulation policies and initiatives with other countries to encourage agriculture are driving the commercial greenhouse market.

In 2008, Mr. Michael Caballes personally witnessed the already advanced commercial greenhouses during Rijk Zwaan Open days at De Lier Netherlands. The height of the typical Dutch Glass Houses ranges up to 6 meter tall. Strict biosecurity protocol is in place even requiring a full PPE suit before entering the greenhouse. Also, they are utilizing an advance controlled environment set-up. Full automation in the greenhouses were employed from auto dosing, climate sensing and data analytics, generating data driven cop production. Irrigation and nutrition, CO2 injection, heating, lighting, ventilation, temperature, and humidity were specifically

***Photo Credits:*** *M. Caballes, 2018*

controlled for different crops. With this set-up, typically they have 80% higher greenhouse crop production than here in the Philippines. For example, the dutch tomato production is 25-30kgs/plant compared to the 3-6kgs/plant in the Philippines.

Furthermore, they have been using supplemental artificial lighting, hydroponics, and use of bees for pollination. Optimized farm operation management were in place with highlights on careful breeding and selection, pest scouting and monitoring, automatic sorting and grading up to direct packaging, palleting and shipping.

## B. THE PHIIPPINE GREEN-HOUSE VEGETABLE INDUSTRY

The Philippines is essentially an agricultural country with a land area of 298,170 km2 (World Bank, 2021), about 47% of which is earmarked for agriculture (Perlas, 2020). Many people in the country are dependent on agriculture as their primary source of income


supporting themselves through farming activities. In 2020, a total of around 13.42 million hectares were devoted to agricultural crop cultivation (Statista, 2022), and this generated a gross value added (GVA) of about 1.78 trillion Philippine pesos (32.4 bn. USD) equivalent to 10.2% of the country's gross domestic product (GDP) (Statista, 2021). The Philippines Statistics Authority (PSA) reported in 2020 that the total number of Filipinos employed in agriculture over a five year reference period was about 9.7 million (PSA, 2021). In Southeast Asia, although rice is the major crop produced and has a significant function in ending hunger and malnutrition (IRRI, 2020), the cultivation of vegetables is one of the main sources of income for millions of Filipino vegetable growers (FAO, 2014); the Crop Production Survey (CPS) estimated that from October to December 2021, 78,849 hectares were utilized for the production of major vegetables and other root crops (PSA, 2021). Generally, Filipinos farmers produce vegetables in the open field, which is imperiled by hostile climatic conditions, pests, and diseases. These factors have impacted food security, food safety, and the quality of produce for a long period of time. Compared to nearby modern countries, the Philippines has not adopted modern technologies to solve the endless food crisis. Filipinos were rated as poor adopters of technology in a report by the Australian Center for International Agricultural Research (ACIAR, 2021). Protected cultivation of vegetables is a technology that is common in many countries for the production of various vegetables irrespective of the season. In the Philippines, protected cultivation is in the development stage, and is not normally practiced among farmers despite its potential for higher yield and safer produce (Gonzaga et al, 2017).

Crop commodities in the Philippines are very low in terms of yield compared to neighboring countries (Dogello and Cagasan, 2021). Thus, Filipinos are at a higher risk for low consumption of vegetables than others in the Southeast Asian region (Peltzer and Pengpid, 2012). In general, low agricultural productivity can be alleviated through government -supported programs such as full access to credit or agricultural loans, and agriculture-related microfinancing for agricultural producers, fisherfolks, and stakeholders since most farmers are incapable of fully financing their crop production costs. Moreover, crop insurance can protect farmers from losses due to natural calamities and biological infestations (Dogello and Cagasan, 2021).

The World Health Organization (WHO) recommends consuming a minimum of 200-250g of vegetables daily to meet the nutrient demand. However, vegetable consumption per capita in the Philippines is below the dietary guidelines (Our World in Data, 2017). Overweight and malnourishment in Filipinos is most likely due to imbalanced nutrition. Thus, the vegetable industry in the Philippines is an important and promising business, with high potential for local consumers and international markets. Producing horticultural crops including vegetables under a protected cultivation system should be required for most vegetable farmers in the Philippines when considering food safety, better yield quality, and food security. Indeed, the Philippines is vulnerable to natural calamities including frequent and strong typhoons. Heavy rainfall varies from 965 to 4,064 mm annually (DOST-PAGASA), furthermore, there are scorching temperatures during summer, pests and disease out-breaks. Furthermore, poor vegetable varieties are cultivated, and farmers have limited skill sets. A further exasperating problem is that farming populations are aging in spite of increasing population numbers. Despite a growth rate of 1.36% (World Population Review, 2022), 24% of farmers are within the 55-64-year-old range while 16% are more than 65 years old (Palis, 2020). Moreover, protective structures such as highly equipped greenhouses require a high investment cost for the initial structure, reflecting technical aspects such as managing temperature, humidity, and irrigation systems together with proper operations (Gruda et al., 2019). Nonetheless, using a protective structure for horticultural crop cultivation in the Philippines have the potential to open up extraordinary opportu-nities for many related industries since various technologies such as organic production, hydro-ponic and aquaponic systems, and smart farming techniques can be applied to the protective structure.

## C. OPPORTUNITIES AND CHALLENGES IN THE PHILIPPINE GREEN-HOUSE VEGETABLE BUSINESS

Agriculture has always been considered to be the backbone of the Philippine economy (Business Mirror, 2021). However, based on the Department of Agriculture (DA) statement, the import-dependency of agricultural products in the country gradually increased in 2016, 2017, and 2018 at 22.5%, 22.7%, and 29.2%, respectively (PSA, 2020). According to the World Bank data, the country imported vegetables valued at USD1034.09 million from the United States (WITS, 2019), and also imported from the ASEAN countries including Malaysia, Indonesia, Vietnam, and Thailand (JICA, 2019). One strategy that can be used to increase the production of vegetables in the Philippines is the intensified use of protective structures. But although protected cultivation was introduced into the Philippines about 40 years ago, greenhouse technology has not been upscaled. Upscaling would potentially safeguard the year-round production of common and high-value vegetables in the Philippines, hence aiding in sustaining the supply of food. The climatic conditions in the Philippines are extremely unfavorable to crop cultivation in the open field, resulting in the inconsistency of crop productivity and quality. In the wet season (June to November), excess rains and high winds are serious issues for growing vegetables in the field causing flooding and field damage (Castillo et al, 2021).

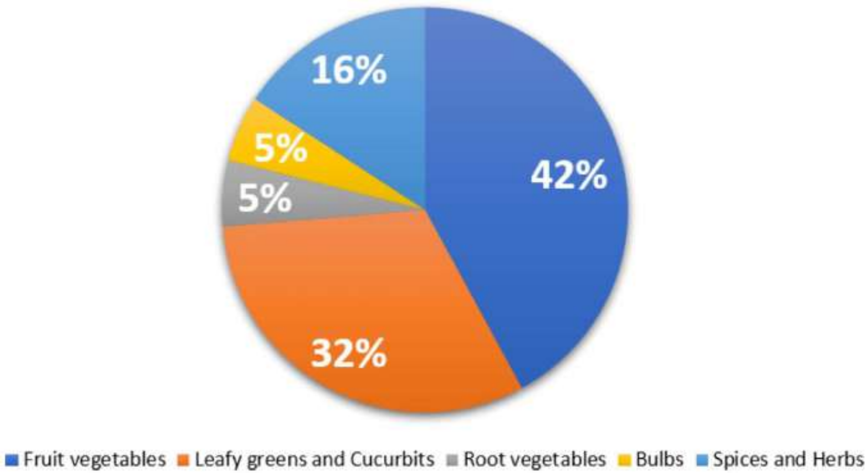
Protected cultivation ensures the protection of the crops from extreme weather conditions as it can relieve the harmful effect of unfavorable environmental conditions for proper plant growth and development. Globally, the area used for protected agriculture for horticultural crops is estimated at 5, 630,000 ha (Cuesta Robles, 2019). In 2011, China had the greatest land area of protected cultivation, with more than 2,760, 000 ha; this area is continuously being increased every year. The second largest area is found in South Korea with more than 57, 444 ha, followed by Spain with 52,170 ha. The Philippines thus has great potential and opportunity for the development of protected cultivation of vegetables.

Most of the Philippines' vegetable crops are cultivated in the open field, leaving the plants exposed to various chemical elements in the surrounding environment. In general, organic vegetable growers in the Philippines, particularly in Central Luzon are small-hold farmers with less than 2 ha of farmland. In a survey conducted in Central Luzon, Philippines, 16.8% of the

72 organic vegetable growers responded that cultivating organic vegetables under protected structures is unaffordable, and it is disadvantageous for farmers due to a lack of knowledge of greenhouse cultivation techniques (Porciuncula, et al. 2015).

Economic analyses of the greenhouse technology demonstration farm in the Central Luzon State University, Philippines using the Israel Negev model showed that the farm was profitable for growing high-value crops such as honeydew melon (Sace, 2002). The study revealed that the payback period would be achieved within 3.34 years for ten cropping seasons with an expected 30% internal rate of return (IRR). This means that the project's initial investment would have earnings of a 30% compound growth annual rate. In addition, a recent study reported that protected cultivation contributes to increased yield and quality of products as well as income for vegetable growers (Castillo, et al. 2021).

Moreover, several vegetables including tomato, sweet pepper, and lettuce were grown under a protective induce a higher gross margin compared to those from open fields. Recently, Basquial,et al. (2021) investigated the effect of low-tunnel and mulch



*Distribution of commonly studied crops under protective structures in the Philippines* on the growth and development of lettuce for alleviating cold stress in Benguet Province, the Philippines. The study showed that lettuce grown in a low-tunnel exhibited a better performance compared to the control grown without the low-tunnel. Researchers attempted to evaluate the feasibility of vegetable production under protected cultivation in the Eastern Visayas. They found that lowcost protective structures for vegetable cultivation are economically feasible once growers are technically skilled in production management (Armenia, et al. 2013).

Generally, greenhouse design is affected by regional climatic conditions. Regardless of the design and type of the protective structure tested, however, higher yields of vegetable crops were observed for vegetables grown in the protective structures compared to those grown in the open field (Capuno, et al. 2015). As the country is continuously hit by typhoons and heavy rainfall associated with flash floods, vegetable crop production in the open field is constrained, thus resulting in low yield and quality of produce. A comprehensive study on the effect of lowcost protected cultivation on the year-round production of vegetables in the Philippines showed that four crops -tomato, sweet pepper, bitter melon, and lettuce – generated significantly higher yields under the protected cultivation condition compared to those directly exposed to heavy rains in the open field.

The commonly studied crops under protective structures in the Philippines are presented in the figure below. Several results determining the crop productivity of fruits and vegetables under protective structures have been reported (Aganon et al., 2004; Sace and Estigoy, 2015; Gonzaga et al., 2016; Gonzaga et al., 2021; Basquial et al., 2021; Poliquit and Aquino, 2022). Increased yield of selected crops grown under protected cultivation systems has been shown in spite of their different designs and operating systems in various locations. The economic analyses of protective structures and greenhouses are feasible and profitable (Sace, 2002; Aganon and Aganon, 2009; Aremia et al, 2013; Capuno et al, 2015; and

Castillo et al, 2021), and the utilization of household greenhouses and environmental control techniques enhance yield and quality of produce (Mojica et al., 2017; Pascual, et al., 2018; Pascual et al. 2019; Rivera, 2016). Out of 19 crops studied, 42% are fruit vegetables such as tomato, eggplant, muskmelon, sweet & chili pepper, and strawberries followed by vegetables with 32% leafy greens and cucurbits, 16% for herbs and spices such as peppermint and sweet basil, and 5% for root crops and bulbs.

## WORKSHOP

The objective of this workshop is to guide participants in developing clear, actionable market goals for their business or product. This workshop will focus on identifying key market opportunities, setting measurable targets, and crafting strategies to achieve them.

**Activity:** Begin with a brief presentation on what market goals are, why they are important, and how they can guide business decisions and growth.

**Discussion:** Ask participants about their current business goals and challenges, particularly in relation to reaching and engaging their target market in their greenhouse business.

**Presentation:** Let each participant to present and discuss in the group their set market goals of their greenhouse business.

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**Lesson 3:**

# Greenhouse Crop Typology Overview

**OBJECTIVES:**

Participants will be able to explain the different cultivars and variety preferences and market specifications of both domestic and international market.

**COVERAGE:**

This lesson covers the following topics:

1. Greenhouse Leafy Vegetable/ Lettuce Crop Typology
2. Greenhouse tomato crop typology
3. Greenhouse Bellpepper crop typology
4. Greenhouse Cucumber crop typology
5. Greenhouse Melon crop typology
6. Greenhouse Eggplant crop typology

**TIME ALLOTMENT:** 2 hours

**METHODOLOGIES:** Lecture-participatory discussion

**INSTRUCTIONAL MATERIALS:** PowerPoint presentation



## A. Greenhouse Leafy Vegetable/ Lettuce Crop Typology

Lettuce crop typology refers to the classification of different lettuce varieties based on their characteristics, such as head formation, leaf shape, and growth habit. This classification helps growers understand the unique traits of each variety and select the most suitable ones for their specific needs.

### 1. Crisp head or Iceberg:

**Characteristics:** Crisp head lettuce, the most recognizable type, forms a tightly packed head of crisp leaves, often associated with the familiar ice-berg lettuce. These varieties have a high-water content and a crisp, crunchy texture.

**Growth Habit:** Crisp head lettuce forms a compact, upright head with a distinct, rounded shape.

**Leaf Texture:** The leaves are thick, crisp, and have a smooth, waxy surface.

**Flavor:** Crisp head lettuce has a mild, slightly sweet flavor.

**Ideal Conditions:** Crisp head lettuce thrives in cool, moist conditions and prefers well-drained soil.

**Examples:** Iceberg, Great Lakes, and Salinas

### 2. Summer Crisp, French Crisp, or Batavia

**Characteristics:** This type is a cross between crisphead and looseleaf lettuce, producing large heads with thick, crisp outer leaves.

**Growth Habit:** Summer crisp lettuce forms a loose, open head with a slightly elongated shape.

**Leaf Texture:** The leaves are thick, crisp, and have a slightly crinkled surface.

**Flavor:** Summer crisp lettuce has a sweet, juicy flavor.

**Ideal Conditions:** These varieties are more tolerant of warmer temperatures than traditional crisphead lettuce and suitable for summer production.

**Examples:** Summertime, Buttercrunch, and Red Sails

### 3. Butterhead, Boston, or Bibb

**Characteristics:** Butterhead lettuce features soft, pale, and waxy leaves that tend to lay low on the soil, forming a loose head.

**Growth Habit:** Butterhead lettuce forms a loose, open head with a slightly rounded shape.
Leaf Texture: The leaves are soft, tender, and have a slightly crinkled surface.

**Flavor:** Butterhead lettuce has a delicate, buttery texture and a mild, sweet flavor.

**Ideal Conditions:** Butterhead lettuce prefers cool, moist conditions and well-drained soil.

**Examples:** Boston, Bibb, and Red Buttercrunch.

### 4. Romaine or Cos

**Characteristics:** Romaine lettuce produces upright leaves that fold in at the top of the head, creating a long-hearted shape.

**Growth Habit:** Romaine lettuce forms a tall, upright head with a distinctive, elongated shape.

**Leaf Texture:** The leaves are crisp, firm, and have a slightly ribbed surface.

**Flavor:** Romaine lettuce has a crisp texture and a slightly bitter flavor.

**Ideal Conditions:** Romaine lettuce is more tolerant of warmer temperatures than other lettuce types and can be grown in a variety of climates.

**Examples:** Romanesco, Parris Island Cos, and Little Gem

### 5. Looseleaf, Leaf, Cutting, or Bunching

**Characteristics:** This type does not form a head or heart, producing loose leaves that can be harvested individually.

**Growth Habit:** Looseleaf lettuce grows in a spreading, bushy habit, producing multiple leaves that can be harvested as needed.

**Leaf Texture:** The leaves can range from soft and tender to crisp and crunchy, depending on the variety.

**Flavor:** Looseleaf lettuce offers a variety of flavors, from mild and sweet to peppery and tangy.

**Ideal Conditions:** Looseleaf lettuce is adaptable to various growing conditions and can be grown in both cool and warm climates.

**Examples:** Black Seeded Simpson, Red Salad Bowl, and Green Salad Bowl

### 6. Summer Crisp/Batavia

**Characteristics:** This type is a hybrid between crisphead and looseleaf lettuce, known for its large heads with thick, crispy outer leaves.

**Growth Habit:** Summer crisp/ Batavia lettuce forms a loose, open head with a slightly elongated shape.

**Leaf Texture:** The leaves are thick, crisp, and have a slightly crinkled surface.

**Flavor:** Summer crisp/Batavia lettuce has a sweet, juicy flavor.

**Ideal Conditions:** These varieties are more tolerant of warmer temperatures than traditional crisphead lettuce and suitable for summer production.

**Examples:** Summertime, Buttercrunch, and Red Sails

## B. Greenhouse Tomato Crop Typology

The tomato is the most popular garden vegetable. Tomatoes come in many shapes, sizes, and colors, but the most popular is the medium-sized (6 to 8 ounces) red globe. Tomato plants require full sun, moderate amounts of fertilizer, staking or caging, and an insect and disease control program. Determinate (short, self-topping) varieties like Celebrity, Mountain Pride, and Mountain Spring are gaining in popularity, but the indeterminate varieties like Better Boy are used more widely.

Most tomatoes are set out as transplants, since it takes several weeks longer to harvest from tomatoes planted as seeds. Do not set out transplants too early in the spring. Cool soils as well as cool air temperatures chill plants, resulting in delayed harvest. Use a starter solution when setting the transplants. If transplants have small fruit at planting time, remove fruit to prevent stunting the plants.

Plants set out in spring are sometimes maintained through the summer in hopes of a fall crop. With mulching, irrigation, fertilization, and a good pest control program, this is possible, but the fall fruit that develop are frequently small. This results from failure to maintain a season-long pruning program. A second planting of tomatoes for a fall crop provides large, attractive fruit. Start seedlings in June and set plants out in July or early August. You can use rooted cuttings (suckers) that were removed in pruning to start a second planting.

Set tomato transplants deeper than they were growing in the plant bed, peat cup, or plastic tray; the deeper the better.

All garden tomato plants, indeterminate as well as determinate, must be supported off the ground in some manner to prevent loss of fruit to rots and sunburn. Wooden stakes, placed at planting time or shortly after, are the most common type of support.

**Varieties**

1. Amelia—large-fruited with tomato spotted wilt virus resistance; D.
2. Better Boy—VFN hybrid; 8- to 12-ounce red fruit; 72 days; I.
3. Big Beef—large-fruited beef stake with good disease resistance; I; AAS 1994 .
4. Celebrity—VFNT hybrid; 7- to 8-ounce red globe; firm, flavorful fruit; D; 72 days; AAS 1984.

5. Cherry Grande—VF hybrid; large cluster of 11⁄2-inch firm, round, red fruit; D; 60 days.
6. Floramerica—VF hybrid; 8- to 12-ounce red fruit; 76 days; D; AAS 1978.
7. Floradel—F; 8-ounce red fruit; 75 to 85 days; I; old variety; open-pollinated.
8. Marion—F; 6-ounce red fruit; 79 days; I; old; open-pollinated.
9. Mini Charm—miniature cherry tomato with indeterminate growth and abundant production.
10. Mountain Spring—VF hybrid; early; resistance to cracking; D.
11. Park's Whopper—VFNT hybrid; large fruit; I; 70 days.
12. Super Fantastic—VF hybrid; 8-ounce red fruit; 70 days; I.
13. Sweet 100—hybrid; large clusters of 1-inch, round, red fruit; I; 65 days.

## C. Greenhouse Cucumber Crop Typology

Capsicum (Capsicum spp.), also called as pepper, is a main vegetable and spice crop originated in the American tropics and today cultivated all over the world for fresh, dried, and processing products. Around the genus Capsicum there is an increasing interest and fascination due to the considerable variation for several traits, which makes this crop extremely versatile and suitable for innumerable uses as food and non-food products. The genus Capsicum includes over 30 species, five of which (C. annuum, C. frutescens, C. chinense, C. baccatum, and C. pubescens) are domesticated and mainly grown for consumption. A large number of accessions of domesticated and wild species are stored in the world seed banks, representing a valuable resource for breeding in order to transfer traits related to resistances to various abiotic and biotic stresses as well for quality improvement. The recent advances in terms of genetic and genomic knowledge will help to unlock the potentiality of these resources.

World pepper production has grown considerably over 20 years from 2 to about 4.5 million tons of dry types and from over 17 to 36 million tons as fresh. The area


harvested followed a similar trend, with an increase of the surface cultivated area of about 35% in the last 20 years, being today about 3.8 million of hectares. Fresh pepper is cultivated in 126 countries of the world in all the continents. The world's largest producer is China with over 18 million tons annually, followed by the Mexico with about 3.5 million tons (FAOSTAT 2017). Dry pepper is cultivated in 70 countries and no relevant production is reported in Oceania. India is the largest producer with about 2.0 million tons, followed by Thailand (349.615 tons). Peppers are grown almost all over the world and are fairly easy to cultivate both in the field and in the greenhouse in a wide range of climatic and environmental conditions. Africa, Europe, and America contribute in the same proportion to the total world production (about 10–12% each) for fresh pepper; while for dry pepper, Asia and Africa are the main producers contributing to the 70.3 and 21.2%, respectively. The economic value of pepper production has increased since 1991 becoming a good source of income for producers in many countries and giving an important role in international trading. The present worth of dry pepper is 3.8

billion dollars, while fresh pepper contributes with 30,208 billion dollars. For both, the increase observed over the past 25 years is four times higher in dry pepper and six times higher in fresh pepper. Around the genus Capsicum, there is an increasing interest and fascination due to the amazing diversity in many characteristics, such as plant architecture, flower morphology, fruit typology, colors, pungency, and qualitative traits which make this crop extremely versatile and suitable for innumerable uses. As food, a variety of recipes are ensured thanks to the presence of sweet and hot types. The former are mainly widespread in temperate regions of Europe and North America where they are used freshly or cooked as vegetables. The latter are instead mainly spread in the tropical regions of America, Africa, and Asia, where they are mostly consumed fresh or dried as condiment as spice in powder or salsa in many dishes. Food uses of peppers could then be summarized in the following classes: (a) fresh use, of immature green fruits, mature red fruits, and leaves; (b) fresh processing, for sauces, pastes, pickles, beer etc.; (c) dried spices, from mature whole fruits and powder (Poulos 1994). Based on pod shape and size, more than 20 market types (e.g. bell, cayenne, ancho, jalapeño, pasilla, Hungarian wax, jwala, and Thai) are commercially cultivated. Furthermore, within each of these market types, there may be several variants; for instance, bell may have blocky, conical, or mini pods and cherry bell may have small or big pods.

## D. Greenhouse Cucumber Crop Typology

**Plant:** The cucumber, Cucumis sativus, is a creeping vine (climbing or sprawling) that roots in the ground and grows up trellises on other supporting frames, wrapping around ribbing with thin, spiraling tendrils. Cucumber plants are annual plants, surviving only one growing season and the vines can reach up to 5 m in length. The plant may have 4 or 5 main stems from which the tendrils branch.

**Leaves:** The plant has large leaves that form a canopy over the fruit. The leaves of the plant are arranged alternately on the vines, have 3-7 pointed lobes and are hairy; branched tendrils at leaf axes support climbing.

**Flowers:** Cucumber plants are tendril bearing vines with triangular prickly hairy leaves and yellow flowers which are either male or female. The male flowers are in clusters with short, slender pedicels. The female flowers are usually solitary with stout, short pedicels. Female flowers are yellow with 5 petals, and develop into a cylindrical fruit, which may be as large as 60 cm long and 10 cm in diameter. The color ranges from green to yellow to whitish; in many varieties, fruits are bicolored with longitudinal stripes from stem to apex. The female flowers are recognized by the swollen ovary at the base which will become the edible fruit. Traditional varieties produce male blossoms first, then female, in about equivalent numbers. New gynoecious hybrid cultivars produce almost all female blossoms. However, since these varieties do not provide pollen, they must have a pollenizer variety interplanted with them, and the number of beehives per unit area is increased.


**Fruits:** Having an enclosed seed and developing from a flower, cucumbers are scientifically classified as fruits. It should be noted that vegetable is a purely culinary term and as such there is no conflict in classifying cucumber as both a fruit and a vegetable. Cucumbers are usually more than 90% water. The flesh of cucumbers is firm and crisp, and really not very sweet, but delicious nevertheless. Cucumbers grown to be eaten fresh (called slicers) and those intended for pickling (called picklers) are similar.

## E. Greenhouse Melon Crop Typology

There are many types of melons that come in all shapes, sizes, and colors. Varieties of melon such as honeydew melons, cantaloupes, and watermelons are among the most popular kinds of melons consumed in summer. Melons originated in South Asia, Africa, India, and Iran and have been cultivated for thousands of years. Melons are botanically a type of berry in the Cucurbitaceae family of fruit. Melons can be oblong, oval, perfectly round, have rough jagged skin or smooth skin. The juicy flesh in melons can be orange, yellow, red, pink, or green. Some melon varieties are small enough to easily hold in the palm of your hand. Other kinds of melons can grow to a weight of more than 90 kg.

All types of popular melons are rich sources of vitamins, minerals, and essential nutrients. Also, the flesh of melons contains a lot of water and fiber, therefore, they are also very good for your digestion.

### Muskmelons (a species of melon)

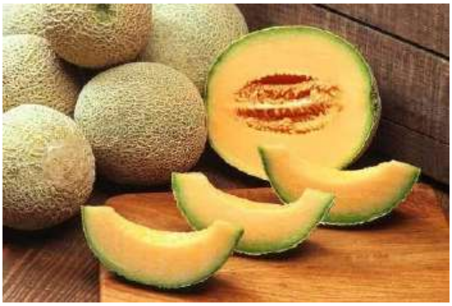
Muskmelon (*Cucumis melo)* is a variety of melon. This variety of melon includes a number of melon cultivars such as cantaloupes, honeydews, casaba, and Persian melons.

Some types of muskmelons are smooth-skinned varieties whereas others have light to pronounced netting over their green skin.

### Canary Melon


The Canary melon has bright smooth yellow skin, an oval elongated shape, and has a mildly sweet taste. The name of this type of melon comes from the fact that the yellow skin resembles the canary bird. Slicing a Canary melon in half reveals soft light green or creamy-yellowish flesh that is similar to a pear but tastes much sweeter. Some people describe the flavor as mildly tangy when compared to a honeydew melon. When this type of melon is ready to eat, the flesh will be extremely juicy and succulent and not too sweet. Similar to honeydew melons, all the salmon-colored seeds in this golden melon are in the center of the fruit. You know when a Canary melon is ripe when the melon looks bright yellow without any hints of green on it. Also, check the rind as it should have a waxy feel to it when fully ripe. Canary melons grow to about 4 or 5 lb. (1.8 – 2.2 kg).

### Cantaloupe Melon



Cantaloupe melon (*Cucumis melo var. cantalupo)* with their netted green and beige skin and deliciously sweet orange flesh are one of the most popular types of melon. This type of melon came to the US and Europe from Asia in the late 1800s. European cantaloupes and North American cantaloupes are both round types of melon that have an unusual peel. The mesh-like markings and dark stripes on some types of cantaloupes may resemble the look of a basketball.

Cantaloupe melons are actually a type of muskmelon that have a floral aroma. The green rind covers light-orange flesh that is very sweet and juicy. The best way to eat these wonderful melons it to chop the flesh and eat it raw.

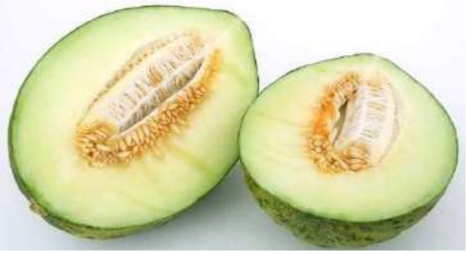
Many experts agree that green cantaloupes are unique among all the varieties of melon due to their smooth silky texture and aromatic fragrances. If you want to know how succulent a fresh cantaloupe is, compare its weight with similar melons. The heavier the fruit, the more succulent it will be. Ripe cantaloupes should give off a delightful floral aroma and be very slightly soft to touch. These ball-shaped green beige melons can grow between 1 lb. and 11 lb. (0.45 – 5 kg).

Other types of cantaloupe melons include the Asian Cantaloupe with lightly netted green skin and the Infinite Gold cantaloupe with dark orange flesh. One Israeli type of melon is the Galia cantaloupe with green flesh and a distinct banana aroma.

### Ananas Melon (a Variety of Muskmelon)

The Ananas type of muskmelon has an oval rather than round shape as the cantaloupe has. These are very juicy muskmelons that have pale creamy flesh and a smooth texture. “Ananas” is actually the name for pineapple in many European languages. Of course, pineapples aren’t melons; however, the name well describes the pleasant pineapple aromas that come from a perfectly ripe Ananas melon.

### Honeydew Melon



Honeydew melons are oval-shaped with pale green peel and flesh of a similar color. Honeydews are at their sweetest when left to ripen fully on the vine. Being a type of muskmelon, honeydews (also called honeymelons) have silky smooth flesh that tastes wonderful. Unlike types of cantaloupes, honeymelons don’t have brightly colored flesh. However, that doesn’t detract from the fact that these are a deliciously sweet type of melon.

Honeydews are one of the most popular types of winter melons available in North America. This is due to their long shelf life and exceptional sweetness when they have been allowed to ripen slowly.

To tell when a honeydew melon is ripe and ready to eat, gently press the blossom end of this pale green fruit to see if it gives lightly fruity aroma.

Honeydew melons generally range in weight from 4 to 8 lb. (1.8 to 3.6 kg). In many countries, you can expect to find these muskmelons in stores all year round.

## Watermelon

The watermelon (*Citrullus lanatus)* is one of the largest types of melon. This is a green-skinned melon that often has dark-green stripes. The thick melon rind hides vibrant red melon flesh that is very succulent.

The most common type of watermelon is the kind with red or pink colored flesh. However, you can also find varieties with orange or even yellow flesh. Most types of watermelon have lots of seeds throughout the flesh, although seedless watermelons are also becoming more popular. Watermelons definitely belong on the list of large types of melon. In some cases, they can grow up to 24" (60 cm) in diameter and weigh between 20 and 51 lb. (9 – 23 kg).

## Korean Melon

Korean melon is a type of small melon. Korean melons are a yellow type of oval muskmelon with light stripes on the skin and light-colored flesh. Unlike many types of muskmelons, Korean melons have smooth yellow skin and white, almost translucent, crisp flesh. This bright yellow melon is incredibly sweet and some say it tastes similar to honeydew melons or pears. One of the interesting facts about Korean melons is that their skin is so thin that it is edible. Just make sure to thoroughly wash the melon if you plan on eating it with its skin.

Despite being a small variety of melon, Korean melons are still very popular due to their unique taste. A ripe Korean melon can weigh around 1.5 lb. (700 g) and only be about 5" (12.5 cm) long.

## Santa Claus Melon

Santa Claus melons are a large oval green variety of melon

with pale-green flesh and a thick dark blotchy rind. Some say that the color of the Santa Claus melon skin (also called Christmas melon) looks like a watermelon but it has the shape of a canary melon. However, the skin on some varieties of this type of melon can also be a greenish-yellow color.

The light green flesh in the melon is mildly sweet and tastes similar to a honeydew melon. You can usually tell which are the sweet varieties of Santa Claus melons by the color of the rind – the yellower the color, the sweeter the taste. To tell if this kind of melon is ripe, you should gently squeeze the blossom end to see if it gives slightly. Due to the thick green/yellow skin, there is little aroma from fully ripened Santa Claus melons. These large green melons can weigh up to 9 lb. (4 kg).

## Honey Globe Melon

Honey Globe melons are a large and white type of melon with pale green flesh and a round to oval shape. The white melon's webbed rind can sometimes have markings of green lines on it. This gives the melon a very striking look when compared to other green and yellow types of melon.

Many describe this type of melon as one of high quality and extremely sweet. And it's the delicious taste of the Honey Globe that sets this apart from other melons.

The light green flesh is thick and succulent and, because over 15% of its weight is sugar, it's one of the sweetest melons. Biting into chunks of Honey Globe melon, you will find that the flesh is chewable and tender. Expect the average Honey Globe melon to weigh around 4 lb. (1.8 kg)

## Valencia Melon

Valencia melons have an elongated oval shape with thick dark green skin and pale white juicy flesh. The Valencia melon originates in Spain and looks like a shorter version of the Santa Claus melon. Biting into succulent chunks of Valencia melon you will find that the flesh is sweet, tender and very refreshing.


Image: ProjectManhattan - Wikimedia Commons

Due to the thick melon skin, it has a very long shelf life and is still edible in December and January. This is the reason why this variety is also called the Valencia Winter melon.

One unusual type of melon is a variegated Valencia melon. This melon variety has striking yellow and dark green markings on its thick skin.

## Sprite Melon

The pale-yellow colored Sprite melon is one of the smaller types of melons that has firm succulent flesh. Sprite melons originate from Japan and they are now widely grown in North Carolina. Compared to other melons, the Sprite melon is one of the sweetest melons you can buy. This is due to the ivory-colored flesh containing 18% sugar, which is nearly one-quarter more than other melons. It is also one of the smallest melons you can buy with its average size being that of a grapefruit.


Image: Night Ranger - Wikimedia Commons

The yellowish skin has a netted-look similar to cantaloupes but a sweet taste similar to honey-dews. However, as already mentioned, cantaloupes and honeydews can compete with this small compact melon when it comes to sweetness. The small type of melon weighs between 1 and 1.5 lb. (0.5 to 0.7 kg).

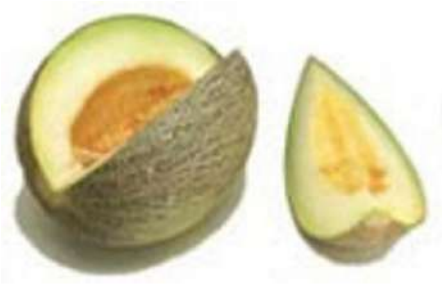
## Jade Dew Melon

Jade Dew is a delicious type of melon that has pale-yellowish flesh and a sweet crunchy taste. This medium-sized oval-shaped melon has a pale semi-webbed rind that covers its delightfully tasty flesh. Unlike some types of cantaloupes, the Jade Dew melon has a distinct crunch when you bite into its flesh. Expect a fully ripened Jade Dew melon to weight about 4.4 lb. (2 kg).

## Crenshaw Melon

Crenshaw melon has light yellow and green coloring on its hard rind. Compared to other regular melons, the Crenshaw melon has an unusual shape. It is somewhat spherical with a flattened bottom at the blossom end and tapered pointed top at the stem end. Slicing this yellowish melon, you will find it has creamy tender flesh that is the color of light peaches. The taste of the Crenshaw melon is very sweet with slightly spicy overtones. A regular Crenshaw melon will weigh on average between 8 and 10 lb. (3.6 to 4.5 kg).

## Sharlyn Melon



Sharlyn melons are a type of oval muskmelon that have the typical webbing of many cantaloupes on the surface of their light-orange skin. One of the differences between Sharlyn melons and cantaloupes is that they are not as sweet. The pale orange flesh is creamy and fruity without being overly sweet. Some say that Sharlyn melons resemble the taste of pineapples. The orange color of their skin is one of the signs that a Sharlyn melon is ripe. The thin skin and firm flesh should give a little when you press it. Sharlyn melons are among the larger melon varieties with their average weight being between 6 and 9 lb. (2.7 to 4 kg).

## Snow Leopard Melon


The Snow Leopard melon is an exotic type of melon that has ivory colored skin with green markings on it. Sometimes called the Ivory Gaya, this type of small oblong melon has creamy white flesh that is very soft and extremely juicy. Many say that the sweet taste of Snow Leopard melons has honey and pear overtones. To tell if a Snow Leopard Melon is ripe, it should give off a rich melon aroma and the light-colored skin should give slightly when pressed. This small variety of melon weighs around 2 lb. (0.9 kg) when ripe and ready to eat.

## Horned Melon

The Horned Melon (*Cucumis metuliferus)* with its vibrant orange skin and soft spikes is one of the most unusual melons you will come across. This type of spiky melon originates in South Africa but is now gown in many countries around the world. It is also called Kiwano, the African Horned Cucumber, the jelly melon, and spiked melon. When you cut open a horned melon, you will find that the gelatinous lime-green flesh is full of edible seeds. The fruity taste of Horned melons is surprisingly refreshing. In many ways, the Horned melon is unlike any other type of melon when it comes to texture. Rather than having firm tender flesh like cantaloupes or honeydews, it resembles the texture of passion fruits or pomegranates.

Apart from being one of the most unusual melons you can find, it is also one of the smallest. An average Horned melon is only 3.5” (9 cm) in length and weighs just over 7 oz. (0.2 kg).

## Bitter melon

Bitter melon is a type of melon with a bitter taste, elongated shape and a dark-green skin Bitter melon (*Momordica Charantia)* was originated from South India and is grown in Asia, Africa, and the Caribbean. There are different cultivars of this type of melon in a variety of shapes and sizes.

The bitter melon cultivar is common in China has long shape which becomes narrower at the ends. This type of bitter melon is usually 20–30 cm (7.9–11.8 in) long and has light green color with light-ly bumpy skin. The bitter melon cultivar which is more common in India is narrower with pointed ends, and the surface is bumpier than the Chinese cultivar with more prominent ridges. It is usually darker shade of green. Some cultivars of bitter melon have miniature size of 6–10 cm (2.4–3.9 in), which are often used as stuffed vegetables. Bitter melon is commonly used in Asian cuisine.

## F. GREENHOUSE EGGPLANT CROP TYPOLOGY

Eggplant is an annual in temperate zones and perennial in the tropics. This plant is a warm-season frost-tender perennial that can be grown as an annual. Eggplants usually grow from 2-4 feet tall with many branches and large, rangy leaves. Eggplant leaves are, alternate and lobed, with the underside of most cultivars covered with dense wool-like hairs. The flowers are violet-colored, star-shaped, and bloom either as a


solitary or in clusters of two or more. These characteristics give the plant an ornamental look.

The fruit can vary in shape from oval to round and long to ob-long. Most growers and con-sumer are accustoming to seeing the mature fruit that is shiny pur-plish black, oval or pear shape. However, the mature fruit can be red, yellowish-white, or green. The purplish black eggplants can be bitter with thick tough skins and fibrous flesh or mild-sweet with thin tender skin and non-fibrous flesh. The white skin eggplant is firmer, drier and milder tasting but has a very thick skin that must be peeled prior to eating.

## REFERENCES:

***Insert here***




# MODULE 3
## Greenhouse Pests and Diseases Management

# MODULE OVERVIEW:

Greenhouse environments provide controlled conditions for growing crops and create ideal habitats for pests and diseases. Integrated Pest Management (IPM) is a sustainable approach that combines biological, cultural, mechanical, and chemical control methods to minimize crop loss while ensuring environmental safety. This module will cover major greenhouse pests and diseases, mitigation strategies, biosecurity measures, and the importance of scouting and monitoring.

Greenhouses provide an ideal microclimate for plant growth but can also harbor pests and diseases that thrive under controlled conditions. This lesson will explore identifying these threats, assessing their impact, and developing proactive management strategies that minimize damage while promoting plant health.

This module covers the following topics:

- Introduction to Greenhouse Pests and Diseases
- Greenhouse Pest and Disease Management
- Greenhouse Biosecurity Protocols
- Scouting and Monitoring Techniques
- Workshop on Pest and Disease Identification, Strategy and Recommendation

# Lesson 1: Introduction to Greenhouse Pests and Diseases

### OBJECTIVES:

At the end of this lesson, participants will be able to explain the major pest and diseases in the greenhouse and how to create mitigation strategies to manage its population and prevent significant crop loss.

### COVERAGE:

This lesson covers the following topics:

1. Major Greenhouse Pests on Fruit Crop
2. Major Greenhouse Diseases on Fruit Crop
3. Factors Affecting Pest and Disease Build Up
4. Workshop Database on Pesticide

**TIME ALLOTMENT:** 4 hours (Lecture-Discussion) | 2 hours (Workshop)

**METHODOLOGIES:** Lecture-Discussion, Workshop

**INSTRUCTIONAL MATERIALS:** PowerPoint presentation

## DISCUSSION

Greenhouse crops face challenges from **insects, fungi, bacteria, and viruses**. Unlike open-field agriculture, the enclosed greenhouse space can cause **rapid pest proliferation** if left unchecked. Participants will learn how to **differentiate common greenhouse pests** such as aphids, thrips, whiteflies, and spider mites, and recognize **early signs of fungal and bacterial diseases** such as powdery mildew and bacterial wilt.

## PRACTICAL EXAMPLE

**Case Study:** A greenhouse growing tomatoes experiences a sudden outbreak of aphids. Participants will discuss how to detect, diagnose, and respond to this problem using IPM principles.

***(Reference:*** *Greenhouse Insect Pest Management Guide)*

# Lesson 2:
# Greenhouse Pests and Diseases Management

## OBJECTIVES:

At the end of this lesson, participants will be able to establish integrated pest and disease management strategies, scouting and monitoring protocols, and identify important pests and diseases for fruit crops.

## COVERAGE:

This lesson covers the following topics:

1. Principle of IPM in the Greenhouse
2. Pest and Disease Scouting and Monitoring Strategies
3. Chemical Control Strategies

**TIME ALLOTMENT:** 2 hours

**METHODOLOGIES:** Lecture-Discussion

**INSTRUCTIONAL MATERIALS:** PowerPoint presentation

## DISCUSSION

Participants will be introduced to **Integrated Pest Management (IPM)**, which combines multiple strategies for controlling pests and diseases sustainably. This session will cover:

- **Biological control:** Using beneficial insects like predatory mites and ladybugs to reduce pest populations naturally.
- **Cultural control:** Maintaining proper sanitation, rotating crops, and selecting resistant plant varieties.
- **Mechanical control:** Installing sticky traps, insect-proof screens, and hand-picking pests.
- **Chemical control:** Responsibly applying pesticides to prevent resistance buildup.
- **Weed Management:** Understanding how weeds serve as alternative hosts for pests and implementing chemical and non-chemical weed control measures.

## PRACTICAL EXAMPLE

**Demonstration:** Using sticky traps to monitor insect populations and interpret the results to determine the severity of infestation.

*(**Reference:** ST2 - IPM Scouting and Monitoring in Greenhouses, ST1 - Integrated Pest Management for Greenhouse Crops, ST3 - Weed Management Strategies in Greenhouses )*

# Lesson 3: Greenhouse Biosecurity Protocol

### OBJECTIVES:

At the end of this lesson, participants will be able to explain the importance of bio-security protocol on farm operation and greenhouse management

### COVERAGE:

This lesson covers the following topics:

1. Establishing a Bio Security System for Greenhouse
2. Do's and Don'ts in and out of a greenhouse

**TIME ALLOTMENT:** 1 hour

**METHODOLOGIES:** Lecture-Discussion

**INSTRUCTIONAL MATERIALS:** PowerPoint presentation

## DISCUSSION

Biosecurity is a **preventive approach** that limits pest and disease introduction into the greenhouse. Topics include:

- **Quarantine procedures** for new plant materials before introduction into the main greenhouse.
- **Sanitation measures**, including proper cleaning of tools, benches, and walkways.
- **Restricted entry protocols** to minimize contamination by workers and visitors.
- **Proper waste management** to eliminate plant debris that could harbor pests.

## PRACTICAL EXAMPLE

**Simulation:** Participants will develop a **biosecurity checklist** for their greenhouse and assess potential weak points.

(***Reference:*** *ST1 - IPM in the Greenhouse Series, ST2 - Pest Management Practices in Greenhouse*)

# Lesson 4: Scouting and Monitoring

## OBJECTIVES:

At the end of this lesson, participants will be able to explain how scouting and monitoring can help prevents uncontrollable disease and pest infection and infestation.

## COVERAGE:

This lesson covers the on-field disease and pest identification.

**TIME ALLOTMENT:** 1 hours

**METHODOLOGIES:** Field Work

**INSTRUCTIONAL MATERIALS:** PowerPoint presentation

## DISCUSSION

Scouting and monitoring are critical for early pest detection. This session will cover:

- **How to conduct a systematic scouting routine** in the greenhouse.
- **Types of scouting tools**, including sticky traps, hand lenses, and digital monitoring systems.
- **Threshold levels** that determine when control measures should be applied.

## PRACTICAL EXAMPLE

**Hands-on Activity:** Participants will inspect real plants, identify signs of pest activity, and record their observations.

*(**Reference:** ST2 - IPM Scouting and Monitoring in Greenhouses )*

## Lesson 5:
## Workshop on Pest and Disease Identification, Strategy, and Recommendation

**OBJECTIVES:**

At the end of this lesson, participants will be able to identify greenhouse pest and disease and to create mitigation control and management of pests.

**COVERAGE:**

This lesson covers formulating a holistic system approach on pest and disease management in a greenhouse.

**TIME ALLOTMENT:** 2 hours

**METHODOLOGIES:** Workshop

**INSTRUCTIONAL MATERIALS:**
Pest and Disease Strategy and Recommendation

### DISCUSSION

Participants will analyze **real or simulated pest and disease samples** and develop control strategies. They will also work in groups to **develop action plans** for different pest and disease scenarios in greenhouses. Key areas include:

- Identifying the pest or disease.
- Selecting appropriate management strategies.
- Implementing control measures while considering economic feasibility and environmental safety.

### PRACTICAL EXAMPLE

**Case Study:** Managing a **whitefly infestation in tomatoes** using IPM techniques.

*(**Reference:** ST2 - Pest Management Practices in Greenhouses )*

## REFERENCES AND RESOURCES:

ST1 - Integrated Pest Management for Greenhouse Crops

ST2 - IPM Scouting and Monitoring in Greenhouses

ST1 - IPM in the Greenhouse Series

ST2 - Pest Management Practices in Greenhouses

ST3 - Weed Management Strategies in Greenhouses

Greenhouse Insect Pest Management Guide

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