Agricultural Science

Year 1

SECTION

3

INTRODUCTION TO VEGETABLE CROPS AND ORNAMENTAL PLANTS

NEW DAWN IN AGRICULTURE

Misconceptions and prospects in agriculture and farming

Emerging technologies in agriculture.

INTRODUCTION

Have you observed some people in your community growing and selling vegetable crops and ornamental plants? As a young entrepreneur, producing vegetable and ornamental plants in Ghana can be a rewarding and profitable venture. Ornamental plants are used to enhance the landscape in many new homes and with the right skills and knowledge, you can turn it into a successful enterprise. In this section, we will first explore the characteristics of successful start-up packages for vegetable crop and ornamental plant enterprises. Also, this section seeks to help learners catalogue the characteristics and patterns of the successful growth of vegetable crops and ornamental plant enterprises. The relevance of this section is to help you acquire the knowledge and skills on how to successfully produce vegetable crops and ornamental plants at a lower cost to entice more Ghanaians to buy these plants. This section will also introduce you to some innovations and emerging technologies improving agricultural production worldwide. It will also help you evaluate the applications of these technologies in the production of vegetable crops and ornamental plants. You will look at the use and importance of tissue culture in vegetable crop and ornamental plant enterprises. By the end of this section's learning journey, you will be able to identify and explain various emerging technologies used in agriculture, such as greenhouses, smart farming, automation and many others. The relevance of this section is to help you acquire knowledge on emerging technologies used to make growing vegetable crops and ornamental plants easier. Again, this section seeks to enhance your appreciation for innovation and technology, and how they improve resource efficiency, enhance plant health and increase crop yield.

At the end of this section, you should be able to:

- Identify characteristics of successful start-up packages of vegetable crop and ornamental plant enterprises.
- Catalogue the characteristics and patterns of growth of successful vegetable crop and ornamental plant enterprises.
- Explain the use of selected emerging technologies in vegetable crop and ornamental plant enterprises.
- Appraise emerging technologies in vegetable crop and ornamental plant production.
- Grow vegetable crops and ornamental plants using known procedures and technologies.

- Describe the use and importance of tissue culture in vegetable crop and ornamental plant enterprises
- Identify other emerging technologies used to make growing of vegetable crops and ornamental plants easier.

Key Ideas

- **Start-up packages** refer to a set of resources, tools, and services provided to individuals or groups who are starting agricultural ventures.
- **Vegetable crop:** This refers to a plant that is grown for its edible parts, such as leaves, stems, roots, tubers, or fruits, and is cultivated for commercial or home garden use (Rubarzky & Yamaguchi, 1997).
- **Ornamental plant:** This refers to a plant that is grown for its decorative features, such as its flowers, foliage, or overall appearance, and is cultivated for aesthetic purposes (Gilman, 2015).
- **Enterprise:** A commercial business or organisation that engages in the production or sale of goods or services to make a profit (Oxford Learner's Dictionaries, 2023).
- **Economies of scale** refer to the production of more units of a good or service on a large scale with fewer input costs.
- **Farm hands** refer to individuals who assist with various agricultural tasks or operations on the farm.
- **Production efficiency** refers to the ability of an enterprise to produce goods or services at the lowest possible cost.
- **Emerging technologies:** Emerging technologies are new developments that are used in agriculture and other industries to drive progress and innovation.
- **Hydroponics:** Hydroponics is a method of growing vegetables on water surfaces, without the use of soil.
- **Tissue culture:** This is the growth of tissue or cells in an artificial medium, separate from the parent organism. This technique is also known as **in vitro cultivation**.
- **Greenhouse planting:** This is a technique for growing plants in a controlled environment, often used to improve growth conditions and extend the growing season.
- **Genetically Modified Organisms (GMOs):** A GMO is a plant, animal, or microorganism that has had its genetic material (DNA) altered using technology. This usually involves the transfer of specific parts of DNA from one organism to another, a process known as genetic engineering.
- **Genetic engineering:** This is a method of altering or interacting with genetic structures to modify the characteristics of an organism.
- **Blockchain (chain of trust):** Blockchain is a technology that tracks information about plants, such as seed quality, crop growth, and the journey of the harvested crop after it leaves the farm.
- **A clone:** A clone is a genetically identical copy of a plant, animal or microorganism. Cloning in some organisms like bacteria and some plants occurs naturally. In most organisms, cloning is done artificially using genetic engineering techniques.
- **Hormones:** Hormones are chemical substances or messengers that help to regulate various bodily functions such as growth and development in organisms. In plants, they are referred to as plant growth regulators. They are added to the medium to promote cell

growth and root formation. Examples of plant hormones include auxins, cytokinins, gibberellins and ethylene.

- **Smart farming:** This refers to the use of advanced technologies like sensors, Global Positioning System (GPS), and data analysis to optimize crop growth, reduce waste, and improve farming efficiency.
- **Remote-control technology:** This in agriculture allows farmers to control and monitor farm equipment, drones, and other devices from a distance.

START-UP PACKAGES FOR VEGETABLE CROP FARMING IN GHANA

A start-up package for farming normally refers to a collection of resources, tools, and services provided to individuals or groups embarking on agricultural ventures. The purpose of such a package is to equip aspiring farmers with the essential resources, knowledge, and support needed to launch their agricultural enterprise and enhance their chances of success in the competitive farming industry. The exact components of a start-up package can vary depending on the organisation offering it and the type of farming proposed, such as crop farming, livestock rearing, or aquaculture.

The package may include:

1. **Market assistance**: The market should be the first consideration, as farmers must know where to sell their produce before starting production. This is essential because vegetables grow quickly and are perishable, meaning they spoil easily. Therefore, the farmer must identify potential buyers or market channels before beginning cultivation. Market assistance is vital in helping farmers find suitable buyers for their produce.

Fig. 3.1: Picture of a lady buying vegetables at a grocery shop.

2. **Capital/financial support:** The amount of money and resources a farmer needs to begin production depends on the scale at which they plan to operate—whether small, medium, or large. Farmers should have access to loans or grants to support their initial investment. They may seek financial assistance from banks, cooperative societies, or local money lenders to secure the funds required to start production.

Fig. 3.2: Picture of an example of a bank where farmers can go for a loan

3. **Access to a designated area for farming activities, land selection, and soil type and quality:** A start-up package may provide aspiring farmers with a lease on a piece of farmland, allowing them to cultivate crops or raise livestock on the premises without an outright purchase of the land. Soil characteristics, such as topography, water content and water holding capacity, soil type, and fertility of soil, must be carefully studied before starting production. Topography is the slope of the land and must be considered when selecting a site, as this influences the growth rate and survival of vegetables.

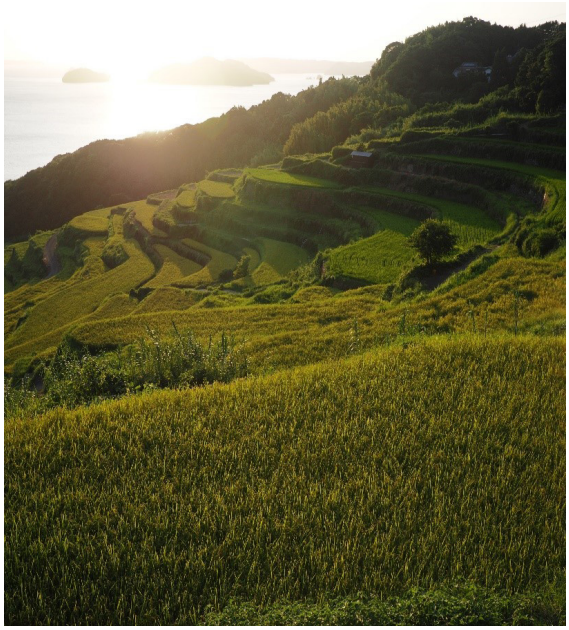

Fig.3.3: A piece of farmland

4. **Kind of vegetables or ornamental plants to grow/assorted seeds:** The farmer should conduct a feasibility study to determine the type of vegetables to cultivate, considering factors such as where to get seeds or vegetative propagules (for example, bulbs, corms, runners, tubers, etc.), ready markets, resources, diseases, and pests that affect vegetables and ornamental plants in the area. The farmer should consider which vegetables are most resistant to pests and diseases common in his/her area and invest in them unless he/she is willing to spend a lot of money on controlling these pests and diseases.

Fig. 3.5: Some vegetable and ornamental plants

5. **Equipment**: The farmer requires a range of basic and more sophisticated farming tools for successful production. The start-up package could supply essential tools like hoes, shovels, and watering cans, but also tractors, ploughs, and irrigation systems (refer to the notes under the topic, 'Simple Farm Tools and Equipment and Their Uses' for pictures of some of the farm tools and machinery). These tools help with soil preparation, planting, irrigation, weed control, pest and disease control, harvesting, and post-harvesting operations.
6. **Training**: Unskilled practitioners require guidance and training on agricultural techniques and best practices to aid successful production, minimise cost, and maximise profit in their enterprises. Aspiring farmers might receive workshops or hands-on training sessions covering topics such as crop rotation, pest management, water conservation, fertiliser application, and sustainable farming practices before the start of the enterprise.

Fig. 3.6: Farmers at a workshop/training

7. **Support**: This involves technical assistance and advice from experienced farmers and farmhands for a successful enterprise. The start-up package might include access to experienced agricultural advisors or mentors, such as extension officers or experienced labourers, who can provide guidance and answer questions related to farming challenges and decision-making.
8. **Fertilisers and pesticides**: These are necessary inputs for soil improvement and crop protection during the cultivation of crops. The start-up package could include fertilisers like NPK (nitrogen, phosphorus, potassium), sulphate of ammonia, organic manure, as well as pesticides or natural pest control methods to protect crops from pests and diseases.

Fig. 3. 7: organic fertilisers

Fig. 3.8: Inorganic fertilisers

Activity 3.1

Imagine you are preparing to start your own vegetable crop farm. Using the knowledge you have gained from the videos, documentaries, and case studies, create a simple start-up plan. In your plan, include the following:

i. How did you acquire land for farming?

ii. The type of crops you would grow.

iii. The tools and equipment you would need.

iv. The financial support required and where you would seek it (banks, cooperative societies, etc.).

v. What type of fertilisers do you apply to your crops?

vi. What pesticides do you use to control pests on your farm?

vii. The potential challenges you might face and how you would address them. Write this as a one-page proposal outlining your farming start-up plan.

Activity 3.2

In groups of three, read the case study below and answer the questions that follow.

Case Study

Kwesi grew up in a small town in Ghana where farming was the main source of income for many families. After completing secondary school, he decided to pursue farming as a career, but he didn't have enough money to start on his own. Determined to make it work, Kwesi began researching ways to secure funding and discovered a local agricultural cooperative that offered start-up packages for young farmers.

The cooperative provided Kwesi with a small loan to purchase seeds, fertilisers, and basic farming tools. They also connected him with a mentor—an experienced farmer who guided him through the process of preparing the land, planting, and maintaining his crops. Kwesi decided to focus on growing tomatoes and peppers, crops that were in high demand in his community.

Despite some initial challenges, such as pests attacking his crops and unpredictable weather, Kwesi managed to produce a successful first harvest. He sold his vegetables at the local market and made enough profit to repay part of his loan. Encouraged by his success, he expanded his farm the following year and hired two additional workers to help with the growing workload.

Kwesi's success didn't go unnoticed. Local agricultural officers invited him to speak at a farming workshop for young aspiring farmers. He shared his story, highlighting the importance of securing a good start-up package, seeking mentorship, and staying persistent in the face of challenges. Kwesi's vegetable farm continues to thrive, and he now plans to explore new markets outside his town.

Follow-Up Questions:

1. What steps did Kwesi take to secure funding for his vegetable farm?
2. How did the agricultural cooperative help Kwesi in starting his farm?
3. What were the initial challenges Kwesi faced when he started farming, and how did he overcome them?
4. Why was having a mentor important to Kwesi's success?

5. Based on Kwesi's story, what advice would you give to someone planning to start their own farm?
6. How did Kwesi's success impact his community and other aspiring farmers?
7. If you were Kwesi, what additional steps would you take to further grow your farming business?
8. How does Kwesi's story demonstrate the importance of persistence in achieving success in farming?

Note: Put your answers together in the form of a presentation and share them with the class for review.

PATTERNS OF GROWTH OF SUCCESSFUL VEGETABLE CROP AND ORGANIC PLANT ENTERPRISES

Successful vegetable crop and organic plant enterprises have shown diverse patterns of growth across various regions. These enterprises often begin on a small scale, gradually expanding as farmers adopt improved practices and access better resources. Factors such as market demand, sustainable farming techniques, and the use of technology play significant roles in their development. Additionally, a focus on quality, consistency, and eco-friendly practices has contributed to the success of many organic plant ventures. Observing these patterns can provide valuable insights into how such businesses grow and thrive in the competitive agricultural sector.

Patterns of Growth in Vegetable and Ornamental Plant Production

This refers to the trends, characteristics, or behaviours observed in the expansion or development of vegetable farming or cultivation over a specific period. It focuses on how vegetable production has changed or evolved, looking at factors such as the quantity and quality of vegetables produced, the geographical distribution of production, and the rate of increase or decrease in production levels.

Understanding these patterns of growth helps policymakers, agricultural experts, and farmers to make informed decisions about resource allocation, market opportunities, and potential challenges in the vegetable industry. It can also shed light on the impact of factors like climate change, technological advancements, and market demands on vegetable production practices and yields.

Below are some factors used to measure growth patterns in vegetable crop and ornamental plant enterprises:

1. **The demographic characteristics of a region**: Factors such as population size, age distribution, level of education, and income levels can influence the demand for vegetables and ornamental plants. For example, an increasing population with a higher disposable income may lead to higher demand for fresh produce and ornamental plants, driving production growth.
2. **Crop profitabilit**y: The profitability of growing certain vegetables or ornamental plants can impact production patterns. Farmers are more likely to invest in crops that offer higher returns on their investment, leading to shifts in production to more profitable varieties.
3. **Access to credit**: This positively affects profitability. There is a positive effect on the growth of enterprises due to access to finance, which affects a farmer's ability to invest in modern agricultural technologies, better seeds, and fertilisers. One study concluded that the growth of enterprises is mainly limited by the lack of access to finance in developing countries. Easy access to credit can empower farmers to expand their operations and invest in higher-yielding crops, positively influencing production patterns.
4. **Educational level of a farmer/farm manager**: Farmers with higher levels of education may be more receptive to adopting modern farming techniques, efficient practices, and sustainable methods. This could lead to increased productivity and better utilisation of resources, affecting the growth patterns in vegetable and ornamental plant production.
5. **Farm size**: The size of the farm plays a crucial role in production patterns. Larger farms may have economies of scale, enabling them to invest in advanced technologies and practices, leading to increased production. On the other hand, smaller farms might focus on speciality crops or niche markets. A niche market is a small market that is a subset of a larger market. For example, producing crops without synthetic fertilisers or pesticides, targeting consumers willing to pay a premium for a sustainably grown period.
6. **Experience in farming**: Experienced farmers often possess valuable knowledge and skills that can improve production efficiency and crop quality. Their expertise might lead to increased yields and more successful farming ventures.
7. **Number of employees and assets**: Farms with more employees and assets can handle larger-scale operations and may have a competitive advantage in the market. Having access to skilled labour and modern machinery can enhance production efficiency and influence growth patterns. It is also used as a measure of growth, especially for capital-intensive firms, while asset value discriminates against labour-intensive firms.

Activity 3.3

On your own, read the case study below and answer the questions that follow.

Case Study

Elizabeth Asante, a small-scale farmer in Aputuogya, Bosomtwe District, Ghana, has been farming for five years. She grows both vegetables and ornamental plants on her 3-acre farm. While her vegetable crops have been growing rapidly and generating high returns, she has faced challenges with her ornamental plants. These plants are not growing as well, and she has been struggling to find a reliable market for them.

Instructions:

1. Based on the case study, identify and discuss the possible factors affecting the growth patterns of Elizabeth's vegetable crops and ornamental plants. Consider how these factors might impact each type of crop differently. Write down at least three (3) factors for both the vegetable crops and the ornamental plants, explaining how each one influences their growth.
2. In your own words, explain why it is important for Elizabeth—and farmers like her—to study and understand the growth patterns of their vegetable crops and ornamental plants. Reflect on how this knowledge could help improve their business, identify challenges early, and make better decisions about their crops.
3. Write your responses in a report. In the report, explain the importance of studying growth patterns in crop enterprises.

Activity 3.4

1.

   a. On your own, use the internet or other resources to research a successful vegetable or ornamental plant enterprise in Ghana.

   b. Write a report about how the enterprise started and how it has grown over time. In your report, describe the factors that helped the business succeed, such as the use of technology, sustainable farming methods, etc. Your report should be between 200 and 250 words long and should include details on how the enterprise continues to grow.

   c. Submit your report to your teacher for constructive feedback.

EXTENDED READING

- Asiedu, J.B.K., et al. (2012). The Nursery Industry in Ghana: Prospects and Challenges. Asian Research Publishing Network, Volume 7, No. 6.
- https://www.youtube.com/watch?v=LGF33NN4B8U
- https://www.youtube.com/watch?v=9AIyAi4qziE

SELECTED EMERGING TECHNOLOGIES IN VEGETABLE CROP AND ORNAMENTAL PLANT ENTERPRISES.

The cultivation and production of vegetable and ornamental plants in Ghana can be both rewarding and profitable. There are also emerging technologies that can be employed to make this production more effective and efficient. Agriculture is undergoing significant changes, with new developments being introduced daily to improve production. In agriculture, anything perceived as new in a particular locality or environment is regarded as an innovation. These new developments may have existed elsewhere but once introduced to a new environment where they had not been previously applied, they are considered innovative.

Innovations are continuously being developed to support agricultural advancement across the world. Many people still associate agriculture with traditional tools such as hoes and cutlasses, along with the hard labour that accompanies them. However, modern agriculture is now evolving, with technology taking centre stage in production and processing activities.

The rapid advancement of technology has brought significant changes to vegetable crop and ornamental plant enterprises. These innovations are transforming traditional farming methods, enhancing productivity, and addressing challenges such as climate variability, pest management, and resource efficiency. The adoption of emerging technologies allows farmers to optimise their operations, improve crop quality, and reduce labour costs. In this section, you will explore some of the key technological developments that are shaping the future of vegetable and ornamental plant production, and how they are being applied to create more sustainable and profitable farming practices.

Technology

Machinery and equipment developed from the application of engineering or applied science to reduce drudgery in agriculture, research, and industry. Technology is at times described as the application of scientific knowledge for practical purposes, especially in industry. Some major technologies include seeding, weeding, harvest automation, and the use of drones.

Emerging Technologies

Emerging technologies, ranging from robotics to machine language, have helped transform modern agriculture, both on a small scale and large scale. They help address challenges such as slow and small production per unit time by producing more with less, minimising the threat to the environment, surviving water and energy crises, and satisfying the increasing food needs of the people.

Several technologies are being developed in vegetable and ornamental plant enterprises. Some emerging technologies in agriculture include:

1. **Organic Farming**: Also known as ecological farming or ecological agriculture, organic farming is a method that avoids the use of chemical pesticides and synthetic fertilisers. Instead, it employs natural extracts from living organisms or decomposed matter as fertilisers, which do not harm the environment. This approach eschews synthetic chemicals, genetically modified organisms (GMOs), and cloned animals, focusing instead on maintaining the health of soils, ecosystems, and people. The primary goal is to create sustainable farming practices with minimal negative impact on the environment.
2. **Vertical Farming**: Vertical farming involves growing crops in vertically stacked layers, often within controlled environment agriculture systems. This technique utilises plant growth mediums and soilless farming methods, such as hydroponics, aquaponics, and aeroponics (growing plants in the air). By operating in a closed and controlled environment, vertical farming maximises space usage and reduces water consumption, making it ideal for urban areas and regions with limited arable land. Artificial lighting can supplement natural sunlight, allowing for year-round crop production and enhanced yield while minimising environmental impact.

Fig. 3.9: Lettuce grown in an indoor vertical farming system.

3. **Precision Agriculture Technology**: Precision agriculture, or precision farming, employs advanced technologies to improve the accuracy of farming practices. This approach integrates information and computer technology (ICT) with best agricultural practices. Key technologies include drones, the Internet of Things (IoT), GPS (Global Positioning System) guidance, sensors, robotics, autonomous vehicles, telematics, and satellite imagery. These tools help monitor crops, assess soil conditions, and optimise irrigation and fertiliser application, leading to better resource management and increased crop yields.
4. **Artificial Intelligence (AI)-Driven Farming**: Artificial intelligence is increasingly being used in vegetable farming to analyse data, predict crop performance, and optimise farming practices. This integration of AI helps enhance the efficiency and sustainability of cultivation processes.
5. **Drones** are remotely controlled aerial devices used for various agricultural activities. They are equipped to fly and perform tasks such as crop monitoring and spraying chemicals, all without the need for a human operator.

Fig. 3.10: Agricultural drones.

6. **Automation technology**: This refers to any tool that can reduce operator workload by combining sensors, computers, feeding mechanisms, and robots. For example, robotic arms equipped with sensors and grippers are used for tasks such as harvesting, pruning, and planting.

Fig. 3.11: Robotic harvester

Fig. 3.12: Man operating a robotic cotton harvester

7. **Machine learning**: Machine learning (ML) is an emerging field of artificial intelligence (AI). It refers to the automated detection of meaningful patterns in given data. Machine learning in agriculture allows for more accurate disease diagnosis and crop disease prediction. AI and ML algorithms are helping farmers sift through data to come to powerful insights to help them increase efficiency, production, and productivity in agriculture and manufacturing.
8. **Big data**: The big data age involves the generation of huge volumes of information and managing this to add value to our daily lives. As farmers use large amounts of data from connected devices to better understand their farms, big data is set to change how they manage their work. Instead of relying on guesses, farmers can now use big data to make more accurate and informed decisions.
9. **Blockchain (chain of trust)**: This is a technology that tracks all types of information about plants, such as seed quality, crop growth, and even the travel of the harvested crop after it leaves the farm. It consists of a shared or distributed database used to maintain a growing list of transactions, called blocks. It streamlines or makes business processes very easy. This is because it establishes trust and makes each group accountable and more transparent. It addresses issues such as food fraud, safety recalls, supply chain inefficiency, and food traceability and enables transactions to be easily and promptly verified.
10. **Radio Frequency Identification (RFID) technology**: This uses radio waves to identify objects, animals, or people. For example, a bag of rice can have a barcode that can be scanned with a smartphone to retrieve information about the source, the farmer, and the date of bagging the rice.

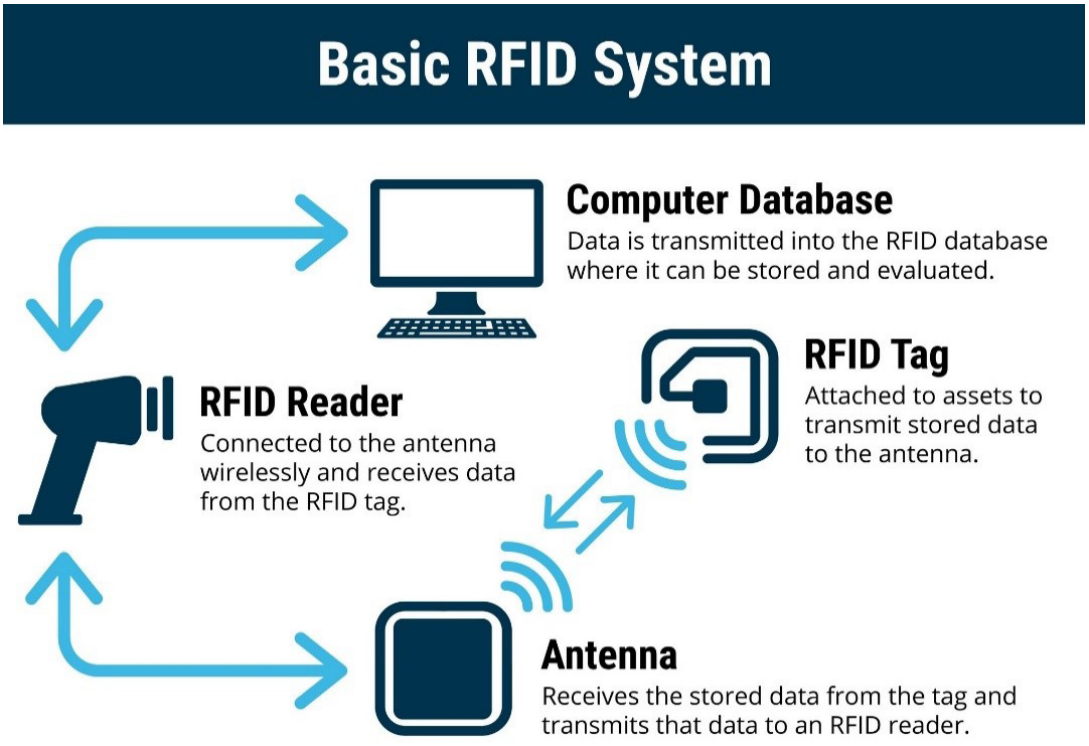

Fig. 3.13: Diagram of a basic RFID system

11. **Internet of Things (IoT)**: This concept connects anything, anytime and anywhere, through the internet. It is the network of devices that are connected and allows the exchange of data among themselves.

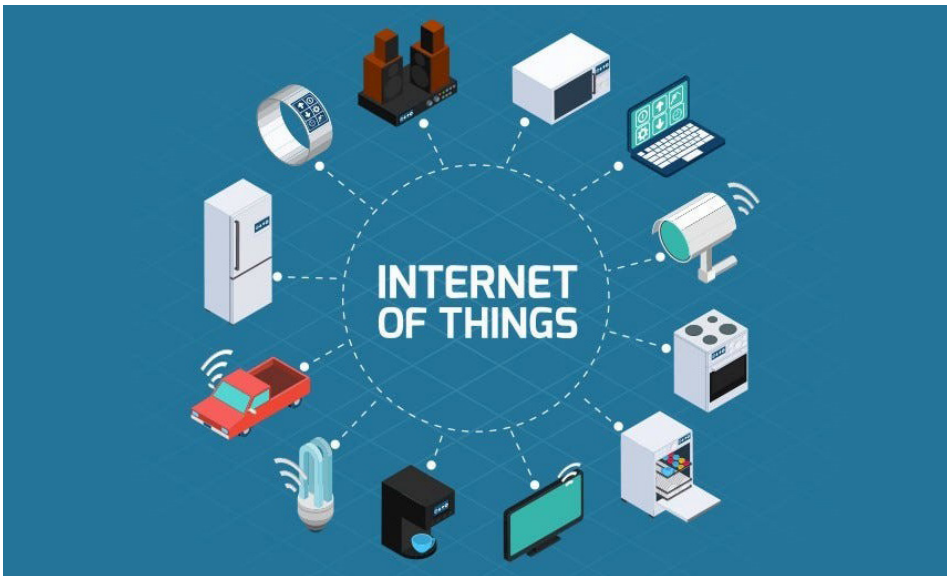

Fig. 3.14: The Internet of Things (IoT)

12. **Satellite greenhouses**: Greenhouse vegetable farming is the type of farming in which vegetable crops are grown in built structures (wood, plastic, metal, net). The types of vegetables grown in a greenhouse include cucumbers, sweet peppers, lettuce, and tomatoes.

Fig. 3.15: Satellite greenhouses

13. **Hydroponics and Aquaponics**: These are methods of growing plants using a water-based nutrient solution instead of soil. Sometimes, an extra material like vermiculite, coconut coir, or perlite is used as a growing medium. When fish farming is combined with hydroponics, it is called aquaponics. This method leads to higher crop yields and uses less water. Hydroponic systems are used by small farmers, hobbyists, and large businesses. In a hydroponic greenhouse system, plants receive nutrients in liquid form at set times, a process called sub-irrigation culture. After transplanting the seedlings, an automatic system takes care of the rest. In hydroponic systems, vegetables grow in sand, gravel, or soil-less mixes in containers that allow nutrient solutions to circulate and help the plants grow.

Fig. 3.16: A picture of coriander cultivated using Hydroponics

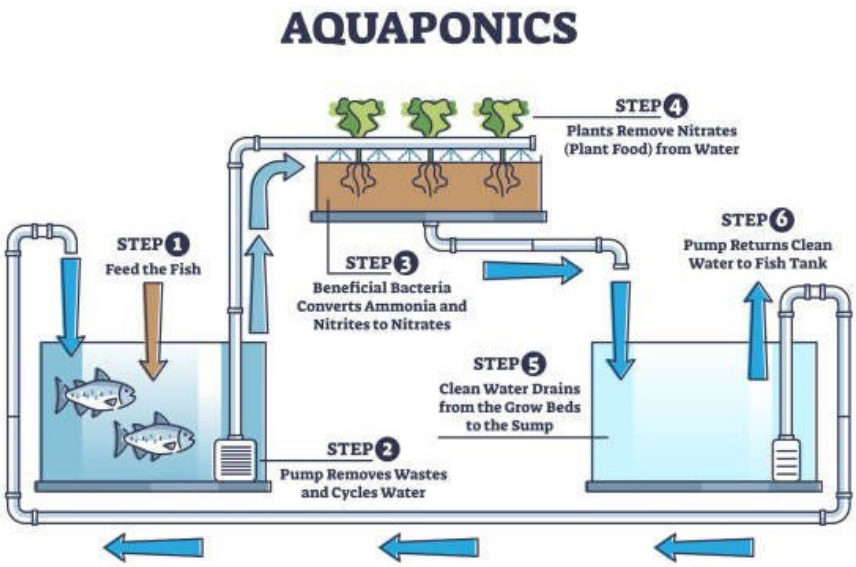

Fig. 3.17: Illustration of an aquaponics system

14. **Biodegradable packaging**: Biodegradable materials for packaging vegetables are gaining popularity, promoting sustainable practices and reducing plastic waste.
15. **Tissue culture**: This is sometimes called micropropagation. Tiny fragments of plants are treated with plant hormones in a sterile growing medium. The hormones stimulate the growth of a callus, from which a new seedling can grow. This method is used to produce large numbers of identical seedlings. This is a technique that is essential in the production of improved varieties of crops, particularly of crops whose multiplication is not possible through seed. It is also used for the conservation of endangered plant and crop species.

Fig. 3.18: Picture of a scientist observing crops in lab (left) and crops produced from tissue culture in a lab (right)

16. **Biotechnology**: It is the use of biology to develop new products, methods, and organisms intended to improve human health and society. Biotechnology is often referred to as biotech. Biotech has existed since the beginning of civilisation with the domestication of plants and animals and the discovery of fermentation. It has led to breakthroughs in the following areas:
    a. Medicines and therapeutics that prevent and treat disease.
    b. Medical diagnostics such as pregnancy tests.
    c. Sustainable biofuels, reducing waste and pollution.
    d. Genetically Modified Organisms (GMOs) that lead to more efficient and cost-effective agriculture.

A GMO (Genetically Modified Organism) is a plant, animal, or microorganism that has had its genetic material (DNA) changed using technology. This generally involves the transfer of specific parts of DNA from one organism to another. Scientists often refer to this process as genetic engineering (click on link). Genetic engineering works by modifying or interacting with the genetic cell structures. Every cell in an animal or plant contains genes that produce proteins that determine the characteristics of the organism. By modifying or interacting with genes, scientists can strengthen the characteristics of an organism or create an entirely new organism. These modified and new organisms may be beneficial to humans, such as crops with greater yields or increased resistance to some environmental stress such as pests, disease, or drought. Genetic engineering also enables the genetic modification or changes and cloning of animals.

In Ghana, local scientists from the Savanna Agricultural Research Institute of the Council for Scientific and Industrial Research (CSIR-SARI) have employed biotechnology to develop two crops: nitrogen- and water-use-efficient (NEWEST) rice and the genetically modified cowpea, also known as the pod borer-resistant (PBR) cowpea. Neither of these crops has been commercialised yet, although they have gone through various stages of evaluation and field trials.

Activity 3.5

Follow the steps below to explore vertical farming and how it can be implemented in your school or home environment.

Steps:

1. Search online for images of vertical farms to understand how they are structured and function. Take note of the key features that allow for space-saving and efficient use of resources.
2. Reflect on how vertical farming works, and write a brief explanation in your own words. Identify why it is useful and under which conditions it is beneficial for growing vegetables, especially in urban areas or small spaces.
3. Identify materials available in your school or home environment that could be used to construct a simple vertical farming structure. Think about items like wooden planks, plastic containers, or recycled materials.
4. Based on your findings, sketch a vertical farming structure, labelling its components. Indicate how this structure could solve common farming challenges, such as limited space or water shortages. Include a brief report on the potential benefits of this method for growing vegetables in a controlled space.

Activity 3.6

Perform the following tasks to complete this activity.

1. Create a portfolio by collecting images and information on tools and equipment used in emerging agricultural technologies. This could include items such as drones, hydroponic setups, etc.
2. Organise your portfolio into categories based on the technologies. Include a brief description of each tool and explain how it helps improve vegetable and ornamental plant production.
3. Present your portfolio in a creative and visually appealing way, either as a digital presentation or a booklet.

Activity 3.7

Follow the steps below to research the use of robotics in agriculture and explore other emerging technologies for vegetable and ornamental plant production.

Steps:

1. Search online for information on how robotics is being used to harvest crops. Focus on specific examples where robots have been employed on farms to perform tasks like picking, sorting, and packaging.
2. Investigate the advantages and limitations of using robotics for crop harvesting. Identify how these technologies can improve efficiency and productivity, as well as potential challenges such as cost and maintenance.
3. Use the link provided to find information on the benefits of emerging technologies in vegetable and ornamental plant production. (You can also search online for other sources) Watch short documentaries or videos that demonstrate how emerging technologies are applied in vegetable crop and ornamental plant enterprises. Pay attention to real-life examples and their impact on agriculture.
4. Reflect on the social, economic, and environmental implications of using these technologies in agriculture. Discuss your findings with two classmates, focusing on how these innovations can affect communities, job opportunities, and environmental sustainability.
5. Present your findings visually on cardboard posters, highlighting key points about the use of robotics and other technologies. Attach these posters to the walls for others to view and learn from your research.

Activity 3.8

Follow these steps to understand how practical and cost-effective it is to use one specific emerging technology in vegetable and ornamental plant production:

1. Choose one emerging technology used in vegetable and ornamental plant production, such as hydroponics, vertical farming, or robotics.
2. Research online to find information about the economic viability and feasibility of implementing this technology. Look for details on costs, benefits, and potential challenges.
3. Summarise your findings in a short report, highlighting the key points about how this technology can be practically and economically applied in farming.
4. Present your report to the class, using visual aids, if possible, to explain the economic aspects of the chosen technology.

Appraisal of Emerging Technologies in Vegetable Crop and Organic Plant Production

As agriculture continues to evolve, emerging technologies are increasingly shaping the way we grow vegetables and ornamental plants. This appraisal explores the latest advancements that promise to enhance productivity, sustainability, and efficiency in farming practices. By evaluating these technologies, we can understand their potential impact on crop production and their role in meeting the challenges of modern agriculture. This topic will guide you through the innovative solutions transforming the industry and their implications for both small-scale and large-scale farming operations.

The emerging technologies are:

1. **Hydroponics**
    a. Plants in hydroponics do not have to compete for resources. Hence, they can be planted more densely and vertically, thus saving space.
    b. Hydroponics can be used for growing vegetables in areas with limited land available for conventional horticulture and other farming activities.
    c. Hydroponics is far less labour-intensive than conventional agriculture.
2. **Tissue Culture:**
    a. This technique is essential in the production of improved varieties of crops, particularly of crops whose multiplication is not possible through seed.
    b. It is also used for the conservation of endangered plant and crop species.
3. **Greenhouse Planting:**
    a. It is a technique for growing plants in a controlled environment.
    b. The production process and the physical environmental factors can be automated.
    c. Enables all-year-round or off-season production of plants, particularly vegetable crops.
4. **Genetically Modified Organisms (GMOs)**

    Some benefits of GMOs include the following:

    a. Reduced pesticide use: Some GMOs are designed to be resistant to certain pests or diseases, reducing the need for chemical pesticides. It results in lower production costs, minimised environmental impact, and decreased exposure to harmful chemicals for farmers and consumers.

    b. Increased crop productivity*:* It enables plants to grow more efficiently, withstand adverse conditions, and hence produce more per unit area.

    c. Extended shelf life: Some crops can be engineered to have longer shelf life, reduce post-harvest losses, and ensure fresher products reach consumers.

d. **Improved nutritional content***:* GMOs can be developed to enhance the nutritional profile of vegetables, such as by increasing vitamin or mineral content, thus addressing nutritional deficiencies.

e. **Adaptation to changing climates***:* By introducing specific genetic modifications, crops can be adapted to thrive in different climates and regions, helping to address challenges posed by climate change.

f. **Cost-effectiveness***:* GMOs can offer cost-effective solutions for farmers, enabling them to produce more with fewer resources.

g. **Improved beauty or aesthetic characteristics***:* Ornamental plants can be engineered to have specific aesthetic characteristics, such as unique colours, longer bloom durations, and novel shapes, which can increase their attractiveness in the market.

Some Challenges of GMOs include:

a. **Public perception and acceptance***:* GMOs often face public scrutiny and scepticism regarding their safety and potential long-term effects on human health and the environment. Public perception can negatively impact consumer acceptance and demand for GMO products.

b. **Environmental concerns***:* The introduction of GMOs may lead to unintended environmental consequences, such as cross-breeding with wild relatives or non-GMO crops, potentially affecting biodiversity and ecosystem balance.

c. **Loss of traditional varieties***:* The widespread adoption of GMOs may lead to a reduced diversity of traditional crop varieties as farmers opt for commercially available genetically modified seeds.

d. **Ethical concerns***:* Some individuals and organisations have ethical objections to genetic engineering, particularly when it involves transferring genes between species or organisms.

5. **Benefits of Emerging Technologies in Vegetable Farming:**

a. **Increased yields**: Precision agriculture, AI-driven farming, and hydroponics can optimise resource allocation, leading to larger crop yields and improved productivity.

b. **Resource use efficiency***:* Technologies like precision agriculture and hydroponics enable better water and nutrient management, reducing waste and minimising negative environmental impact.

c. **Sustainable practices***:* Many emerging technologies promote sustainable farming practices by minimising synthetic pesticide usage, reducing water consumption, and adopting eco-friendly packaging solutions.

d. **Year-round production***:* Vertical farming and indoor cultivation allow for year-round vegetable production, regardless of external weather conditions, providing a more stable and consistent supply.

e. **Labour savings**: Automation and robotics decrease the need for manual labour, making farming more efficient and potentially reducing production costs.

6. **Challenges of Emerging Technologies in Vegetable Farming:**
   a. **High initial investment**: Implementing advanced technologies can require significant upfront costs, making it a challenge for small-scale farmers to adopt these practices.
   b. **High level of technical expertise needed**: Farmers need to acquire new skills and knowledge to effectively use and maintain emerging technologies, which may pose a barrier to their adoption.
   c. **Data privacy and security issues**: With AI-driven farming and precision agriculture relying on data collection and analysis, ensuring data privacy and protecting against cyber threats has become more crucial.
   d. **Power and systems failure or disruption**: Relying heavily on technology may lead to potential risks if systems fail or are disrupted, impacting crop production and supply chains.
   e. **Environmental concerns**: While many technologies promote sustainability, there may still be concerns about energy consumption and the environmental impact of certain farming practices.
   f. **Compatibility and interoperability**: Integrating different technologies into existing farm systems can be complex, and ensuring compatibility and interoperability among various tools may require additional effort.

Activity 3.9

Follow the steps below to design a technology implementation plan.

1. Select an emerging technology you are interested in, such as vertical farming or hydroponics.
2. Use online sources, books, or documentaries to understand how the chosen technology works and its benefits for vegetable or ornamental plant production.
3. Outline how you would set up the technology in a local farm or garden. Include:
   - **Materials needed:** List the materials and equipment required.
   - **Setup steps:** Describe the steps needed to set up the technology.
   - **Improvement areas:** Explain how this technology will improve vegetable or ornamental plant production.

4. Draw a diagram or flowchart to visually represent your implementation plan. This should include the setup process and key components of the technology.
5. Put together your plan and diagram/flowchart on a poster or digital slide. Ensure it is clear and easy to understand.
6. Share your completed plan with your teacher or submit it as a digital document.

Activity 3.10

1

a. Watch the following videos or documentaries on an emerging technology in agriculture.

   https://www.youtube.com/watch?v=_tijHjup-gM&t=148s

   https://www.youtube.com/watch?v=JeU_EYFH1Jk

   https://www.youtube.com/watch?v=NSdPgLVpLCc

   https://www.youtube.com/watch?v=Our-F5Fh3Go

   https://www.youtube.com/watch?v=cXUlhSbP1_c

   https://www.youtube.com/watch?v=mYdt6CAwKAY

b. Write a report summarising the key points discussed in the videos. Focus on the technology's benefits and potential challenges.

c. Your summary(report) should include how the technology can be implemented in vegetable crop and ornamental plant production.

d. Submit your summary as a written report or a digital document.

EXTENDED READING

- Defining Precision Agriculture in Vegetable Growing: Growing Produce.
- 18 Emerging Agriculture Technologies: The Future of Agritech (businessexceed.com).

TECHNIQUES USED TO PRODUCE VEGETABLE CROPS AND ORNAMENTAL PLANTS ON THE SCHOOL PREMISES

Hello learner! You are welcome to Week 5, and before we proceed to study what is in this week, know that the growing and production of vegetable and ornamental plants in Ghana can be a rewarding and profitable venture. Ornamental plants are being used to enhance the landscape in many new homes. With the right skills and knowledge in procedures and technologies in vegetable and ornamental plant production, you can turn your passion into a successful enterprise. This section therefore explains how to grow vegetable crops and ornamental plants successfully. It then goes on to look at the use of emerging technologies in vegetable crop and ornamental plant enterprises. The relevance of this section is to help you acquire knowledge and skills on how to grow vegetable crops and ornamental plants successfully and at a lower cost to entice more Ghanaians to buy these plants.

Let us now discuss the stages of vegetable crop and ornamental plant production.

Stages of Vegetable Crops and Ornamental Plants Production

Every plant production exercise is an elaborate process with several stages, each of which must be carried out in an ordered manner. The major stages are listed and explained below.

1. **Pre-production:** These have to be done or assembled before starting the project
    a. Purpose or aims of production
    b. Choice of vegetable crop or ornamental plant
    c. Capital for the project
    d. Site selection (type of soil)
    e. Sourcing of seed or planting materials
    f. Tools, equipment and machines needed
    g. Size of garden and proximity / Use of plastic, metal or wooden containers or bags/sacks.
    h. Agronomic management system to employ
    i. Source and system of water supply
    j. Access to road networks and market
2. **Production stage:** Some vegetables are planted directly while others require nursing before transplanting.

a. **Nursing and nursery practices:** Seeds and planting materials can be sown on seed beds, seedboxes, polybags or in containers. On seedbeds and boxes, the seeds can either be drilled or broadcast, shade is provided and seeds watered early morning and late afternoon.

   Nursery Management:

   i. Watering
   ii. Fertiliser application
   iii. Weed control
   iv. Pests and disease control
   v. Pricking out
   vi. Thinning
   vii. Hardening off
   viii. Transplanting

b. **Land Preparation**: This depends on the type of soil, available tools and type of plant to be grown. While some vegetables are planted directly others require special land preparations such as beds, ridges, mounds, furrows, and ploughed and harrowed lands.

c. **Transplanting**: Transplanting of most vegetable seedlings is done when seedlings develop two pairs of leaves. Tools such as the dibber (for making holes), and hand trowel can be used. Care should be taken to minimise root damage. Seedlings can be watered before transplanting to ease uprooting and minimise root damage.

d. **Planting distance:** Land is marked out and pegged if necessary, considering inter-row and inter-planting distances depending on the type of vegetable crop and ornamental plant to be established and the fertility level of the soil. On the other hand, pots, boxes, sacks and bottles can also be filled with soil and placed at specific distances apart.

e. **Cultural/management practices**

   i. Watering or irrigation (rain-fed and artificial supply)
   ii. Fertiliser application (side placement, drill methods, broadcasting)
   iii. Weed control (chemical and mechanical means)
   iv. Pest and disease control (chemical control, farm hygiene, good agronomical practices and biological means)
   v. Other practices such as mulching, staking, pruning, sleeving
   vi. Harvesting (hand plucking, use of sharp knives, sickle)
   vii. Postharvest processes and storage operations
   viii. Marketing

Hydroponics versus conventional method for growing vegetable crops and ornamental plants

Hydroponics:

Advantages of hydroponics over conventional cultivation include:

1. **Growing medium:** In hydroponics, plants are grown without soil and their roots are directly immersed in a nutrient-rich water solution. This allows for a precise supply of nutrient levels, optimising plant growth and development.
2. **Water efficiency:** Hydroponic systems typically use up to 90 % less water compared to traditional soil-based farming because water is recirculated within the system.
3. **Space efficiency:** Hydroponic systems can be vertically stacked or designed in compact setups, making them suitable for urban areas or locations with limited arable land.
4. **Faster growth:** With consistent access to nutrients and water, hydroponically grown vegetables often exhibit faster growth rates compared to their soil-grown counterparts.
5. **Reduced pests and diseases:** Hydroponic systems reduce the risk of soil-borne pests and diseases, leading to higher plant vigour and rapid development.
7. Fertiliser and resource saving.

Disadvantages of hydroponics versus conventional cultivation

1. High investment costs.
2. A very high level of technical know-how is required.
3. Higher amount of energy consumption.

Characteristics of conventional soil-based farming:

1. **Nutrient diversity:** Soil naturally contains a wide range of nutrients, minerals, and beneficial microorganisms that contribute to the overall health and nutritional value of the crop.
2. **Environmental adaptability:** Soil-based farming allows plants to develop deep root systems, which can help them access nutrients and water in various soil conditions.
3. **Sustainable soil practices:** Organic matter and crop residues from soil-based farming contribute to soil fertility and support sustainable farming practices.
4. **Low initial investment:** Traditional soil-based farming typically requires lower upfront costs compared to setting up hydroponic systems.
5. **Genetic diversity:** Soil-based farming allows for a wider range of vegetable varieties to be grown, supporting biodiversity in agriculture.

Now that you have successfully studied the content, do the following activities.

Activity 3.11

Develop a crop management plan that outlines the step-by-step procedures for growing a selected vegetable crop or ornamental plant and share your plan with a friend.

Follow the steps below to assist you develop a crop management plan.

Steps in developing a crop management plan:

1. Select a vegetable crop or ornamental plant you intend to cultivate or grow.
2. Indicate where the crop is to be planted either directly in the soil or in a container filled with appropriate soil.
3. Indicate whether the seeds selected will be planted directly in the soil or nursed in pots or trays before transplanting.
4. State the date you intend to sow the seeds.
5. If the seeds are to be nursed and transplanted, indicate the date that the transplanting of seedlings should be done.
6. Indicate how the sown seeds are going to be looked after before and after germination eg watering, weed control, pest and disease control.
7. Share your plan with your friends.

   I hope you have enjoyed developing a crop management plan with your friends.

Activity 3.12

1. Grow a vegetable crop or ornamental plant on your school premises or at home:

   The steps below will guide you on how to grow a vegetable crop or an ornamental plant on your school premises or at home.

   Materials needed: Empty milk or milo tin, plastic container or sac, soil, water and vegetable seed (such as cabbage, tomato, pepper, carrots etc.) or seeds of plants (such as flamboyant, milk bush, periwinkle etc.) or vegetative parts of such plants such as cuttings, suckers, bulbs, stolons etc.)

   Steps:

   a. Fill the containers or the sacs with the soil, preferably loamy soil or any other suitable substrate.

   b. If metal or plastic containers are to be used, they must have small holes in their base to allow excess water to drain.

   c. Sow some seeds of the selected vegetables or ornamental plants in the soil-filled containers or sacs.

d. Water the soil immediately after sowing the seed.

e. Place the container with the sown seeds under a very good shade in an appropriate environment.

f. Observe what happens after one to three weeks and record your observations.

g. Share your observation with your friends and let them also tell you what they have done.

Well, done! I hope you and your friends are fine with this practical activity.

Activity 3.13

Search online for information about hydroponic systems to understand their roles in conserving water and delivering precise amounts of nutrients to crops. Or write a report about hydroponics as presented by the resource person invited by your teacher and share it with friends.

Guidelines

Option A (Online search):

Steps:

a. Search online. Make sure that your data is on.

a. Type "roles of hydroponics in conserving water and delivering precise amounts of nutrients to crops" in the browser and hit on the enter key. Wait for it to open and read carefully. Jot down relevant notes.

a. Discuss your findings with your friend.

Option B (Resource person's presentation):

Steps:

a. Attend the class that the resource person presents on hydroponics.

b. Jot down relevant notes

c. Prepare a report on the presentation under these heading; introduction, main points and conclusion.

d. Submit the written report to your teacher.

Good! Well done, now try your hand at these review questions.

EXTENDED READING

- Access to extension support were important factors affecting the decision of traditional African vegetable farmers to adopt improved technology. Issaka (2021)
- Advantages of Growing Vegetable Crops in Modern Greenhouses By Dubravka Savic and Zarko M. Ilin; Reviewed: November 2nd, 2021 Published: March 18th, 2022; DOI: 10.5772/intechopen.101469; IntechOpen
- Agricultural Biotechnology (https://www.fda.gov/food/consumers/agricultural-biotechnology)
- A Review of Hydroponics and Conventional Agriculture Based on Energy and Water Consumption, Environmental Impact, and Land Use by Dimitra I. Pomoni et al.; *Energies* **2023**, *16*(4), 1690; https://doi.org/10.3390/en16041690
- Cryopreservation of Endangered Ornamental Plants and Fruit Crops from Tropical and Subtropical Regions by Behzad Kaviani et al. (2022). Biology, 11, 847. https://doi.org/10.3390/biology11060847
- https://www.mdpi.com/journal/biology

EXPLANATION OF THE PROCESSES OF TISSUE CULTURE AND ITS IMPORTANCE IN VEGETABLE CROP AND ORNAMENTAL PLANT PRODUCTION

Hello learner! Tissue culture is one of the new emerging technologies in the field of agriculture. It is used to propagate most plants, especially those that cannot be propagated by natural means. With an understanding of the use and importance of tissue culture in vegetable crops and the ornamental plant production industry, you will gain knowledge that can help you improve crop yield and quality, and enhance food security.

Now, let's get to the processes of tissue culture and its importance in vegetable crop and ornamental plant production

Tissue culture is a technique of growing new plant tissues by transferring them into an artificial environment where they can continue growing and functioning. The production of new plants from small pieces of plant tissue or cells removed from the growing tips of a plant in a suitable growth medium is called tissue culture. In this process, the growth medium or cultured solution is very important because it contains various plant nutrients in the form of jelly known as agar and plant hormones which are necessary for the growth of the plants.

The Process of Tissue Culture for Producing New Plants

1. A small piece of plant tissue is taken from the growing point or the tip of the plant and placed on a sterile agar jelly that contains nutrients and plant hormones.

The hormone makes the cells in the plant tissue divide rapidly producing many cells which form a shapeless lump of mass called a "callus."

2. The callus is then transferred to another jelly containing suitable plant hormones that stimulate the callus to develop roots.
3. The callus with the developed roots is then put on yet another jelly or agar containing different hormones that stimulate the development of shoots.
4. The callus with roots and shoots separates into tiny plantlets. In this way, many tiny plantlets are produced from just a few original plant cells or tissue.
5. The plantlets that are produced are transplanted into pots, containers, poly bags, seed boxes or soil where they can grow to form matured plants.

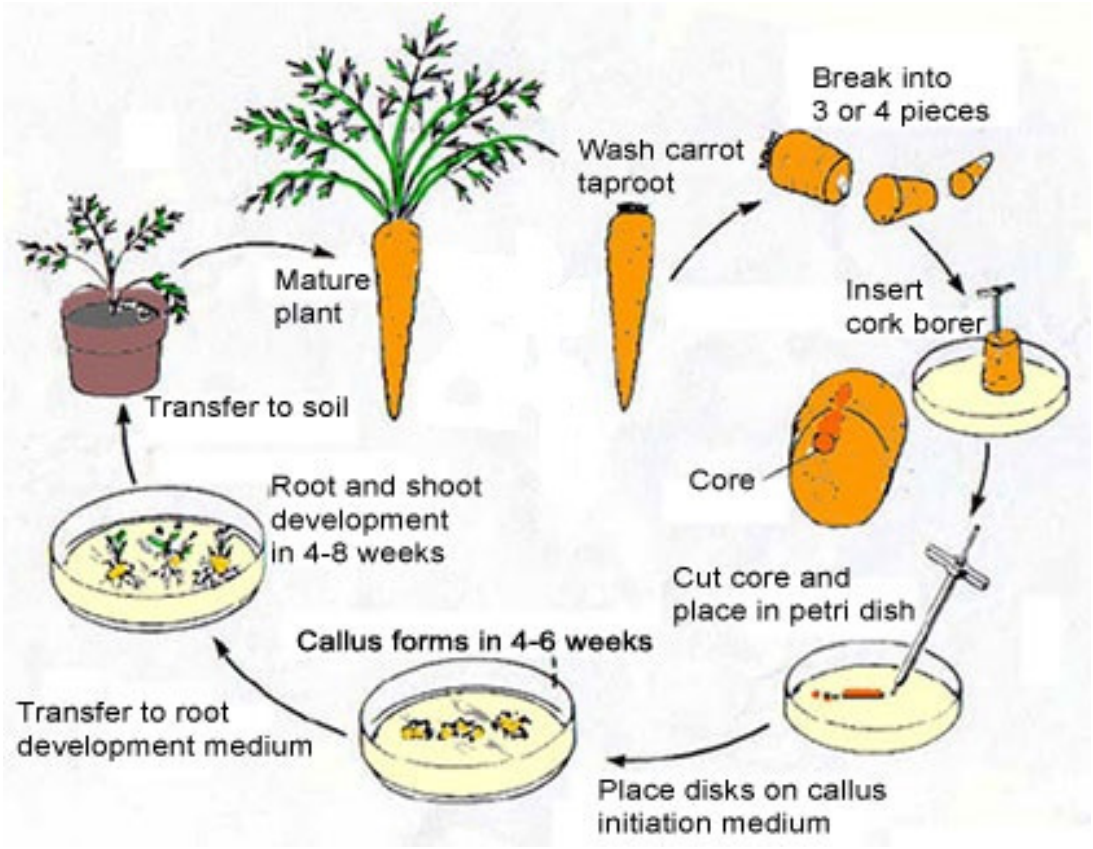

Fig. 3.19: Diagram of the process of tissue culture in carrot

Seeds and Clones

Seeds are usually produced from the process of sexual reproduction in plants. Each seed has its own genetic material that is unique from other seeds and also from the parent plant. Generally, tissue culture plants are micro-propagated cuttings or clones, genetically identical to the mother and all daughter plantlets.

Uses of Tissue Culture Technique

The tissue culture technique is used for the production of plantlets or clones of plants that do not produce easily or are propagated by vegetative means. It is used for vegetables and ornamental plants like carrots, potatoes, orchids, dahlias and chrysanthemums.

Advantages of tissue culture in crop husbandry and horticulture

1. Tissue culture helps to produce disease-free plantlets.
2. Plants can be raised and grown throughout the year regardless of the season.
3. The practice of tissue culture does not require a large plot of land or space to undertake it.
4. It helps produce vegetables, fruits and ornamentals of different varieties in commercial quantities quickly.
5. The use of tissue culture techniques helps to enhance the market competitiveness of the crops. This is because tissue culture can be used to achieve mass production.
6. Tissue culture can be used to preserve endangered plant species and rare genotypes.
7. Tissue culture enhances crop yields and improves food security.
8. It can be used to produce disease-free planting materials thus reducing the risk of disease transmission.

Disadvantages of tissue culture

1. The practice of tissue culture is costly. This is because it requires a specific controlled environment, equipment and some cultured solutions.
2. It is labour-intensive. The practice of tissue culture requires a lot of labour to achieve success
3. Any change in hormonal and other external conditions can alter the physiological properties of the new plant.
4. If it is not properly carried out there is always a risk of possible contamination of the processes.
5. There is always a challenge of negative public perception about the safety and ethics of tissue culture.
6. The is always a problem of limited trained personnel who can successfully undertake tissue culture.
7. There is always a problem of scaling up. This means transferring cultures from a small-scale lab to a larger commercial setting can be a very big challenge.

Activity 3.14

Read about tissue culture techniques on the Internet and analyse the advantages and disadvantages of tissue culture compared to traditional propagation methods. Share your findings with friends.

To be able to achieve Activity 3.14, follow the steps below.

Steps:

1. Search online. Make sure your data is on.
2. Type "Tissue culture techniques" in the browser and hit on the enter key. Wait for it to open and read carefully. Jot down relevant notes.
3. Again, type "the advantages and disadvantages of tissue culture compared to traditional propagation methods" in the browser and hit the enter key. Wait for it to open and read carefully. Jot down relevant notes.
4. Analyse your findings with your friend.

Activity 3.15

Discuss with your friends the role of tissue culture in improving crop yield, reducing production costs, and enhancing market competitiveness.

Follow the steps below to achieve Activity 3.15

Steps:

1. Search online. Make sure your data is on.
2. Type "the role of tissue culture in improving crop yield, reducing production costs, and enhancing market competitiveness" in the browser and hit the enter key. Wait for it to open and read carefully. Jot down relevant notes.
3. Discuss your findings with your friend.

Activity 3.16

Watch the video using this link (Carrot Callus Induction 2 - Tissue Preparation - Plant Tissue Culture (youtube.com) to understand the processes involved in tissue culture.

Share with your friends what you gathered from the video on the various steps involved in tissue culture.

I hope you enjoyed watching the video!

Activity 3.17

Surf the Internet on the benefits and challenges of using tissue culture. Present your findings on cardboard posters and attach them to the walls.

Follow the steps below to achieve Activity 3.17.

Steps:

1. Search online. Make sure your data is on.
2. Type "the benefits and challenges of using tissue culture" in the browser and hit the enter key. Wait for it to open and read carefully. Jot down relevant notes.
3. Present your findings on cardboard posters and attach them to the walls.

   Great! Thank you for your effort. Now answer the review questions below.

EXTENDED READING

- Cryopreservation of Endangered Ornamental Plants and Fruit Crops from Tropical and Subtropical Regions by Behzad Kaviani et al. (2022). Biology, 11, 847. https://doi.org/10.3390/ biology11060847 https://www.mdpi.com/journal/biology
- Effect of Tissue Culture in Vegetable Improvement by Amba Kumari et al. International Journal of Current Microbiology and Applied Sciences, ISSN: 2319-7706 Volume 9 Number 9 (2020); Journal homepage: http://www.ijcmas.com
- Emerging Technologies in Agriculture by Matthew N. O. Sadik et al., from International Journal of Scientific Advances ISSN: 2708-797 Online: www.ijscia.com 8. Ghana's first GMO food crop:
- All you need to know by Dennis Baffour-Awuah, March 31, 2022, 9. Greenhouse Manual, An Introductory Guide for Educators; A publication of the National Centre for Appropriate Technology in collaboration with the United States Botanic Garden and City Blossoms by Andy Pressman and Thea Rittenhouse, NCAT Agriculture Specialists et al.
- Ragaveena, S.; Shirly Edward, A.; Surendran, U. Smart controlled environment agriculture methods: A holistic review. Rev. Environ. Sci. Bio/Technol. 2021, 20, 887–913. [Google Scholar] 20. Science Learning Hub, 24 Sept 2013 21.

OTHER EMERGING TECHNOLOGIES USED TO MAKE THE GROWING OF VEGETABLE CROPS AND ORNAMENTAL PLANTS EASIER

Hello learner! In earlier lessons on this section, you were exposed to the use of some selected emerging technologies in vegetable crop and ornamental plant enterprises and appraised them. In this lesson, we will delve into the emerging technologies that make growing vegetable crops and ornamental plants easier, more productive, and

environmentally friendly. Let us move straight to the other emerging technologies used to make the growing of vegetable crops and ornamental plants easier.

Welcome to the world of innovative agriculture!

As an SHS learner, you are about to explore the exciting realm of emerging technologies that are transforming the way we grow vegetable crops and ornamental plants. Some of these emerging technologies include satellite greenhouses, robotics and automation (use of agricultural robots (agribots)), smart farming, and sensors and remote-control technology. These technologies are explained briefly below.

Satellite greenhouses

Greenhouse vegetable farming is the type of farming in which vegetable crops are grown in built structures (wood, plastic, metal and net). Some vegetables grown in greenhouses include cucumbers, sweet peppers, lettuce and tomatoes. Ornamental plants grown in greenhouses include orchids, roses, African violets, geraniums, chrysanthemums, poinsettias and bougainvillaea.

Fig 3.20: Pictures of greenhouses

Process of growing vegetables in a greenhouse

1. **Soil preparation and bedding**: Prepare the soil inside the greenhouse by tilling, removing debris and levelling the surface. Raise beds and create planting rows or place pots/bags/boxes filled with soil for planting.
2. **Plant selection and transplanting**: Choose vegetable varieties that are well-suited for greenhouse cultivation. Start seedlings in a separate nursery area or purchase young plants from reputable suppliers. Transplant the seedlings into the prepared beds or pots/bags/boxes following the appropriate spacing and depth.
3. **Irrigation and fertiliser application**: Use an efficient irrigation system, such as drip irrigation or soaker hoses, to deliver water directly to the plant roots and minimise water wastage. This also ensures that alleys between plant rows are kept dry for other cultural operations to be done. Implement a balanced fertiliser application programme to provide essential nutrients for healthy plant growth. Use organic or inorganic fertilisers.

4. **Temperature and humidity control**: It is usually necessary to regulate the temperature and relative humidity inside the greenhouse, especially during the hot afternoons and cool nights.
5. **Pest and disease management**: Control pests and diseases in an environmentally friendly manner. Use biological control agents such as natural predators and organic pesticides when necessary to minimise the impact of pests on the crops.
6. **Pruning and trimming**: Regularly prune and trim the plants to promote better air circulation and light penetration. This practice encourages healthy growth and reduces the risk of disease.
7. **Harvesting and post-harvest handling**: Monitor the maturity of the vegetables and harvest them at the appropriate time for optimal flavour and nutritional content. Handle harvested produce with care to minimise damage and maintain freshness during post-harvest handling and storage.
8. **Crop rotation and succession planting**: Plan crop rotations and succession planting to optimize space utilisation and ensure a continuous supply of vegetables throughout the year.
9. **Monitoring and record-keeping**: Regularly monitor the greenhouse environment, including temperature, humidity and plant health. Keep detailed records of cultivation practices, pest control and harvest data to assess performance and make informed decisions for future growing seasons.

Robotics (use of agricultural robots (agribots) and automation

Robotics is the use of robots or automated machines in place of humans to perform physical tasks. Robots are employed by farmers to automate agricultural processes, such as planting, soil maintenance, irrigation, weeding, spraying, harvesting, and fruit picking.

Fig. 3.21: Picture of Agricultural robot. Image source: pictures of robotics and automation in agriculture - Search Images (bing.com)

Smart farming

Smart farming is an application of the Internet of Things (IoT). IoT devices are pieces of hardware such as sensors, actuators or machines, that are programmed for certain applications and can transmit data over the Internet to other networks. Smart farming involves the adoption of information and communications technologies (ICT) to enhance and automate agricultural processes and operations. Smart farming technologies cover all aspects of precision agriculture. They are replacing inefficient, inconsistent and unreliable traditional farming techniques resulting in an increase in the reliability of certain farming activities. Wireless sensor networks are used for monitoring the soil properties and environmental factors continuously.

Fig. 3.22: Picture of smart farming. Image source: pictures of smart farming in agriculture in africa - Search Images (bing.com)

Sensors and remote-control technology

Sensors are strategically placed throughout the land to view the crops from anywhere in the world.

Sensors enable a real-time understanding of current farm, forest or water conditions. They help to monitor and manage crop production.

Fig.3.23: Picture of a sensor. Image source: pictures of sensors in agriculture - Search Images (bing.com)

Congratulations! Now that you have studied some of the emerging technologies used in vegetable crop and ornamental plant production, do the following activities.

Activity 3.18

Search online to find out other technologies that make the growing of vegetable crops and ornamental plants easier. Share your findings with other members of the class.

Follow the steps below to search online to find other technologies that make the growing of vegetable crops and ornamental plants easier.

Steps:

1. Search online. Make sure your data is on.
2. Type "other technologies that make the growing of vegetable crops and ornamental plants easier" in the browser and hit on the enter key. Wait for it to open and read carefully. Jot down relevant notes.
3. Discuss how these emerging technologies help ease work in vegetable crop and ornamental plant production with some members of your class.

Activity 3.19

With a friend discuss how these emerging technologies improve resource efficiency, enhance plant health and increase crop yield. Surf the Internet and search for more information.

Follow the steps below to achieve Activity 3.19. Respect each other's views in your discussions.

Steps:

1. Search online. Make sure your data is on.
2. Type "how emerging technologies improve resource efficiency, enhance plant health and increase crop yield" in the browser and hit on the enter key. Wait for it to open and read carefully. Jot down relevant notes.
3. Pair up with a friend and discuss your findings with each other.

Activity 3.20

Watch video documentaries on the use of drones online and discuss your observations with

other members of the class.

Follow the steps below to perform Activity 3.20. Respect each other's views in your discussions.

Steps:

1. Go to the seventh link provided under Extended Reading sections in this lesson and click on it. Make sure that your internet connection is on.
2. Go to any of the links the browser opened for you on your tablet or laptop and click on the link to watch any of the documentaries on the use of drones.
3. Observe what you see carefully and discuss your observations with other members of the class.

Activity 3.21

Visit a greenhouse in your locality to observe its structure and function or, if not possible, watch documentaries on the operations of a greenhouse. Share your findings with other members of the class.

Guidelines

Option A (Visit to the greenhouse in your locality)

Steps:

1. Visit a greenhouse site you find in your locality.
2. Go to the owner or manager of the greenhouse and explain what you would like to know.
3. Observe its structure and function. Jot down notes and share your findings with other members of the class.

Option B (Watching suitable documentaries)

Steps:

1. Search online again. Make sure that your data is on.
2. Type "***documentaries on the operations of a greenhouse***" in the browser and hit on the enter key. Wait for it to open and watch carefully. Jot down relevant notes.
3. Observe what you see carefully and share your findings with other members of the class.

Congratulations! Now that you've explored other emerging technologies used in the production of vegetable crops and ornamental plants, try to answer the review questions below.

EXTENDED READING

- Advantages of Growing Vegetable Crops in Modern Greenhouses By Dubravka Savic and Zarko M. Ilin; Reviewed: November 2nd, 2021 Published: March 18th, 2022; DOI: 10.5772/intechopen.101469; IntechOpen
- Cryopreservation of Endangered Ornamental Plants and Fruit Crops from Tropical and Subtropical Regions by Behzad Kaviani et al. (2022). Biology, 11, 847. https://doi.org/10.3390/biology11060847 https://www.mdpi.com/journal/biology
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REVIEW QUESTIONS 3.1

1. Identify and catalogue the main successful vegetable crop and ornamental crop farmers in your locality.
2. Describe four start-up packages needed to start a vegetable crop or ornamental plant enterprise.
3. Analyse factors and processes that account for the success and challenges of vegetable crop and ornamental plant enterprises.
4. Explain three factors that affect the growth patterns of vegetable crop and ornamental plant enterprises.
5. Explain the relevance of studying factors that affect the growth patterns of vegetable crops and ornamental plant enterprises.

REVIEW QUESTIONS 3.2

1. How would you convince your parents to let you study agriculture science at senior high school if a relative argues that farming still relies on traditional tools like hoes and cutlasses and involves a lot of hard work? Use examples of modern technologies that show how farming has improved.
2. How would you persuade vegetable and ornamental crop growers in your community to use new technologies instead of sticking to old methods that are hard work and give lower yields? Explain the benefits of these new technologies.
3. After explaining the benefits of new technologies in vegetable and ornamental plant production to your relatives, how would you evaluate the effects or challenges of at least one of these major technologies?
4. Genetically modified organisms (GMOs) are a controversial topic, and farmers in your community are reluctant to use them. How would you explain the benefits of growing or consuming GMOs to them?
5. A family member wants to use robots in her vegetable and ornamental crop production but is concerned about their limitations. How would you reassure her that the advantages of using robots outweigh their drawbacks?

REVIEW QUESTIONS 3.3

1. Explain the steps involved in the conventional ways of growing crops.
2. Explain hydroponics and its benefits in vegetable crop and ornamental plant production.
3. Compare the benefits of cultivating crops in other media such as water or artificial substrate rather than in soil.

REVIEW QUESTIONS 3.4

1. Explain tissue culture and its relevance in the production of vegetable crops and ornamental plants.
2. Explain the importance of each step in the tissue culture process for producing new plants.

   NB: Tissue culture cannot be carried out in a school environment. Therefore, this case study aims to provide a mental picture for learners. It should also help them appreciate the importance of each of the processes involved.

   Case Study:

   Eric Amoah Junior and Stephanie Brenya became very interested in performing tissue culture in their school after the teacher took them through the processes. Unfortunately, the teacher told them that to attain perfect results, the whole process must be carried out in a biotech laboratory where the environment is controlled and the tools and chemicals are all available. They decided then to go to a nearby biotech laboratory to perform the tissue culture. The technician in charge of the laboratory told them that the process would take several days to obtain the results. He asked them to follow his instructions as he explained the processes involved and the reasons for each step.

   He said, that in the initiation stage, take a small piece of plant tissue from the growing point or the tip of the plant using a sterilised knife. A sterilised knife, he explained, should be used to avoid contamination. At the multiplication stage, the sterile selected tissue is placed in an appropriate medium (sterile agar jelly) to multiply. The technician further explained that sterile agar jelly contains nutrients and plant hormones. The hormone makes the cells in the plant tissue divide rapidly producing many cells which form a shapeless lump of mass called a “callus.” The callus is then transferred to another jelly containing suitable plant hormones that stimulate the callus to develop roots.

   At the root formation stage, the hormones in the agar jelly help it to root so that the plantlets will be formed. The technician further asked them to put the callus with the developed roots into another jelly or agar containing different hormones that stimulate the development of shoots. This, he explained, is the shoot formation stage. Finally, at the acclimatisation stage, he asked them to move the plantlets or shoots developed to a greenhouse where they could grow in a controlled environment.

   Provide answers to the following questions:

   a. Can you achieve the results of tissue culture in a day?
   b. Why should a sterilsed knife be used to take the tissue instead of any knife?

c. How many stages are involved in the entire tissue culture process? Name them.

d. What are the two major things that are found in the sterilised agar jelly?

e. What is the function of the hormones found in the agar jelly?

f. What is the name of the shapeless lump of mass formed after some time?

g. What is done to that shapeless mass at the root formation stage?

h. What is done after the root of the callus is formed?

i. What is the final stage to be performed after the shoot is formed?

3. Compare and contrast the production of vegetable crops and ornamental plants using conventional procedures and tissue culture.

REVIEW QUESTIONS 3.5

1. Explain any one of the emerging technologies used in the production of vegetable crops and ornamental plants.
2. A farmer in your locality wants to reduce the drudgery involved in growing vegetable crops and ornamental plants and wants to consider the introduction of some emerging technologies on the farm. Outline how any two of these emerging technologies reduce drudgery in vegetable crop and ornamental plant production.

   Next week, we shall be looking at an interesting area in vegetable crop and ornamental plant production that focuses on irrigation systems. Have a wonderful week!

ANSWERS TO REVIEW QUESTIONS 3.1

1.

a. Gyempeh Veggi Farms, Location: Aputuogya, Bosomtwe District, Crops grown: tomatoes, cucumbers, lettuce, Contact: 0244XXXXXX, E-mail address: gyempehveggiefarms@gmail.com

b. Northern Veggie Farms, Location: Tamale, Crops grown: onions, garlic, potatoes, Contact: 0267XXXXXX, E-mail address: northernveggiefarms@gmail.com

c. Eastern Region Flowers, Location: Koforidua, Crops: tulips, daffodils, hyacinths, bougainvilla, Contact: 0549XXXXXX, E-mail address: easternregionflowers@yahoo.com

Note: The answers to **Question 1** will also be dependent on what learners find in their localities.

2. Start-up packages needed to start a vegetable crop or ornamental plant enterprise consist of

- market assistance
- capital/financial support
- access to a designated area for farming activities/land selection/soil type and quality
- kinds of vegetables or ornamental plants to grow/assorted seeds
- equipment, training, support
- fertilisers and pesticides

3. The factors and processes that contribute to the success and challenges of vegetable crop and ornamental plant enterprises are as follows: **Success factors** include quality seeds and planting materials, effective soil management, adequate water supply, pest and disease management, marketing and sales strategies, good agricultural practices, diversification, record-keeping, and data analysis. **Challenges** include climate change and weather variability, soil degradation and nutrient depletion, pests and diseases, market fluctuations and competition, limited access to credit and financing, labour shortages and high labour costs, and limited access to technology and extension services.

4. Factors that influence the growth patterns of vegetable crop and ornamental plant enterprises include the demographic characteristics of a region, crop profitability, access to credit, the educational level of the farmer or farm manager, farm size, farming experience, and the number of employees and assets. (Explain any three of these points).

5. Understanding the factors that affect the growth patterns of vegetable crops and ornamental plant enterprises is crucial for policymakers, agricultural experts, and farmers. It enables informed decision-making regarding resource allocation, market opportunities, and potential challenges in the vegetable industry. It also highlights the impact of factors such as climate change, technological advancements, and market demands on vegetable production practices and yields.

ANSWERS TO THE REVIEW QUESTIONS 3.2

1. Many new and emerging technologies are replacing conventional farming. Some of these emerging technologies include:
   - **Organic farming:** The system sustains the health of soils, ecosystems, and people. Its main goal is to develop sustainable enterprises that have little or no negative effect on the environment.
   - **Vertical farming**: Vertical farming can increase crop yields and reduce the impact of farming on the environment. Crops can be grown all year round.
   - **Artificial intelligence (AI)-driven farming:** Artificial intelligence is increasingly being integrated into vegetable farming processes to analyse data, predict crop performance, and optimise farming practices, leading to more efficient and sustainable cultivation.
   - **Drones**: They are used for crop monitoring and spraying chemicals on crops.
   - **Automation technology**: This refers to any tool that can reduce operator workload by combining the use of sensors, computers, feeding mechanisms, and robots. Its use helps to generally increase agricultural productivity.
   - **Machine learning**: It helps farmers sift through data to come to powerful insights to help them increase efficiency and productivity in agriculture and manufacturing.
   - **Big data**: Rather than relying on educated guesses, farmers can now rely on big data to make better and more informed decisions to enhance agricultural productivity.
   - **Blockchain (chain of trust)**: Blockchain addresses issues such as food fraud, safety recalls, and supply chain inefficiency, traces food in the system, and enables transactions to be easily and quickly verified.
   - **Radio frequency identification (RFID) technology**: This uses radio waves to identify objects, animals, or people.
   - **Internet of Things (IoT)**: The network of devices that are connected allows the exchange of data among themselves.
   - **Satellite greenhouses**: greenhouse vegetable farming is the type of farming in which vegetable crops are grown in built structures made of wood, plastic, metal, or net.
   - **Hydroponics and aquaponics**: These are the techniques of growing plants using a water-based nutrient solution rather than soil. It enables crops and fish to be raised in the same water bodies. In this case, it is called aquaculture.
   - **Biodegradable packaging materials**: Biodegradable packaging materials help to promote sustainable practices and reduce plastic waste that causes harm to the environment.

- **Tissue culture (micropropagation.)**: This method is used to produce large numbers of identical seedlings. It is also essential in the production of improved varieties of crops, particularly those whose multiplication is not possible through seed. It is also used for the conservation of endangered plant and crop species.
- **Biotechnology**: This has helped to develop new products, methods, and organisms intended to improve human health and society.

2. **Benefits of emerging technologies in vegetable farming:**
   - **Increased yields:** Precision agriculture, AI-driven farming, and hydroponics can optimise resource allocation, leading to larger crop yields and improved productivity.
   - **Resource use efficiency:** Technologies like precision agriculture and hydroponics enable better water and nutrient management, reducing waste and minimising negative environmental impact.
   - **Sustainable practices:** Many emerging technologies promote sustainable farming practices by minimising synthetic pesticide usage, reducing water consumption, and adopting eco-friendly packaging solutions.
   - **All year-round production:** Vertical farming and indoor cultivation allow for year-round vegetable production, regardless of external weather conditions, providing a more stable and consistent supply.
   - **Labour savings:** Automation and robotics decrease the need for manual labour, making farming more efficient and potentially reducing production costs.
   - **Economic use of space:** Most of the emerging technologies like vertical farming, precision agriculture, and hydroponics all help in the economic use of space. They can therefore be efficiently practised in areas where there is limited land space for extensive cultivation.
3. **Effects of a named emerging technology (GMO's)**
   - **Public perception and acceptance:** GMOs often face public scrutiny and scepticism regarding their safety and potential long-term effects on human health and the environment. Public perception can negatively impact consumer acceptance and demand for GMO products.
   - **Environmental concerns:** The introduction of GMOs may lead to unintended environmental consequences, such as crossbreeding with wild relatives or non-GMO crops, potentially affecting biodiversity and ecosystem balance.
   - **Loss of traditional varieties:** The widespread adoption of GMOs may lead to a reduced diversity of traditional crop varieties as farmers opt for commercially available genetically modified seeds.

- **Ethical concerns:** Some individuals and organisations have ethical objections to genetic engineering, particularly when it involves transferring genes between species or organisms.

OR

The **named** emerging technology is robots in agriculture (agribots).

Effects of the use of robotics in agriculture (agribots).

- The potential for unsafe pesticide usage without the supervision of human beings.
- There is also potential for higher fertiliser use due to lower application costs.
- There is difficulty in maintaining standards in the use of robotics if they are not properly controlled.
- There are safety concerns in the use of robotics in agriculture.
- There is a need for expert knowledge in the use of remote-controlled robots to achieve success (i.e., expert knowledge is required for success).
- Continuous training of experts is needed to abreast them with new robots that are being developed.
- In the use of robots, there is always a problem with managing workflows (i.e., how the work to be done will flow from one sequence to another).
- Inadequate information technology (IT) infrastructure always hinders the use of robotics in most small holding farms.
- There is a high initial cost involved in purchasing and servicing robotics in the farming industry.

4. Some benefits of GMOs include:

- **Reduced pesticide use:** Some GMOs are designed to be resistant to certain pests or diseases, reducing the need for chemical pesticides. It results in lower production costs, minimised environmental impact, and decreased exposure to harmful chemicals for farmers and consumers.
- **Increased crop productivity:** It enables plants to grow more efficiently and withstand adverse conditions, hence producing more per unit area.
- **Extended shelf life:** Such crops can be engineered to have a longer shelf life, reduce post-harvest losses, and ensure fresher products reach consumers.
- **Improved nutritional content:** GMOs can be developed to enhance the nutritional profile of vegetables, such as by increasing vitamin or mineral content, thus addressing nutritional deficiencies.
- **Adaptation to changing climates:** By introducing specific genetic modifications, crops can be adapted to thrive in different climates and regions, helping to address challenges posed by climate change.
- **Cost-effectiveness:** GMOs can offer cost-effective solutions for farmers, enabling them to produce more with fewer resources.

- **Improved beauty or aesthetic characteristics:** Ornamental plants can be engineered to have specific aesthetic characteristics, such as unique colours, longer bloom durations, and novel shapes, which can increase their attractiveness in the market.

5. Benefits or merits of the use of robotics in agriculture (agribots).

The use of robotics has several benefits. Some of these benefits include, but are not limited to:

- Reduce the cost of agricultural production at the end. This is because very limited human labour is employed.
- Saves time and meets the timeliness of farm operations: It saves time because operations can quickly be carried out without the use of human interventions.
- Reduce farm drudgery: The tiredness associated with human labour is completely absent with the use of robotics.
- Improves efficiency: Work can be done more efficiently if an expert is involved in the use of remote-controlled devices.
- It guarantees or ensures higher yields and clean farm produce.

Limitations or side effects of the use of robotics in agriculture (agribots).

- The potential for unsafe pesticide usage without the supervision of human beings.
- There is also potential for higher fertiliser use due to lower application costs.
- There is difficulty in maintaining standards in the use of robotics if they are not properly controlled.
- There are safety concerns in the use of robotics in agriculture.
- There is a need for expert knowledge in the use of remote-controlled robots to achieve success.
- Continuous training of experts is needed to abreast them with new robots that are being developed.
- In the use of robots, there is always a problem of managing workflows (i.e., how the work to be done will flow).
- Inadequate information technology (IT) infrastructure always hinders the use of robotics in most small holding farms.
- There is a high initial cost involved in purchasing and servicing robotics in the farming industry.

ANSWERS TO REVIEW QUESTIONS 3.3

1. Steps involved in conventional ways of growing crops.

   a. **Pre-production: These have to be done or assembled before starting the project**

      - Purpose or aims of production.
      - Choice of vegetable crop or ornamental plant.
      - Capital for the project.
      - Site selection (type of soil).
      - Sourcing of seed or planting materials.
      - Tools, equipment and machines needed.
      - Size of garden and proximity or Use of plastic, metal or wooden containers or bags/sacks.
      - Agronomic management system to employ.
      - Source and system of water supply.
      - Access to road networks and market.

   b. **Production stage:** Some vegetables are planted directly while others require nursing before transplanting.

   c. **Nursing:** Seeds and planting materials can be sown on seed beds, seedboxes, polybags or in containers. On seedbeds and boxes, the seeds can either be drilled or broadcast, shade is provided and seeds watered early morning and late afternoon.

      Nursery Management:

      - Watering.
      - Fertiliser application.
      - Weed control.
      - Pests and disease control.
      - Pricking out.
      - Thinning out.
      - Hardening-off.
      - Transplanting

2. **Explanation and benefits of hydroponics in vegetable crop and ornamental plant production**

Hydroponics: This is a technique of growing plants using a water-based nutrient solution rather than soil, and can include an aggregate substrate, or growing medium, such as vermiculite, coconut coir or perlite.

Benefits of hydroponics in vegetables and ornamental plant production

- Plants in hydroponics do not have to compete for resources. Hence, they can be planted more densely and vertically, thus saving space.
- Hydroponics can be used for growing vegetables and ornamental plants in areas with limited land available.
- Hydroponics is less labour-intensive.

3. Benefits of cultivating crops in other media such as water or artificial substrate rather than in soil.

- **Growing medium**: In hydroponics, plants are grown without soil and their roots are directly immersed in a nutrient-rich water solution. This allows for a precise supply of nutrient levels, optimising plant growth and development.
- **Water efficiency**: Hydroponic systems typically use up to 90% less water compared to traditional soil-based farming because water is recirculated within the system.
- **Space efficiency**: Hydroponic systems can be vertically stacked or designed in compact setups, making them suitable for urban areas or locations with limited arable land.
- **Faster growth**: With consistent access to nutrients and water, hydroponically grown vegetables often exhibit faster growth rates compared to their soil-grown counterparts.
- **Reduced pests and diseases**: Hydroponic systems reduce the risk of soil-borne pests and diseases, leading to higher plant vigour and rapid development.
- **Fertiliser and resource saving**.

I hope you enjoyed answering these questions successfully.

Good! Well, done, share your answers with your friends or show them to your teacher.

ANSWERS TO REVIEW QUESTIONS 3.4

1. Tissue culture is the process of growing plants in a controlled laboratory setting using tissue samples. The production of new plants from a small piece of plant tissue or cells removed from the growing tips of a plant in a suitable growth medium is called tissue culture.

Relevance or advantages of tissue culture in vegetable crops and ornamental plants

- Tissue culture helps to produce disease-free plantlets.
- Plants can be raised and grown throughout the year regardless of the season.
- The practice of tissue culture does not require a large plot of land or space to undertake it.
- It helps produce vegetables, fruits and ornamentals of different varieties in commercial quantities quickly.
- The use of tissue culture techniques helps to enhance the market competitiveness of the crops. This is because tissue culture can be used to achieve mass production.
- Tissue culture can be used to preserve endangered plant species and rare genotypes.
- Tissue culture enhances crop yields and improves food security.
- It can be used to produce disease-free planting materials thus reducing the risk of disease transmission.

2. Answers to the case study.

a. No, results will only show after several days.

b. To avoid all forms of contamination

c. **Five stages:** initiation stage, multiplication stage, rooting stage, shooting stage, acclimatisation stage.

d. Nutrients and hormones.

e. The hormone makes the cells in the plant tissue divide rapidly producing many cells which form a shapeless lump of mass called a “callus.”

f. Callus

g. The “callus’’ is then transferred to another jelly containing suitable plant hormones that stimulate the callus to develop roots.

h. The developed roots are transferred into yet another jelly or agar containing different hormones that stimulate the development of shoots.

i. Acclimatisation stage.

3. Comparing and contrasting the production of vegetable crops and ornamental plants using conventional procedures and tissue culture.

Criteria	Conventional procedures	Tissue culture.
1. Method	Plant propagation is done through seeds, cuttings layering, etc.	Plants propagated or grown in a controlled lab using tissue samples.
2. Accuracy	It is prone to changes, contaminations, and genetic variations.	There is higher accuracy and minimal contamination and variations.
3. Speed	The process is very slow and it depends on normal plant growth.	It is very fast and be used to produce multiple generations in a short time.
4. Scalability	It is limited by land and labour availability.	It can be used to produce large numbers of new plants.
5. Disease transmission	Higher risk of disease transmission	Lower risk of disease transmission
6. Genetic uniformity	Lower genetic uniformity.	Higher genetic uniformity.
7. Cost	Lower initial cost	Higher initial cost but can reduce cost in the long run.
8. Specialised labour	This may not require specialised labour.	Requires specialised labour.

ANSWERS TO REVIEW QUESTIONS 3.5

1. Explanation of any one of the emerging technologies used in the production of vegetable crops and ornamental plants
   - **Satellite greenhouses**: Satellite greenhouse farming is the type of farming in which vegetable crops are grown in built structures (wood, plastic, metal and net).
   - **Robotics:** Robotics is the use of robots or automated machines in place of humans to perform physical tasks.
   - **Smart farming:** Smart farming is an application of the Internet of Things (IoT). IoT devices are pieces of hardware such as sensors, actuators or machines, that are programmed for certain applications and can transmit data over the Internet to other networks.
   - **Sensors**: Sensors are strategically placed throughout the land to view the crops from anywhere in the world.
2. Outline how any two of these emerging technologies reduce drudgery in vegetable crop and ornamental plant production
   - **Satellite Greenhouses**: Reduce drudgery (manual labour) for temperature and humidity monitoring
   - **Robotics:** Reduce drudgery (manual labour) for repetitive tasks
   - **Smart farming:** Reduce drudgery (manual labour) for data collection and analysis
   - **Sensors**: Reduce drudgery (manual labour) for monitoring and control.

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Glossary

- **Technology:** It is described as the application of scientific knowledge for practical purposes especially in industry and agriculture.
- **Emerging technologies**: Emerging technologies are new developments in technology that are used for the development of agriculture and other industries.
- **Procedures:** These are the stages involved in the cultivation of vegetable crops and ornamental plants. These include pre-production and production stages.
- **Innovation:** This refers to anything that is perceived as new or an improvement to an existing system or process.
- **A seed:** A seed is a small embryonic plant which is enclosed in a protective covering and naturally designed to grow into a new plant.
- **Robotics:** In agriculture, robotics involves the use of autonomous or remote-controlled machines to perform tasks like planting, spraying, and harvesting.
- **Automation:** In agriculture, automation refers to the use of technology to control and monitor farming processes without human intervention.
- **Sensors:** Sensors in agriculture are devices that detect and measure various parameters like soil moisture, temperature, humidity, and crop health.
- **Greenhouse:** This refers to a special building made of transparent materials like glass or plastic, used for growing plants in a controlled environment.
- **Drudgery:** This refers to a state of hard, tiresome, and unpleasant work or activity that requires a lot of effort and time.

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