MINISTRY OF EDUCATION

Agricultural Science

TEACHER MANUAL

YEAR 1 - BOOK 1

NATIONAL COUNCIL FOR CURRICULUM & ASSESSMENT OF MINISTRY OF EDUCATION

MINISTRY OF EDUCATION

REPUBLIC OF GHANA

Agricultural Science

Teacher Manual

Year One - Book One

NATIONAL COUNCIL FOR CURRICULUM & ASSESSMENT OF MINISTRY OF EDUCATION

AGRICULTURAL SCIENCE TEACHERS MANUAL

Enquiries and comments on this manual should be addressed to:
The Director-General
National Council for Curriculum and Assessment (NaCCA)
Ministry of Education
P.O. Box CT PMB 77
Cantonments Accra

Telephone: 0302909071, 0302909862
Email: info@nacca.gov.gh
website: www.nacca.gov.gh

CONTENTS

INTRODUCTION

The National Council for Curriculum and Assessment (NaCCA) has developed a new Senior High School (SHS), Senior High Technical School (SHTS) and Science, Technology, Engineering and Mathematics (STEM) Curriculum. It aims to ensure that all learners achieve their potential by equipping them with 21st Century skills, competencies, character qualities and shared Ghanaian values. This will prepare learners to live a responsible adult life, further their education and enter the world of work.

This is the first time that Ghana has developed an SHS Curriculum which focuses on national values, attempting to educate a generation of Ghanaian youth who are proud of our country and can contribute effectively to its development.

This Teacher Manual for Agricultural Science covers all aspects of the content, pedagogy, teaching and learning resources and assessment required to effectively teach Year One of the new curriculum. It contains this information for the first 12 weeks of Year One, with the remaining 12 weeks contained within Book Two. Teachers are therefore to use this Teacher Manual to develop their weekly Learning Plans as required by Ghana Education Service.

Some of the key features of the new curriculum are set out below.

Learner-Centred Curriculum

The SHS, SHTS, and STEM curriculum places the learner at the center of teaching and learning by building on their existing life experiences, knowledge and understanding. Learners are actively involved in the knowledge-creation process, with the teacher acting as a facilitator. This involves using interactive and practical teaching and learning methods, as well as the learner's environment to make learning exciting and relatable. As an example, the new curriculum focuses on Ghanaian culture, Ghanaian history, and Ghanaian geography so that learners first understand their home and surroundings before extending their knowledge globally.

Promoting Ghanaian Values

Shared Ghanaian values have been integrated into the curriculum to ensure that all young people understand what it means to be a responsible Ghanaian citizen. These values include truth, integrity, diversity, equity, self-directed learning, self-confidence, adaptability and resourcefulness, leadership and responsible citizenship.

Integrating 21st Century Skills and Competencies

The SHS, SHTS, and STEM curriculum integrates 21st Century skills and competencies. These are:

- **Foundational Knowledge:** Literacy, Numeracy, Scientific Literacy, Information Communication and Digital Literacy, Financial Literacy and Entrepreneurship, Cultural Identity, Civic Literacy and Global Citizenship
- **Competencies:** Critical Thinking and Problem Solving, Innovation and Creativity, Collaboration and Communication
- **Character Qualities:** Discipline and Integrity, Self-Directed Learning, Self-Confidence, Adaptability and Resourcefulness, Leadership and Responsible Citizenship

Balanced Approach to Assessment - not just Final External Examinations

The SHS, SHTS, and STEM curriculum promotes a balanced approach to assessment. It encourages varied and differentiated assessments such as project work, practical demonstration, performance assessment, skills-based assessment, class exercises, portfolios as well as end-of-term examinations and final external assessment examinations. Two levels of assessment are used. These are:

- Internal Assessment (30%) – Comprises formative (portfolios, performance and project work) and summative (end-of-term examinations) which will be recorded in a school-based transcript.
- External Assessment (70%) – Comprehensive summative assessment will be conducted by the West African Examinations Council (WAEC) through the WASSCE. The questions posed by WAEC will test critical thinking, communication and problem solving as well as knowledge, understanding and factual recall.

The split of external and internal assessment will remain at 70/30 as is currently the case. However, there will be far greater transparency and quality assurance of the 30% of marks which are school-based. This will be achieved through the introduction of a school-based transcript, setting out all marks which learners achieve from SHS 1 to SHS 3. This transcript will be presented to universities alongside the WASSCE certificate for tertiary admissions.

An Inclusive and Responsive Curriculum

The SHS, SHTS, and STEM curriculum ensures no learner is left behind, and this is achieved through the following:

- Addressing the needs of all learners, including those requiring additional support or with special needs. The SHS, SHTS, and STEM curriculum includes learners with disabilities by adapting teaching and learning materials into accessible formats through technology and other measures to meet the needs of learners with disabilities.
- Incorporating strategies and measures, such as differentiation and adaptative pedagogies ensuring equitable access to resources and opportunities for all learners.
- Challenging traditional gender, cultural, or social stereotypes and encouraging all learners to achieve their true potential.
- Making provision for the needs of gifted and talented learners in schools.

Social and Emotional Learning

Social and emotional learning skills have also been integrated into the curriculum to help learners to develop and acquire skills, attitudes, and knowledge essential for understanding and managing their emotions, building healthy relationships and making responsible decisions.

Philosophy and Vision for each subject

Each subject now has its own philosophy and vision, which sets out why the subject is being taught and how it will contribute to national development. The Philosophy and Vision for Agricultural Science is:

Philosophy: The next generation of learners of Agriculture can reach their full potential through climate-aware learner-centred pedagogies to develop an interest in agriculture to improve food production.

Vision: Learners equipped with 21st Century skills and competencies who are excited about agriculture and create employment and wealth through the application of technology in agriculture.

ACKNOWLEDGEMENTS

Special thanks to Professor Edward Appiah, Director-General of the National Council for Curriculum and Assessment (NaCCA) and all who contributed to the successful writing of the Teacher Manuals for the new Senior High School (SHS), Senior High Technical School (SHTS) and Science Technology, Engineering and Mathematics (STEM) curriculum.

The writing team was made up of the following members:

Subject	Writer	Institution
Home Economics	Grace Annagmeng Mwini	Tumu College of Education
	Imoro Miftaw	Gambaga Girls' SHS
	Love Boateng	Juaso SHS
	Jusinta Kwakyewaa (Rev. Sr.)	St. Francis SHTS
Religious Studies	Richardson Addai-Mununkum	University of Education Winneba
	Dr. Bonsu Osei-Owusu	West Africa SHS
	Prince Osei Adjei	Adventist SHS, Bantama
	Dr Francis Opoku	Valley View University College
	Yaw Sarkodie Agyemang	University of Cape Coast
	Aransa Bawa Abdul Razak	Uthmaniya SHS
	Godfred Bonsu	Prempeh College
RME	Anthony Mensah	Abetifi College of Education
	Joseph Bless Darkwa	Volo Community SHS
	Clement Nsorwineh Atigah	Tamale SHS
Arabic	Murtada Mahmoud Muaz	AAMUSTED
	Abas Umar Mohammed	University of Ghana
	Adam Abubakar	Uthmaniya SHS
	Mahey Ibrahim Mohammed	Tijjaniya Senior High School
French	Osmanu Ibrahim	Mount Mary College of Education
	Maurice Adjetey	
	Mawufemor Kwame Agorgli	Akim Asafo SHS
Performing Arts	Latipher Osei Appiah-Agyei	University of Education Winneba
	Desmond Ali Gasanga	Ghana Education Service
	Yaw Owusu Asiamah	Adventist SHS, Bantama
	Chris Ampomah Mensah	Bolgatanga SHS, Winkogo

Subject	Writer	Institution
Art and Design Studio and Foundation	Dr. Ebenezer Acquah	University for Education Winneba
	Dr. Osuanyi Quaicoo Essel	University for Education Winneba
	Seyram Kojo Adipah	Ghana Education Service
	Jectey Nyarko Mantey	Kwame Nkrumah University of Science and Technology
	Yaw Boateng Ampadu	Prempeh College
	Kwame Opoku Bonsu	Kwame Nkrumah University of Science and Technology
	Dzorka Etonam Justice	Kpando SHS
Applied Technology & Design and Communication Technology	Joseph Asomani	AAMUSTED
	Dr. Prosper Mensah	AAMUSTED
	Dr. Sherry Kwabla Amedorme	AAMUSTED
	Esther Pokuah	Mampong Technical College of Education
	Wisdom Dzidzienyo Adzraku	AAMUSTED
	Kunkyuuri Philip	Kumasi SHTS
	Antwi Samuel	Kibi SHTS
	Gabriel Boafo	Kwabeng Anglican SHTS
	Josiah Bawagigah Kandwe	Walewale Technical Institute
	Emmanuel Korletey	Benso SHTS
	Isaac Buckman	Armed Forces SHTS
	Daniel K. Agbogbo	Kwabeng Anglican SHTS
	Tetteh Moses	Dagbon State SHS
	Awane Adongo Martin	Dabokpa Technical Institute
Business Studies	Emmanuel Kodwo Arthur	ICAG
	Dr. Emmanuel Caesar Ayamba	Bolgatanga Technical University
	Ansbert Baba Avole	Bolgatanga SHS, Winkogo
	Faustina Graham	Ghana Education Service, HQ
	Nimako Victoria	SDA SHS, Akyem Sekyere
Agriculture	Dr Esther Fobi Donkoh	University of Energy and Natural Resources
	Prof. Frederick Adzitey	University for Development Studies
	Eric Morgan Asante	St. Peter's SHS

Subject	Writer	Institution
Agricultural Science	David Esela Zigah	Achimota School
	Prof J.V.K. Afun	Kwame Nkrumah University of Science and Technology
	Dr. Kwadwo Amankwah	Kwame Nkrumah University of Science and Technology
	Alex Adu Frimpong	Benso SHTS
	Mrs. Benedicta Foli	
Government	Josephine Akosua Gbagbo	Ngleshie Amanfro SHS
	Augustine Arko Blay	University of Education Winneba
	Samuel Kofi Adu	Fettehman SHS
Economics	Peter Anti Partey	University of Cape Coast
	Charlotte Kpogli	Ho Technical University
	Joseph Agbevanu	Kinbu SHS
	Adams Abdul-Somed	Kalponin SHS
	Benjamin Agyekum	Mangoase SHS
Geography	George Boateng	Berekum College of Education
	Dr. Esther Yeboah Danso-Wiredu	University of Education Winneba
	Dr. Matthew Krusah	University of Education Winneba
	Raymond Nsiah Asare	Methodist Girls' High School
History	Kofi Adjei Akrasi	Opoku Ware School
	Anitha Oforiwah Adu-Boahen	University of Education Winneba
	Prince Essiaw	Enchi College of Education
Ghanaian Language	David Sarpei Nunoo	University of Education Winneba, Ajumako
	Catherine Ekua Mensah	University of Cape Coast
	Ebenezer Agyemang	Opoku Ware School
Physical Education and Health	Paul Dadzie	Accra Academy
	Sekor Gaveh	Kwabeng Anglican SHTS
	Anthonia Afosah Kwaaso	Junkwa SHS
	Mary Aku Ogum	University of Cape Coast
Social Studies	Mohammed Adam	University of Education Winneba
	Simon Tengan	Wa SHTS
	Jemima Ayensu	Holy Child School

Subject	Writer	Institution
Computing and Information Communication Technology (ICT)	Victor King Anyanful	OLA College of Education
	Raphael Dordoe Senyo	Ziavi SHTS
	Kwasi Abankwa Anokye	Ghana Education Service, SEU
	Millicent Heduvor	STEM SHS, Awaso
	Mohammed Abdul-Samed	Dagbon State SHS
	Dr. Gaddafi Abdul-Salaam.	Kwame Nkrumah University of Science and Technology
English Language	Esther Armah	Mangoase SHS
	Kukuaa Andoh Robertson	Achimota School
	Cecilia Amponsah	Presbyterian Boys' SHS
	Alfred Quaittoo	Kaneshie SHTS
	Benjamin Orsoo	Islamic SHS
	Fuseini Hamza	Tamale Girls' SHS
Intervention English	Roberta Emma Amos-Abanyie	Ingit Education Consult
	Prof. Charles Owu-Ewie	University of Education Winneba
	Perfect Quarshie	Mawuko Girls SHS
	Sampson Dedey Baidoo	Benso SHTS
Literature in English	Blessington Dzah	Ziavi SHTS
	Angela Aninakwah	Ghana Education Service
	Dr. Emma Sarah Eshun	University of Education Winneba
	Samuel Kwame Kassah	St. Peter's SHS
	Juliana Akomea	Mangoase SHS
General Science	Dr. Comfort Korkor Sam	University for Development Studies
	Saddik Mohammed	Ghana Education Service
	Robert Arhin	SDA SHS, Akyem Sekyere
Chemistry	Ambrose Ayiku	St. Francis College of Education
	Awumbile Patrick Nsobila	Bolgatanga SHS, Winkogo
	Bismark Tunu	Opoku Ware School
	Gbeddy Neurus Anthony	Ghanata SHS
Physics	Linus Labik	Kwame Nkrumah University of Science and Technology
	Henry Benyah	Wesley Girls' SHS
	Sylvester Affram	Kwabeng Anglican SHS

Subject	Writer	Institution
Biology	Damoah Paul	Prempeh College
	Maxwell Bunu	Ada College of Education
	Ebenezer Delali Kpelly	Wesley Girls' SHS
	Doris Osei-Antwi	Ghana National College
Mathematics	Edward Dadson Mills	University of Education Winneba
	Zacharia Abubakari Sadiq	Tamale College of Education
	Faustina Nana Ackob	Mfantsiman SHS
	William Ababu	Swedru SHS
	Collins Kofi Annan	Mando SHS
Additional Mathematics	Dr. Nana Akosua Owusu-Ansah	University of Education Winneba
	Gershon Mantey	University of Education Winneba
	Very Rev. Prof. William Obeng Denteh	Kwame Nkrumah University of Science and Technology
	Charles B. Ampofo	Kibi College of Education
	Bismark Twum	SDA SHS, Akyem Sekyere
	Innocent Duncan	KNUST SHS
Intervention Mathematics	Florence Yeboah	Assin Manso SHS
	Mawufemor Adukpo	Ghanata SHS
	Jemima Saah	Winneba SHS
	Mohammed Shani Abdulai	Yendi SHS
Robotics	Dr. Eliel Keelson	Kwame Nkrumah University of Science and Technology
	Dr. Nii Longdon Sowah	University of Ghana
	Kwabena Osei-Kusi	Prempeh College
	Michael Wilson	CSIR
	Isaac Nzoley	Wesley Girls' SHS
Engineering	Daniel K. Agbogbo	Kwabeng Anglican SHTS
	Prof. Abdul-Rahman Ahmed	Kwame Nkrumah University of Science and Technology
	Dr. Griffth Serlorm Klogo	Kwame Nkrumah University of Science and Technology
	Japheth Kwadwo Bumusi	Mawuli School
	Valentina Osei-Himah	Atebubu College of Education

Subject	Writer	Institution
Aviation and Aerospace Engineering	Opoku Joel Mintah	Altair Unmanned Technologies
	Dr. Eunice Akyereko Adjei	Kwame Nkrumah University of Science and Technology
	Dr. David Kofi Oppong	Kwame Nkrumah University of Science and Technology
	Sam Ferdinand	Afua Kobi Ampem Girls' SHS
Biomedical Science	Dr. Dorothy Yakoba Agyapong	Kwame Nkrumah University of Science and Technology
	Jennifer Fafa Adzraku	Université Libre de Bruxelles
	Dr. Isaac Acquah	Kwame Nkrumah University of Science and Technology
	David Ayah	St. John's Grammar School
	Dr. Eric Worlawoe Gaba	Br. Tarcisius Prosthetics and Orthotics Training College
Manufacturing Engineering	Benjamin Atribawuni Asaaga	Kwame Nkrumah University of Science and Technology
	Dr. Samuel Boahene	Kwame Nkrumah University of Science and Technology
	Issahaku Iddrisu	Ada SHS
	Dr. Mizpah Ama D. Rockson	Kwame Nkrumah University of Science and Technology
	Prof Charles Oppon	Cape Coast Technical University
Spanish	Setor Donne Novieto	University of Ghana
	Franklina Kabio	University of Ghana
	Mishael Annoh Acheampong	University of Media, Art and Communication
Assessment	Benjamin Sundeme	St. Ambrose College of Education
	Victor Gideon Obeng	Retired
	Prof. Eric Francis Eshun	Kwame Nkrumah University of Science and Technology
	Dr. Ruth Annan-Brew	University of Cape Coast
	Dr. Isaac Amoako	Atebubu College of Education

Subject	Writer	Institution
Curriculum Writing Guide	Paul Michael Cudjoe	Prempeh College
	Prof. Winston Abroampa	Kwame Nkrumah University of Science and Technology
	Cosmos Eminah	University of Education Winneba
	Ahmed Amihere	University of Education Winneba
	Evans Odei	Achimota School
	Ellen Abakah	CEGENSA, University of Ghana
	Hasiyatu Abubakari	CEGENSA, University of Ghana
	Eyram Eric Kwasi Fiagbedzi	CEGENSA, University of Ghana
	Deborah Atobrah	CEGENSA, University of Ghana
	Ayine Akoglo	CEGENSA, University of Ghana
	Theodora Akweley Asiamah	CEGENSA, University of Ghana
NaCCA	Matthew Owusu	Ebenezer Ankamah
	Reginald Quartey	Alice Abbiw Donkor
	Rebecca Abu Gariba	Abigail Birago Owusu
	Anita Collision	Samuel Owusu Ansah
	Joachim Honu	Richard Teye
	Joana Vanderpuije	Joseph Barwuah
	Uriah Otoo	Anthony Sarpong
	Nii Boye Tagoe	Jephtar Adu Mensah
	Eric Amoah	Nancy Aseiduwaa Gyapong
	Francis Agbalanyo	Godwin Senanu
	Dennis Adjasi	Godfred Mireku
	Samuel Amankwa Ogyampo	Juliet Owusu-Ansah
	Sharon Antwi Baah	Thomas Kumah Osei
	Ayuba Sullivan	Seth Nii Nartey

SCOPE AND SEQUENCE

Agricultural Science Summary

S/N	STRAND	SUB-STRAND	YEAR 1			YEAR 2			YEAR 3		
			CS	LO	LI	CS	LO	LI	CS	LO	LI
1	New Dawn in Agriculture	Misconceptions and Prospects in Agriculture and Farming	2	2	4	1	1	2	1	1	2
		Emerging Technologies in Agriculture.	2	2	5	2	2	5	2	2	5
		Agricultural Machineries	2	2	5	2	2	6	2	3	6
2	Farming for jobs and income	Economic Production of Crops	1	1	3	1	1	3	1	1	3
		Economic Production of Animals	1	1	3	1	1	3	1	1	3
3	Mobilisation of Resources and Networks	Land Tenure Systems for Agriculture.	1	1	3	-	-	-	-	-	-
		Support Systems in Agriculture.	2	2	5	2	2	5	2	2	5
4	Agriculture and Climate	Climate Variability	1	1	2	2	2	2	2	2	2
		Climate Change Adaptation	1	1	2	-	-	-	-	-	-
		Climate Change Mitigation Strategies	1	1	1	-	-	-	-	-	-
Total			**14**	**14**	**33**	**11**	**11**	**26**	**11**	**12**	**26**

Overall Totals (SHS 1 – 3)

Content Standards	**36**
Learning Outcomes	**37**
Learning Indicators	**85**

SECTION 1: MEANING AND IMPORTANCE OF AGRICULTURAL SCIENCE

Strand: **New Dawn in Agriculture.**

Sub-Strand: Misconception and Prospects in Agriculture and Farming

Learning Outcomes:

1. *Explain the meaning and importance of agriculture.*
2. *Use the knowledge acquired in the importance of agriculture to dispel misconceptions about the study of agriculture.*

Content Standard: Demonstrate knowledge and understanding of the meaning and importance of agriculture.

INTRODUCTION AND SECTION SUMMARY

This section introduces learners to the meaning and importance of agriculture to households and the national economy. It highlights misconceptions about agriculture and how to address these misconceptions. The percentage of Ghanaians engaged in agriculture as well as the number of people interested in the study of agriculture is gradually decreasing. The decreasing interest of young people, especially, is due to the misconceptions about the sector. Should this trend continue, it will result in dire consequences for Ghana. Learners are expected to have in-depth knowledge about agriculture and explain the contributions of the sector to individuals and the economy at large.

This Section covers Week 1: Misconceptions and Prospects in Agriculture

SUMMARY OF PEDAGOGICAL EXEMPLARS

To help learners successfully achieve an understanding of the meaning and importance of agriculture and misconceptions about agriculture, pedagogies such as Initiating Talk for Learning, Think-Pair-Share, Digital and Collaborative Learning should be used. The teacher should set ground rules to discourage the teasing of learners with speech problems and those who might give wrong answers in class to encourage all learners, including shy and introverted learners, to actively participate in the lesson. This will encourage learners to listen to their peers' opinions and express disagreements in constructive ways. Learners should be encouraged to work in mixed-ability and mixed-gender (where appropriate) groups, in pairs or as individuals as and when necessary. To ensure best use of time, activities such as farm, industry and community visits to seek information or collect data should be kept to the minimum. However, on-campus projects which mimic real field experience should be encouraged. Resource persons, for example award winners in any agro-enterprise, may be invited to speak about their accomplishments, to kindle the interest of learners. The teacher should assess the performance of learners to identify strengths and areas that need improvement, and provide constructive feed-back to learners. The teacher should encourage the development of national values among learners.

ASSESSMENT SUMMARY

The teacher should assign tasks to cover the misconceptions about the study of agriculture and emphasise tasks on the meaning and importance of agriculture that are geared towards dispelling any

misconceptions. The assessment should consider the various levels of learner proficiency and the expected depth of knowledge of the learners. The assessment should include class tests, assignments, and project-based work, while responses can be either oral or written and presented by individuals or groups.

WEEK 1

Learning Indicators:

1. *Explain the meaning and importance of agriculture*
2. *Identify and address misconceptions in agriculture and farming at the community and national levels.*

Theme or Focal Area 1: Meaning and Importance of Agriculture

Meaning of Agriculture

Agriculture is the science or practice of farming, including the cultivation of the soil for the growing of crops and the rearing of animals to provide food, wool, and other products.

Agricultural Science is the academic and scientific study of agriculture that involves researching and understanding the principles behind farming practices, developing new technologies and techniques to improve agricultural productivity, and addressing challenges such as pests, diseases and environmental health. Invariably, agricultural science is the platform for developing the theories and tools and equipment that are adopted and adapted for agricultural production.

Importance of Agriculture to Society

1. **Food diversity and nutrition**: Agriculture contributes to the diversity of food available in Ghana. Traditional crops, fruits, vegetables and livestock provide essential nutrients and contribute to a balanced diet. Promoting agricultural diversity enhances nutrition, improves dietary diversity, and helps combat malnutrition and related health issues.
2. **Cultural heritage**: Agriculture is deeply intertwined with Ghana's cultural heritage. Traditional farming practices, indigenous crops and agricultural rituals hold cultural and historical significance. Preserving and promoting these traditions help maintain cultural identity, foster community cohesion and support cultural tourism.
3. **Provision of raw materials**: Agriculture is the source of raw materials for various industries such as textiles, pharmaceuticals and biofuels. It supplies essential inputs for manufacturing processes.
4. **Food security**: Agriculture is the backbone of Ghana's food security. The majority of Ghanaians rely on agriculture for their daily sustenance and the sector provides the country with a significant portion of its food supply.
5. **Employment and livelihoods**: Agriculture is a major source of employment and livelihood for a significant portion of the population, particularly in rural areas. Smallholder farmers and agricultural workers make up a significant part of the workforce, contributing to poverty reduction, income generation and economic stability.
6. **Poverty alleviation**: Agriculture has the potential to alleviate poverty in Ghana. By improving agricultural productivity and promoting value-added activities, the sector can create income opportunities and reduce poverty levels, particularly in rural communities.
7. **National economic growth**: Agriculture plays a crucial role in Ghana's economy. It contributes to the country's gross domestic product (GDP) and export earnings. The agricultural sector provides income opportunities for farmers, traders, processors, and other stakeholders along the agricultural value chain. It therefore stimulates economic growth, reduces rural-urban migration and supports sustainable development.

8. **Trade and foreign exchange**: Ghana exports various agricultural products, such as cocoa, cashew nuts, timber and fish, which generate foreign exchange earnings for the country. Agricultural exports contribute to Ghana's trade balance, enhance its international competitiveness, and promote economic stability.
9. **Rural development**: Agriculture is closely linked to rural development in Ghana. Investments in agricultural infrastructure, irrigation systems, rural roads, market access and access to education can stimulate rural development and improve the living conditions of rural populations. It helps create sustainable livelihoods, enhances social services and reduces regional disparities.
10. **Environmental sustainability**: Sustainable agriculture practices are crucial for protecting Ghana's natural resources and environment. Implementing practices such as conservation agriculture, agroforestry and organic farming can help maintain soil fertility, prevent land degradation, preserve biodiversity and mitigate climate change impacts.
11. **Climate resilience**: Agriculture in Ghana is vulnerable to climate change impacts such as droughts, floods and unpredictable rainfall patterns. Investing in climate-smart agricultural practices and technologies helps build resilience, enhances adaptive capacity and ensures the sector's long-term sustainability.

Learning Tasks:

1. Learners explain the meaning of agriculture.
2. Learners discuss the importance of agriculture.
3. Learners analyse the impact of agriculture on society.

Pedagogical Exemplars

Initiating talk for learning: The teacher guides learners with probing and leading questions to come up with the meaning and importance of agriculture to society and the nation. Learners should be encouraged to provide oral or written responses.

Collaborative learning: The teacher puts learners in groups to discuss the impact of agriculture on society. More confident learners should be encouraged to lead the discussion groups and to provide assistance for other learners.

Key Assessment

Assessment Level 2: Explain the meaning of agriculture.

Assessment Level 3: Explain three reasons agriculture should be studied by all secondary school learners in Ghana.

Assessment Level 4: Discuss how agriculture positively impacts various aspects of Ghanaian society.

Theme or Focal Area 2: Misconceptions about agriculture and farming in Ghana and how to address them.

Meaning of the term misconception in agriculture

Misconceptions are wrong notions people have about agriculture due to lack of education, misinformation, cultural influences and or misinterpretation of information.

Some misconceptions and how to address them

1. **Those involved in agriculture are poor:**

   The majority of farmers do not own land and therefore need to raise capital to purchase or pay for leasing the land. Most farmers do not get access to loans and grants and therefore are unable to acquire large parcels of land and necessary machinery to produce on a large scale. These two factors tend to restrict many potential large-scale farmers to subsistence farming leading to low levels of production and profit, with consequent poverty and poor livelihood. Many learners are wards of farmers and are aware of the financial and economic constrains most farmers face in Ghana. For example, at age 60 years and above, most Ghanaian farmers have no substantial property to bequeath to their wards, compared to other areas of work or employment. Hence farmers' wards are not enthusiastic about farming.

   However, some farmers have become rich and successful in Ghana. Learners should browse the Internet to find the richest farmers and companies in Ghana for the previous year. In addition, outstanding farmers (Best Farmers) in all branches of agriculture are honoured by the Government of Ghana every first Friday in December, which is designated as Farmers' Day.

2. **Agriculture is for males only:** In many parts of Ghana, agriculture is seen as "a man's job," therefore deterring females from practising it. Female workers are mostly required at seed sowing, harvesting, conveyance stages and initial processing while the main farming activities such as land clearing, manual tilling and tractor operation are for males.

   However, there are females who are successful crop, ornamental and animal farmers in various communities in Ghana. Teachers should provide graphs, pictures and videos to demonstrate the involvement of women.

3. **Those in agriculture compel their wards to continue the farming traditions:** It is believed that most farmers practically force their children to continue the farming business and do not expose them to other job opportunities.

   However, there are successful farmers whose children are not engaged in farming but are occupying top managerial positions in other sectors.

4. **Farming is primitive and low-tech:** In Ghana most farmers still use simple farm tools such as cutlasses, hoes, axes, shovels, pick axes, and mattocks, for tedious farm operations such as ploughing, ridging, mounding, planting and harvesting processes that discourage the young people. Most school textbooks do not show farmers operating high tech machinery that saves time and energy. Their artworks depict farmers doing everything by hand with the aid of simple farm tools. Korankye (2019) reported several reasons young people are not interested in agriculture. Paramount among the reasons were poor farming technology and use of primitive tools.

   However, contrary to assertions and beliefs, the world's scientific and technological advancements include farming. Tractors, ploughs, combine harvesters, planters, and other farming machinery are produced to increase efficiency, reduce resource use, and improve outcomes.

5. **Farmers are generally uneducated**: Most Ghanaians think agriculture is just about land clearing or weeding, planting and harvesting.

   However, issues about pest and disease control, hybridisation, genetically modified organisms (GMOs), storage, agro-processing and distribution/marketing, for example, are integral parts of agriculture that require education and scientific approaches. Therefore, a higher education qualification is required to be successful in farming. Some of the very best farmers in Ghana are well educated, some with post-graduate degrees, and this includes females.

6. **People who offer agriculture do not have good job prospects and have limited opportunities for further education**: Erroneously, many young people feel that those who study agriculture at secondary school or university level do not have good job prospects and have limited opportunities for further education.

   But contrary to this misconception, the key advantage for school agricultural learners is self-employment. Most school leavers in other fields in Ghana face unemployment challenges, unlike those that study agriculture. Should the learner decide to procced to further education, there are many programmes for further studies. An agriculture student can become, for example, an animal or crop scientist, horticulturist, agricultural engineer, forensic scientist, biotechnologist, banker, agricultural economist or nurse.

7. **Farmers are uncultured rural folk**: Farming in Ghana, is mostly practised in rural communities where farmers use primitive tools and are usually not well dressed, hence they are seen as primitive and uncultured.

   However, with modernisation, farming operations and farmer appearance on the farm are changing rapidly. For example, commercial farmers and their workers dress in overalls and appropriate protective clothing on the farm.

8. **Genetically modified organisms (GMOs) are evil and harmful and can alter the genes of consumers:** Knowledge about genetically modified (GM) food and biotechnology is low among the Ghanaian public as a result of low levels of education and awareness of the topic.

   It is important that learners are provided with accurate information about the safety and benefits of GMOs based on authentic scientific information. The teacher should also highlight the potential of GMOs to improve crop yields, reduce pesticide use, and address food security challenges. References are provided for more information on GMOs.

Learning Tasks:

1. Learners to discuss the misconceptions about agriculture and the steps to address them.
2. Identify successful male and female Ghanaian farmers who were educated in Ghana.

Pedagogical Exemplars

Initiating talk for learning: The teacher should guide learners with leading questions to identify and discuss misconceptions about agriculture and share their findings with the class in a plenary session. The teacher should look out for gender stereotyping in any misconceptions. For example, female farmers cannot operate tractors and heavy farm machinery.

Digital learning: In groups, learners browse the Internet and come up with ways of addressing misconceptions about agriculture and share their list in a plenary session. More able learners should be allowed to do independent work in addressing the misconceptions.

Key Assessment

Assessment Level 1: Outline at least three misconceptions about the study and practice of agriculture.

Assessment Level 2: Identify and explain at least two reasons to disprove the notion that agriculture is for males only.

Assessment Level 3: Explain four measures to address misconceptions young people have about agriculture.

Assessment Level 4: Working as individuals, search for information on successful female farmers in Ghana and submit a written report on the reasons for their success.

Section 1 Review

Through discussion, learners understand the meaning and importance of agriculture and appreciate the role of agriculture in ensuring food security, employment, livelihood, economic growth, poverty alleviation, foreign exchange and trade, rural development, environmental sustainability, and cultural heritage. The section also exposed learners to misconceptions they had about agriculture especially that it is for the poor, primitive and the uneducated. Also, light jobs like sowing of seeds are for females only. Efforts were made to address these misconceptions including explaining that there are educated and very successful farmers, some of whom are females.

Additional Reading

1. Dennis Baffour-Awuah, May 25, 2020 https://allianceforscience.org/blog/2020/05/misconceptions-about-gmos-in-ghana-due-to-weak-education-study-reveals/
2. Five top richest farmers in Ghana; Agro- learner.com https://agrolearner.com/richest-farmers-in-ghana/
3. Overview of Themes-Misconceptions of Youth About Agriculture(1)
4. Stem Agricultural Science Curriculum
5. The Four Simple Steps To Start Vegetable Farming In Ghana – Check out ''THE FARM DREAMS ''- Raising new breeds of farmers

SECTION 2: AGRICULTURAL MACHINERY

Strand: New Dawn In Agricultural

Sub-Strand: Agricultural Machinery

Learning Outcome: *Explain the functions of farm tools and equipment.*

Content Standard: Demonstrate knowledge, understanding and skills in the operation of farm tools, implements and machines.

INTRODUCTION AND SECTION SUMMARY

This section introduces learners to simple farm tools, equipment, implements and machines used in agriculture. Learners are expected to identify these tools and be able to use them for vegetable crops and ornamental plant production. Teachers should demonstrate and guide learners to understand the uses of these implements and machines at different stages of farming, from soil preparation to planting and harvesting. The concepts in this section are practically oriented. Therefore, teachers should deploy appropriate pedagogical and assessment strategies that will enable learners to acquire the knowledge and skills to use these simple farm tools, equipment, implements and machines. The study of simple farm tools, equipment, implements and machines is directly linked to agricultural engineering which is a specialised field of engineering. Learners should be helped to understand how these fields are linked.

The week covered by the section is Week 2:

1. Identify the functions of agricultural tools and implements used in crop production.
2. Classify and operate different types of machinery used in crop production.

SUMMARY OF PEDAGOGICAL EXEMPLARS

In order for learners to participate fully in a lesson and contribute meaningfully, the choice of the pedagogical strategy is crucial. The teacher's ability to use the appropriate pedagogical approach effectively to stimulate learners is also very important, as this helps build understanding between teachers and learners, as they work towards shared goals. It is the role of the teacher to create activities that facilitate learning and enhance deeper and more meaningful understanding of the subject. It is imperative to adopt activity-based approaches to the use of simple farm tools, equipment, implements and machines through allowing learners to have hands-on experience. Learners should have the opportunity to practice and demonstrate how to use a range of farm tools, implements and equipment. Teachers should take learners to the school garden or farm and teach them how to use simple farm tools. For farm machines, learners could be taken to a nearby farm to give them the opportunity to observe how these machines operate. Alternatively, they could watch short videos on how these machines operate, if the former is not possible. Teachers should make sure learners follow all the appropriate safety precautions during all these activities.

ASSESSMENT SUMMARY

The concept of simple farm tools, equipment, implements and machines is practically oriented. This requires assessment strategies that ensure a blend of recall/reproduction, skills building, strategic reasoning and extended critical thinking. Teachers should use a variety of individual and whole group assessment techniques to assess understanding and demonstration of skills learnt. The assessment strategies to deploy include oral and written responses to questions, demonstration of how to use farm tools safely and the use of essay prompts to assess critical reasoning. The teacher should provide

constructive feedback to the learners based on direct observations, highlighting areas for improvement, reinforcing correct techniques and encouraging further practice. Conscious effort should be made to integrate differentiation into the assessment process to take account of varying levels of learners' abilities and capabilities in the class.

WEEK 2

Learning Indicators:

1. *Identify the functions of agricultural tools and implements used in crop production in Ghana.*
2. *Classify and operate different types of equipment and machinery used in crop production in Ghana.*

Theme or Focal Area 1: Identification and the uses or functions of some common farm tools and equipment for crop production

Simple farm tools and equipment and their uses

1. **Hand fork:** A hand fork is a small, hand-held gardening tool used for loosening hard soil, lifting, turning and mixing compost with the soil. They are also used for removing weeds in seedling trays and plots and lifting and transplanting plants and seedlings. Their use also aerates the soil.

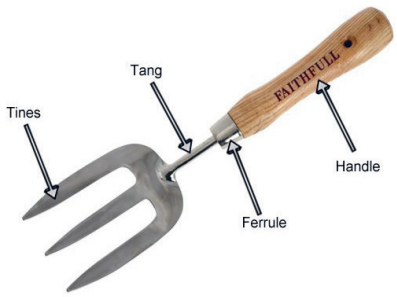


Diagram of a Hand Fork

2. **Hand trowel:** Hand trowels are used for loosening the soil around plants. It has parts like the shovel.

Picture of hand trowel

3. **Hand cultivator:** This is a simple garden instrument used for tilling garden plots and removing weeds.

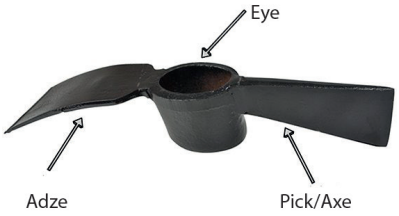
Picture of hand cultivator

4. **Hoe:** The hoe is made up of a flat metal blade and handle which can be made of either wood or metal. The hoe is used for removing weeds, loosening and levelling soil. It is also used for digging furrows for planting and making mounds.

Diagram of a hoe

5. **Knife:** It is a universal tool for cutting. Some are single-edged while others are double-edged. It is a hook-shaped tool consisting of a curved blade made of high carbon steel and manganese steel, attached to a wooden or plastic handle.
6. **Machete/Bolo**: These are large cutting tools usually used for clearing vegetation, cutting tall weeds and grasses, and for chopping branches of trees
7. **Mattock / Pick-mattock:** The mattock has two main parts; the head which is the metal part and the handle which can be made of either wood or fibreglass.

Picture of a mattock



Head of a mattock

The head of the mattock is made up of:

I. The large horizontal blade called the "adze" and is used for digging the earth. The blade of the adze is slightly curved which gives it the correct angle when striking the earth to penetrate further.
II. The eye of a mattock head is the hole in the centre through which the handle is fitted.
III. The vertical part at the back of the head can be either the pick or the axe depending on the type of mattock. It is used for uprooting stumps or cutting roots of trees when digging the soil.

8. **Sickle:** It is a well-known and ancient hand-held agricultural instrument. It has a curved blade that is used for cutting weeds and harvesting cereals such as rice.

Diagram of a sickle

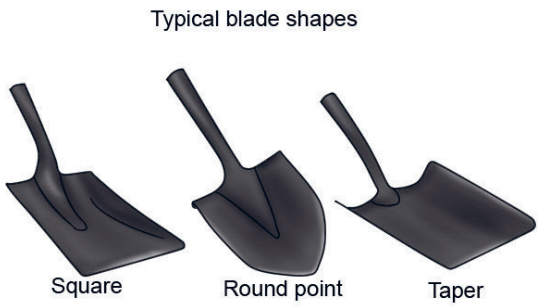
9. **Scythe:** In agriculture, the scythe is a versatile hand-held implement for mowing cereals and other herbaceous plants. It has a curved and sharp blade.

Picture of a scythe

10. **Spade and Shovel**: The spade has a flatter, shallower face for digging, piercing, or cutting. spades have smaller, narrow blades that enable greater precision and control when cutting through the soil. A spade is used primarily for cutting soil and digging holes while a shovel is used for moving materials such as soil, sand and gravel. Shovels typically have larger blades compared to spades. This allows for greater capacity when scooping and lifting materials. There are different types of shovels for specific functions, for example, round digger shovel, post-hole shovel and trench shovel.

    The head of a shovel / spade consists of the blade and a socket. The blade (sometimes called a scoop) holds the material being moved while the socket fits over the hand-held shaft. At the end of the blade is the cutting edge which does the work of cutting through soil, clay, snow and any other material.

A diagram of a Spade



Heads of spade and shovel (middle)

11. **Rake:** A rake is like a broom but made with metal. It consists of a long wooden handle and a serrated wooden or metal part planted at the other end of the handle. Rakes are made today of different materials and can be wood, metal or plastic, and can be long or short, depending on purpose. It is a tool used for gathering trash, hay, gravel, stones and foreign materials from lawns, fields and seed beds.
12. **Spading fork/ Pitchforks /foot forks:** are multi-purpose agricultural tools. They have a handle and sharp points or tines. The handle is made of hardwood oak or beech, with a total length of 150 cm. They are used for digging out roots, loosening soil and turning materials in a compost heap.
13. **Grab-hoe:** A grab-hoe helps to break hard topsoil. It is also used to crush hard soil smoothly.
14. **Cult packer:** This is an equipment used for crushing soil clods. It can be used to eliminate cracks, press small stones and remove air pockets to form a smooth firm seedbed.

Picture of Cultipacker

15. **Pruning shears or pruning scissors:** They are sharp, heavy-duty scissors that have one or two blades and are used for cutting plant stems and branches. The single blade type is for floricultural and vine pruning. The double blade is for orchard pruning.
16. **Secateurs:** These are meant for cutting branches, de-shooting, cutting of scion sticks, disbudding, defoliation from stems and topping off of small trees. They are also useful in pruning off pencil thick branches and making cuttings for propagation.
17. **Grass shear**: Grass shears in various types are used for the maintenance of lawns i.e. trimming and side dressing of lawns. The important parts are cutting blades made of high carbon steel or alloy steel. The blades are sharpened at the cutting edges.
18. **Hedge shear**: It is used for trimming, pruning ,cutting hedges and shrubs into the desired shape. It consists of two blades with tangs. The blades vary from 15–30 cm in length and are 0.8 cm thick.
19. **Manual sprinkler:** A simple hand-held watering can for watering plants.
20. **Wheelbarrow:** The tool consists of a tank or container mounted on a single wheel with two handles for controlling movement. A wheelbarrow is used for moving lightweight items such as fertilisers, manures, plants, seeds and waste materials.

Picture of a wheelbarrow

21. **Axe:** Consists of a metal part (head) and a handle that can be made of different materials, usually wood. It is used for cutting or splitting wood, and big branches of trees.

Implements

These are meant as appendages for mechanised machinery and add more value to that piece of machinery. Implements when added, allows the machine to be used for different purposes. Implements would be pulled or pushed by the machinery in order to perform their designated role. Nowadays tractors are used extensively though there are places where by necessity, oxen or manual methods have to be used. Examples of implements are:

1. **Cultivator:** A cultivator is used to stir and loosen the soil, breaking the clods and destroying the weeds. It performs intermediary ploughing and harrowing. It also maintains a good tilth,

adequate aeration, and prevents run-off and evaporation. Cultivators may be shovel, disc and blade types. Tine and spike cultivators are used to tilth the soil. They are used for removing weeds, for pulverising and stirring the soil before planting. The use of this implement allows for easier water percolation and aeration of soil.

A Cultivator

2. **Plough:** A plough is one of the most ancient agricultural implements whose function is to till the soil and prepare it for sowing. Ploughs are normally pulled by tractors. Some types of plough are:

   a. **Mould-board plough:** This is a tractor operated implement with 1–3 ploughs, whose digging and cutting parts are made from high carbon steel or low alloy steel. The ploughs cut, crumble and invert the soil. The plough leaves a level soil surface and is used where flood irrigation is important.

Mould-board plough

   b. **Disc plough:** It consists of moving circular steel discs of varying diameters and thickness. Discs cut, turn and break furrow slices. These can work well in sticky soil, as well as in very hard and dry soil. It is heavy and leaves the soil rough and cloddy.

   c. **Sub-soil single arm plough (Patashi plough):** This plough is useful for heavy soils. It consists of a single adjustable arm having shears at the base and breaks the hard pan developed below the soil surface. It improves drainage in water stagnant soils. It can be inserted up to 50 cm deep in the soil and is most suitable for making a trench of 5–7 cm wide.

3. **Harrow**: These are usually used after disc ploughing for the preparation of finer soil by breaking clods, cutting weeds and pulverising the soil surface during field preparation. The harrow may be disc, spike, spring or blade types and used in multiples.

4. **Subsoiler:** This tractor-mounted equipment is used to break up and loosen the soil during deep tillage. It is used to improve the growth of crops in areas where soil compaction is a problem.

5. **Irrigation sprinkler or water sprinkler:** An irrigation sprinkler is used to irrigate crops in a field. It helps to irrigate large areas and maintain the optimum level of humidity.

6. **Seed planter:** This is an implement used for calibrated sowing of seeds at equal distance and at the proper depth.

Machinery

Farm machinery refers to a set of mechanised equipment which can run on electricity, diesel, petrol or hydraulic power. Most farm machinery is still operated by humans but there is a gradual introduction of machinery which is smart and can run according to a computer-controlled programme.

Examples of machines

1. **Tractor**: Probably the most widely used and most important machine on a farm. It is used for pulling or pushing agricultural equipment in order to till, plough, harrow, or plant. A tractor is a vehicle specifically designed to deliver a high tractive force at slow speeds, for the purposes of hauling a trailer or machinery used in agriculture or construction.

Picture of a tractor

Parts of a tractor

2. **Harvester:** They are used to harvest larger areas of crops quickly and efficiently.
3. **Knapsack sprayer:** this machine can be manually, electrically or petrol driven. It is used to apply wettable, emulsifiable and water-soluble pesticides and liquid fertilisers to plants.

Learning Tasks

1. Assemble pictures of common agricultural tools and implements.
2. Search for information on the purpose of each of the various agricultural tools and implements.
3. Demonstrate the proper techniques for using each tool safely and effectively.
4. Provide an overview of common agricultural tools and their significance in various tasks.

Pedagogical Exemplars

Activity-based learning: The teacher puts learners in groups and guides them to observe, identify and discuss functions of simple farm tools, implements and machines available in the school. The teacher should support the learners whenever necessary.

Digital learning: In the same groups, the learners watch pictures or short videos of other farm tools and machinery not available in the school and identify each tool or machine and how they are used.

Experiential learning: Take learners to the school garden or farm (if available) and guide them how best to use farm tools. The teacher should encourage all learners to practise how to use the tools and ensure that learners follow all the health and safety procedures when using these tools.

Key Assessment

Assessment Level 1: List five simple farm tools.

Assessment Level 2: Describe the parts and uses of five simple farm tools and implements.

Assessment Level 3: Explain the specific uses of selected farm tools commonly used in agriculture.

Assessment Level 4: Sketch five farm tools, and discuss how they contribute to specific farming tasks.

Theme or Focal Area 2: Classification of farm equipment, implements and machines

There is a wide range of agricultural equipment currently used in farming. In general, these implements can be divided into five main categories, based on their functions. These five categories are briefly described below.

1. **Soil cultivation implements:** These are used for ploughing the soil and preparing it for cultivation. Some examples of soil cultivation equipment include tillers, disc harrows, and mould board ploughs.
2. **Planting machines:** These are used for planting seeds and saplings after the soil has been prepared.
3. **Irrigation machinery:** These are used for watering crops on large farms. They usually include central pivot irrigation systems and pump units.
4. **Harvesting equipment:** These are used to gather crops once they have reached maturity. Examples of harvesting equipment are diggers, pickers and trailers.
5. **Miscellaneous agricultural equipment:** These are used for carrying out supplementary activities such as hay-making, shredding and loading on a tractor.

Learning Tasks:

1. Search for images or diagrams of representative machines for each of the different categories of machinery used in crop production, such as soil preparation tools, planting equipment, irrigation systems and harvesting machinery. Flashcards can be created by the teacher to reinforce understanding.
2. Observe various machines in action and interact with farmers using the machines or watch videos of the machines in action and write a detailed report.

Pedagogical Exemplars

Enquiry-based learning: Learners in groups of five, browse the Internet and come up with classes of farm machinery used in crop production (land tillers, planters, harvesters). Learners who are competent with using the Internet should be encouraged to assist other learners.

Project-based learning: Learners visit farms to observe the practical or simulated demonstrations of the different farm machinery used in crop production and present an oral or written report.

Key Assessment

Assessment Level 1:

1. Describe the operations of any one piece of farm machinery.
2. Identify two types of machines commonly used in crop production and explain their main functions.

Assessment Level 2: Classify three different types of machines used in crop production into specific categories, and describe how they contribute to improving farming efficiency.

Section 2 Review

This section introduced learners to simple farm tools, equipment, implements and machines. The concepts learnt in this section included identification of the parts and functions of the parts as well as the uses of these tools, equipment, implements and machines. The section helped learners to classify farm machinery into various categories based on their uses. The pedagogical exemplars used in this section enabled learners to work collaboratively and to develop manipulative, critical thinking and problem-solving skills. The various assessment strategies such as oral presentation, essay prompts and demonstration of skills learnt were designed to include all the four levels of the Depth of Knowledge.

Additional Reading

1. *https://www.google.com/search?q=hand+trowel+picture&oq=hand+trowel&gs_lcrp*
2. *https://www.google.com/search?sca_esv=781fa1a7ec643214 &sxsrf=ACQVn08mdHbIbxHezJ 9jU36913FHKfT3Qw:1711114727517 &q=hand+cultivator+picture&uds*
3. *https://www.google.com/search?sca_esv=781fa1a7ec643214&sxsrf=ACQVn09IF0HvrPmUopT 7dcWgbUJgko-ONw:1711115520629&q=scythee&si*
4. https://www.google.com/search?sca_esv=781fa1a7ec643214&biw=1094&bih=488&sxsrf=ACQVn0-2ERM-8xxmO6oHatJrOQ0hDdNkPA:1711119045189&q=cultipacker&uds
5. Stem Agricultural Science Curriculum

References

1. Addo-Quaye A. A. (2004) General Agriculture for West African Senior School Certificate. Student's Book 1. Sedco publication Ltd
2. *Smith, D.J. (2008). Discovering Horse-drawn Farm Machinery (2nd ed.),* Buckinghamshire, *England: Shire Publications Ltd,* ISBN 9780852636640, OCLC 212432300.
3. *Wendel, C. H. (2004). Encyclopaedia of American Farm Implements and Antiques (2nd ed.), Iola, WI, USA: Krause Publications,* ISBN 978-0873495684.

SECTION 3: INTRODUCTION TO VEGETABLE CROPS AND ORNAMENTAL PLANTS

Strand: **New Dawn in Agriculture**

Sub-Strands:

1. Misconceptions and prospects in agriculture and farming
2. Emerging technologies in agriculture.

Learning Outcomes:

1. *Explain how to start and manage successful vegetable crop and ornamental plant enterprises in Ghanaian communities.*
2. *Identify emerging technologies in vegetable crop and ornamental plant enterprises.*
3. *Compare and contrast existing and emerging technologies used in vegetable crop and ornamental plant enterprises and their benefits.*

Content Standards:

1. Demonstrate knowledge and understanding of factors and processes that influence successful vegetable crop and ornamental plant enterprises.
2. Demonstrate knowledge and understanding of emerging technologies in vegetable crop and ornamental plant enterprises.
3. Demonstrate knowledge and skills in emerging technologies of vegetable crop and ornamental plant production and their benefits relating to real life situations.

INTRODUCTION AND SECTION SUMMARY

This section explores how to start and manage vegetable crop and ornamental plant enterprises successfully. It then goes on to explore the use of emerging technologies in vegetable crop and ornamental plant enterprises. Producing vegetables is a common pastime in Ghana. However, ornamental plant cultivation on a large scale is now catching up. Even so, it is mainly done in the big towns and cities. Ornamental plants are being used to enhance the landscape in many new homes. This section seeks to help learners to produce ornamental plants successfully and at a lower cost in order to entice more Ghanaians to buy these plants. Technologies are emerging which, when properly used, can help achieve this goal. These include the use of greenhouses, tissue culture, hydroponics and genetically modified organisms (GMOs). The section equips learners with basic knowledge and functional understanding of how to produce vegetable crops and ornamental plants. This section is pivotal for learners not only in the context of agricultural science but also establishes links with related subjects such as economics and social studies.

The weeks covered by the section are:

1. **Week 3**:
   a. Identify characteristics of successful start-up packages of vegetable crop and ornamental plant enterprises.
   b. Catalogue the characteristics and patterns of growth of successful vegetable crop and ornamental plant enterprises.

2. **Week 4**:
   a. Explain the use of selected emerging technologies in vegetable crop and ornamental plant enterprises.
   b. Appraise emerging technologies in vegetable crop and ornamental plant production.
3. **Week 5***:* Grow vegetable and ornamental crops using the known procedures and technologies.
4. **Week 6**: Describe the use and importance of tissue culture in vegetable crop and ornamental plant enterprises.
5. **Week 7:** Identify other emerging technologies used to make growing of vegetable crops and ornamental plants easier.

SUMMARY OF PEDAGOGICAL EXEMPLARS

A range of pedagogical exemplars such as Project-based Learning, Exploratory Learning and Structured Talk for Learning will be used to promote effective learning. Learners should work in pairs, mixed-ability and mixed gender (where appropriate) groups to find information from different sources about selected emerging technologies, watch videos on the feasibility and impact of selected emerging technologies and draw appropriate conclusions. Through using these approaches, learners are encouraged to speak during lessons as they discuss the nature of emerging technologies for the production of vegetable crops and ornamental plants, thus improving their communication skills. More confident learners should be given additional opportunities to perform leadership roles as peer-teachers to help other learners develop a deeper understanding of the concepts. As stated in Section 1, project work should be carried out on the school premises in order to mimic real field experience.

ASSESSMENT SUMMARY

The teacher should assign tasks to cover the key steps in growing vegetable crops and ornamental plants using the known procedures and technologies, including emerging technologies. These are geared towards learners successfully producing ornamental plants at a lower cost to entice Ghanaians to buy. The assessment should consider the various levels of proficiency and expected depth of knowledge of the learners. The assessment should include class tests and assignments, group presentations and project-based work. Teachers should employ a variety of formative and summative assessment strategies to gather information about individual learner's performance. This may include test scores, feedback, and progress over time. This strategy ensures a balanced assessment approach, fostering continuous improvement and holistic learner development.

Week 3

Learning *Indicator(s):*

1. *Identify characteristics of successful start-up packages of vegetable crop and ornamental plant enterprises.*
2. *Catalogue the characteristics and patterns of growth of successful vegetable crop and ornamental plant enterprises*

Theme or Focal Area 1: Start up package for vegetable crop farming in Ghana

A start-up package for farming typically refers to a set of resources, tools, and services provided to individuals or groups who are starting agricultural ventures. The goal of a start-up package for farming is to provide aspiring farmers with the necessary resources, knowledge and support to help jumpstart their agricultural enterprise and increase their chance of success in the competitive farming industry. The specific details of a start-up package can vary depending on the organisation or entity offering it and the type of farming being proposed, for example crop farming, livestock or aquaculture.

The package may include:

1. **Market assistance**: The market should be the first step because farmers have to know where to sell a product before creating the product. This is necessary since vegetables grow very fast and are perishable food crops, which means that they spoil very easily. Therefore, it is important that the farmer, before starting production, finds the people to whom he/she intends to sell. Market assistance helps with finding potential buyers or market channels for the produce.
2. **Capital / Financial support:** The amount of money and resources a farmer requires to start production depends on the scale at which the farmer wants to operate; small, medium or large. The farmer should have access to loans or grants to aid initial investment. Farmers can call on banks, cooperative societies, or local money lenders for loans to start production.
3. **Access to a designated area for farming activities / land selection / 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.
4. **Kind of vegetables or ornamental plants to grow / assorted seeds:** The farmer should conduct a pre-feasibility study to determine the type of vegetables to cultivate, taking into account factors such as where to get seeds or vegetative propagules, 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.
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, watering cans, but also tractors, ploughs, and irrigation systems. These tools help with the 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.

7. **Support**: This involves technical assistance and advice from experienced farmers and farm hands 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 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 disease.

Pictures of organic fertilisers

Pictures of inorganic fertilisers

Learning Tasks

1. Learners prepare a questionnaire to use as they visit farms. Questions could include:
   a. What are the requirements needed to start a vegetable and ornamental plant enterprise?
   b. How did you start the garden or farm?
   c. What factors did you consider when establishing the garden or farm?
   d. How were you able to fund your project?
2. Learners visit a farm/ garden nearby to administer the questionnaire on start-up packages for vegetable and ornamental plant enterprises.
3. Learners analyse their findings and determine how the responses will help them to start a garden or farm.

Pedagogical Exemplars

Digital learning: Teacher guides learners in groups to watch videos or documentaries and pictures of successful start-up packages of male and female farmers. The teacher should ensure that learners with visual and hearing impairments are able to participate fully.

Experiential learning: Teacher and learners embark on educational visits to successful vegetable crop farms and ornamental plant enterprises for learners to observe, ask questions and take field notes on start-up packages using a prepared questionnaire. Alternatively, resource persons should be invited for the same purpose. All learners should be encouraged to participate fully.

Collaborative learning: Learners discuss their observations in class to determine their readiness to start a garden. The teacher should consider shy and introverted learners and encourage their participation.

Key Assessment

Assessment Level 1: Identify and catalogue the main successful vegetable and ornamental crop farmers in your locality.

Assessment Level 2: Describe four start-up packages needed to start a vegetable crop or ornamental plant enterprise

Assessment Level 4: Analyse factors and processes that account for success and challenges of vegetable crop and ornamental plant enterprises.

Theme or Focal Area 2: Patterns of growth of successful vegetable crop and ornamental plant enterprises

Patterns of growth in vegetable and ornamental plants 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 growth in production.
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 growth of enterprise 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 growth of enterprises is mainly limited by 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 specialty crops or niche markets.
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.

Learning Tasks

1. Learners to discuss factors that affect the growth pattern in vegetable crop and ornamental plant crop enterprises.
2. Learners to discuss the relevance of studying the growth pattern in vegetable crop and ornamental plant enterprises.

Pedagogical Exemplars

Talk for learning: Put learners in groups and guide them to discuss factors that affect the growth patterns of vegetable crop and ornamental plant enterprises. The teacher should support all learners to ensure they actively contribute to the discussion.

Experiential learning: Visit successful vegetable and ornamental crop enterprises to observe, ask questions and take field notes on patterns of growth, and present reports.

Key Assessment

Assessment Level 2: Explain three factors that affect the growth patterns of vegetable crop and ornamental plant enterprises.

Assessment Level 3: Explain the relevance of studying factors that affect the growth patterns of vegetable crop and ornamental plant enterprises.

WEEK 4

Learning Indicators:

1. *Explain the use of selected emerging technologies in vegetable crop and ornamental plant enterprises.*
2. *Appraise emerging technologies in vegetable crop and ornamental plant production.*

Theme or Focal Area 1: Selected emerging technologies in vegetable crop and ornamental plant enterprises.

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 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.

Some emerging technologies in agriculture include:

1. **Organic farming (ecological agriculture)**: Organic farming does not harm the environment. It avoids the use of synthetic chemical fertilisers and pesticides, as well as GMOs and cloned animals. The system sustains the health of soils, ecosystems and people. Its main goal is to develop enterprises that are sustainable and harmonious with the environment.
2. **Vertical farming**: Indoor vertical farming is the practice of growing stacked layers of crops in a closed and controlled environment to maximise use of space and reduce water usage, making it suitable for urban areas and regions with limited arable land. In place of natural sunlight, artificial lights can be used to aid growth. Vertical farming can increase crop yields and reduce the impact of farming on the environment. Crops can be grown all year-round.
3. **Precision agriculture technology**: Precision agriculture (or precision farming) involves providing more accurate farming techniques for planting and growing crops. It involves the use of ICT along with best agricultural practices. It is done with the help of several technologies such as drones, internet of things (IoT), GPS guidance, sensors, robotics, autonomous vehicles, telematics and satellite imagery to monitor crops, assess soil conditions, and optimise irrigation and fertiliser application leading to better resource management and increased yields.
4. **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.
5. **Drones**: Drones are autonomous or remotely controlled multipurpose aerial vehicles with no human on board. They are used for crop monitoring and spraying chemicals on crops.

Image of agricultural drone

Image of automation machine

6. **Automation technology**: This refers to any tool that can reduce operator workload combining the use of sensors, computers, feeding mechanisms and robots.

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, productivity in agriculture and manufacturing.

8. **Big data**: The big data age involves generation of huge volumes of information and managing this to add value to our daily lives. As farmers are deploying enormous amounts of data generated by interconnected devices to get an overall understanding of their farms, big data will change how farmers manage their work. Rather than relying on educated guesses, farmers can now rely on big data to make better, more informed decisions.

9. **Blockchain (chain of trust)**: This consists of a shared or distributed database used to maintain a growing list of transactions, called blocks. It streamlines business processes by establishing trust, accountability and transparency. 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, farmer, and the date of bagging the rice.

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

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, lettuces and tomatoes.

13. **Hydroponics and aquaponics**: These are the techniques 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. If the system combines fish farming and hydroponics, it is called aquaponics. It results in larger crop yields and reduced water consumption. Hydroponic production systems are used by small farmers, hobbyists, and commercial enterprises. In a hydroponic greenhouse growing system, plants are supplied with mixed nutrients in liquid forms at periodic intervals – and this method of growing is called sub-irrigation culture. After transplanting the seedlings, the remaining work is done by an automatic system. The hydroponic culture of greenhouse vegetables involves producing crops

in sand, gravel, or artificial soil-less mixes in bags, tubes, tubs, tanks or troughs designed to allow the circulation of nutrient solution needed for crop growth.

A picture of coriander cultivated using Hydroponics

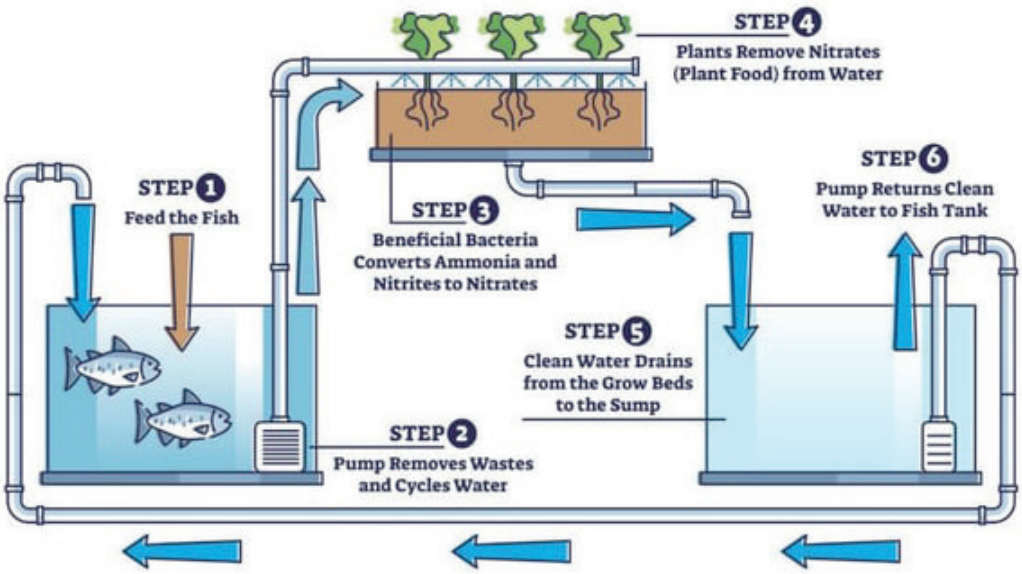


Illustration of an Aquaponics System

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.
16. **Biotechnology**: It is the use of biology to develop new products, methods and organisms intended to improve human health and society. Biotechnology, often referred to as biotech, has existed since the beginning of civilisation with the domestication of plants, 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. biofuels that are sustainable, 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. Genetic engineering works by modifying or interacting with the genetic cell structures. Every cell in an animal or plant contains genes that produce proteins which 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 a pests, disease or drought. Genetic engineering also enables the genetic modification 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.

Learning Tasks:

1. Learners to sketch a vertical farm and indicate which farming constraint it can solve.
2. Learners make a portfolio of equipment and tools of emerging technologies.
3. Learners explore the use of robotics for harvesting crops including the advantages and limitations of using the technology.
4. Learners read about the feasibility and economic viability of implementing a specific emerging technology in vegetable crop and ornamental plants production.

Pedagogical Exemplars

Digital learning: The teacher guides learners to watch short documentaries/videos on selected emerging technologies (greenhouse planting, hydroponics, GMOs and tissue Culture) in vegetable crop and ornamental plant enterprises, then discuss the key observations, and write down their findings.

Structured talk for learning: The teacher guides learners to discuss the use of robotics for harvesting crops including the advantages and limitations of using the technology. The teacher should support al learners and should encourage more able learners to submit a written report on the feasibility and economic viability of implementing a specific emerging technology.

Key Assessment

Assessment Level 2: Describe three emerging technologies used in producing a vegetable crop or an ornamental plant.

Assessment Level 3: Analyse the usefulness and limitations of using drones in agriculture.

Theme/Focal Area 2: Appraisal of emerging technologies in vegetable crop and ornamental plant production.

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 activity.

c. Hydroponics is far less labor-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:

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 hence produce more per unit area.

c. Extended shelf life: Such 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 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: GMOsc can offer cost-effective solutions for farmers, enabling them to produce more with fewer resources.

g. Improved 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.

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:** Farmers need to acquire new skills and knowledge to effectively use and maintain emerging technologies, which may pose a barrier to adoption.

c. **Data privacy and security:** With AI-driven farming and precision agriculture relying on data collection and analysis, ensuring data privacy and protecting against cyber threats become 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.

Learning Tasks

1. Learners use links provided to source information on the benefits of specific emerging technologies in vegetable crop and ornamental plants production.
2. Learners watch documentaries on specific emerging technologies in vegetable crop and ornamental plants production.
3. Learners discuss social, economic, and environmental implications of using emerging technologies in agriculture.

Pedagogical Exemplars:

Structuring talk for learning: Teacher explains the concept of emerging technologies in agriculture and their significance in addressing modern agricultural challenges.

Digital learning: The teacher allows learners to watch short documentaries on specific emerging technologies in agriculture, focusing on their benefits and the possible implementation of selected emerging technologies in vegetable crop and ornamental plant production.

Project-based learning: Teacher guides learners in their groups to search different sources such as books and online articles on challenges of selected emerging technologies on farming.

Key Assessment

Assessment Level 1: Outline two merits and two demerits of a named emerging technology used in agriculture.

Assessment Level 3: Explain why growers should adopt emerging technologies instead of relying on conventional methods of farming.

Assessment Level 4: Evaluate the effect of at least one major emerging technology on vegetable crop and ornamental plant enterprises.

WEEK 5

Learning Indicator: *Grow vegetable crops and ornamental plants using known procedures and technologies.*

Theme/Focal Area 1: Use known technologies to produce vegetable crops and ornamental plants on the school premises

Stages of vegetable and ornamental crop 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

   i. Purpose or aims of production
   ii. Choice of vegetable crop or ornamental plant
   iii. Capital for the project
   iv. Site selection (type of soil)
   v. Sourcing of seed or planting materials
   vi. Tools, equipment and machines needed
   vii. Size of garden and proximity / Use of plastic, metal or wooden containers or bags/sacks.
   viii. Agronomic management system to employ
   ix. Source and system of water supply
   x. Assess 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, seed boxes, 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 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, 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 fertility level of 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, broad casting)
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

A. 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 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.
6. Fertiliser and resource saving.

Disadvantages of hydroponics versus conventional cultivation

1. High investment costs.
2. Very high level of technical know-how 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.

Learning Tasks

1. Learners study the characteristics of different vegetable crops and ornamental plants and their suitability for specific growing environments.
2. Learners develop a crop management plan that outlines the step-by-step procedures for growing selected vegetable crops and ornamental plants.
3. Learners outline soil preparation techniques.
4. Learners read about hydroponic systems to understand their roles in conserving water and delivering precise amounts of nutrients to crops.

Pedagogical Exemplars

Project-based learning: The teacher guides learners in small groups to select appropriate plant varieties based on local climate and soil conditions. Learners grow and care for these plants outdoors or in plastic containers and sacs. The teacher should encourage peer support to enable all learners to complete the activity.

Exploratory learning: Teacher invites a resource person to the school to discuss hydroponics with learners to generate interest. Learners present written reports.

Key Assessment

Assessment Level 1: List the steps involved in the conventional way of growing crops.

Assessment Level 2: Explain hydroponics and its benefits in vegetable crop and ornamental plant production.

Assessment Level 3: Compare the benefits of cultivating crops in soil with the use of other media such as water or artificial substrate.

Assessment Level 4: Present data on the selected vegetable crop being cultivated in a portfolio or folder.

WEEK 6

Learning Indicator: *Describe the use and importance of tissue culture in vegetable crop and ornamental plant enterprises.*

Theme/Focal Area 1: Explanation of 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 in which they can continue and function. 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. In this process the growth medium or culture 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 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 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.

This narrative should be retained as the learners may not have the opportunity to visit any Biotech Lab or even practise the process themselves.

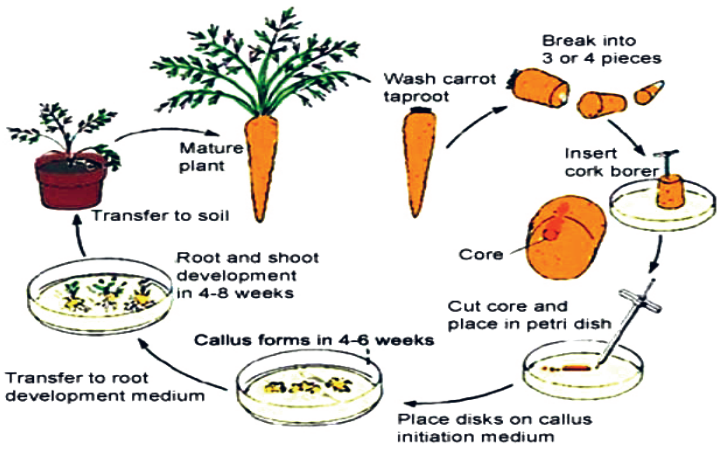


Diagram of the process of tissue culture in carrots

Seeds and clones

Seeds are usually produced from the process of sexual reproduction in plants and 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 vegetatively propagated. 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. Production of disease-free plantlets.
2. Plants can be raised and grown throughout the year regardless of the season.
3. The practice does not require a large plot of land or space.
4. It helps produce vegetables, fruits and ornamentals of different varieties in commercial quantities quickly.

Disadvantages of tissue culture

1. The practice is costly.
2. It is labour intensive.
3. Any change in hormonal and other external conditions can alter the physiological properties of the new plant.

Learning Tasks

1. Learners read about tissue culture techniques.
2. Learners analyse the advantages and disadvantages of tissue culture compared to traditional propagation methods.
3. Learners discuss the role of tissue culture in improving crop yield, reducing production costs, and enhancing market competitiveness.

Pedagogical Exemplars

Collaborative/digital learning: Learners in groups browse the Internet to gain a better understanding of tissue culture in vegetable crop and ornamental plant production.

Initiating talk for learning: Learners in groups discuss the various steps in the tissue culture process. Teacher should support the groups wherever necessary.

Activity-based learning: Learners discuss the benefits and challenges of using tissue culture and present their findings on cardboard posters and attach them to the walls.

Key Assessment

Assessment Level 1: Explain tissue culture and its relevance in the production of vegetable crop and ornamental plants.

Assessment Level 2: Outline the basic steps involved in growing vegetable crops and ornamental plants using conventional methods and tissue culture.

Assessment Level 3:

1. Compare and contrast the production of vegetable crops and ornamentals plants using conventional procedures and tissue culture.
2. Explain the importance of each step in the tissue culture process.

WEEK 7

Learning Indicator: *Identify other emerging technologies used to make growing of vegetable and ornamental crops easier.*

Theme/Focal Area 1: Other emerging technologies used to make the growing of vegetable crops and ornamental plants easier.

Some of these emerging technologies include satellite greenhouses, robotics and automation (use of agricultural robots (agbots)), smart farming, and sensors and remote-control technology. These technologies are explained briefly below.

1. 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, lettuces and tomatoes. Ornamental plants grown in greenhouses include orchids, roses, African violets, geraniums, chrysanthemums, poinsettias and bougainvilleas.

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.

2. Robotics (use of agricultural robots (agbots) 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.

3. 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.

4. Sensors and remote-control technology

Sensors are strategically placed throughout the land in order 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.

Learning Tasks

1. Learners use the Internet to find out other technologies that make the growing of vegetable crops and ornamental plants easier.
2. Learners investigate specific emerging technologies.
3. Learners discuss how these emerging technologies improve resource efficiency, enhance plant health and increase crop yield.

Pedagogical Exemplars

Inquiry-based learning: Teacher guides learners in groups to identify other emerging technologies used to ease work in vegetable and ornamental cultivation.

Experiential learning: Learners under the guidance of their teacher visit a greenhouse to observe its structure and function or, if not possible, learners watch documentaries on the operations of a greenhouse.

Digital learning: With the help of their teacher, learners watch video documentaries on the use of drones.

Talk for learning: In groups, learners discuss how these technologies help ease work in vegetable crop and ornamental plant production. The teacher encourages all learners to be actively involved in the discussion.

Key Assessment

Assessment Level 1: List four examples of other technologies used to produce vegetable crops and ornamental plants.

Assessment Level 2: Explain how any one of the emerging technologies is used in the production of a vegetable crop or an ornamental plant.

Assessment Level 3: Outline how any two of the emerging technologies reduce the drudgery involved in vegetable crop and ornamental plant production.

Section 3 Review

This section introduced learners to start-up packages for vegetable crop and ornamental plant enterprises. It also concentrated on the role of technology in agriculture. Technology keeps changing and improving, all with the aim of reducing drudgery in human activity. Some new technologies that have come into agriculture include tissue culture, satellite greenhouses, robotics and automation, smart farming, sensors and remote-control technology. Emerging technologies help address the challenges of agriculture and simplify farming operations and activities. Emerging technologies include vertical farming, hydroponics, greenhouse farming, tissue culture, automated machines and drones. Emerging technologies help to obtain higher crop yields and improved productivity as well as more efficient use of resources. Other emerging technologies like robots or automated machines replace humans and perform physical tasks like harvesting and irrigation. Tissue culture, which involves the growth of plant tissue in artificial media helps produce disease free plants throughout the year and does not require a large area of land but can generate different varieties in commercial quantities regularly. However, the practice is costly, so labour intensive can alter the physiological properties of the new plant.

Further Reading

1. Access to extension support were important factors affecting the decision of traditional African vegetable farmers to adopt improved technology. Issaka (2021)
2. 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
3. Agricultural Biotechnology ((https://www.fda.gov/food/consumers/agricultural-biotechnology)
4. 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

5. 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

6. 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

7. 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.

10. Greenhouse Vegetable Production; Circular 556, Revised by Stephanie Walker and Israel Joukhadar, College of Agricultural, Consumer and Environmental Sciences, New Mexico State University (https://pubs.nmsu.edu/_circulars/CR556/index.html) (.gov) https://www.*nal.usda.gov › hydroponics*

11. Greenhouse Vegetable Production- General Information and Bibliography by Hunter Johnson, Jr., is Extension Vegetable Specialist, University of California, Riverside.

12. https://www.google.com/search?client=firefox-b-d&q=tissue+culture+process#fpstate=ive&vld=cid:

13. https://www.google.com/search?q=video+documentaries+on+use+of+drones+in+agriculture&client=firefox-b-d&sca_

14. Hydroponic Greenhouse Gardening Systems – Agri Farming; Agri Farming; https://www.agrifarming.in › Agriculture Farming on 30 Apr 2021

15. Hydroponics- National Agricultural Library – USDA, United States Department of Agriculture (.gov) https://www.*nal.usda.gov › hydroponics*

16. Hydroponic Agriculture and Microbial Safety of Vegetables: Promises, Challenges, and Solutions by Shlomo Sela Saldinger et al.; *Horticulturae* **2023**, *9*(1), 51; https://doi.org/10.3390/horticulturae9010051

17. Low Cost Greenhouses for Vegetable Production https://agritech.tnau.ac.in/agricultural_engineering/greenhouse.pdf

18. Overview of themes – Startup vegetable enterprises

19. 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. Stem Agricultural Science Curriculum 1.X.1.2.LO.2; I.X.1.2.CS.2

References

1. Mehbub, H., Akter, A., Akter, M. A., Mohammad Shamim Hasan Mandal, M. S. H., Hoque, A., Tuleja, M. and Hasan Mehraj, H. (2022). Tissue Culture in Ornamentals: Cultivation Factors, Propagation Techniques, and Its Application. *Plants* 2022, *11*(23), 3208

SECTION 4: IRRIGATION SYSTEMS

Strand: **New Dawn In Agriculture**

Sub-Strand: Agricultural Machinery

Learning Outcome: *Evaluate the various forms of irrigation systems in vegetable crop and ornamental plant production.*

Content Standard: Demonstrate knowledge, understanding and skills in the use of various forms of irrigation systems in vegetable crop and ornamental plant cultivation.

INTRODUCTION AND SECTION SUMMARY

The section introduces learners to modern irrigation systems and the use of appropriate irrigation systems to produce vegetable crops and ornamental plants. Agriculture in Ghana is largely rainfed and this explains why crop production is seasonal. It is becoming unsustainable to depend solely on rain as the source of water to produce crops. To change this situation and ensure all year-round crop production, there is a need to introduce irrigation systems. Teachers should, therefore, guide learners to study the various modern and efficient irrigation systems available for crop production. Learners should have detailed knowledge about the irrigation systems and be able to apply/adapt them to produce vegetable crops and ornamental plants in the school garden or farm. For learners to be able to grasp the concepts in this section, pedagogical exemplars such as project-based learning, collaborative learning, and experiential learning should be deployed. Assessment tools such as project work, field demonstrations and oral presentations should be used to assess learning. This section is essential for learners, not only in the context of agricultural science, but also establishes links with related subjects such as engineering and economics.

The weeks covered by the section are:

Week 8: Describe the modern and efficient methods of crop irrigation.

Week 9: Use the appropriate irrigation system to produce vegetable crops and ornamental plants.

SUMMARY OF PEDAGOGICAL EXEMPLARS

The concepts to be learnt under this section require the use of pedagogical strategies such as talk for learning, collaborative learning, experiential learning and project-based learning. Talk for learning should be initiated by guiding learners to think through the modern and efficient irrigation systems in groups and discuss their views. Resource persons could be invited to have interactive discussion with learners on the irrigation systems including their merits and demerits. The presence of the resource person will allow all learners to be more attentive and contribute to the lesson. To consolidate learners understanding of the irrigation systems, experiential learning should be used by embarking on a field trip to farms in the school community or nearby where these irrigation systems are used. Project-based learning should be used to help learners demonstrate how to practise the various irrigation systems discussed to produce vegetable crops or ornamental plants in the school garden or farm. The teacher should create mixed-ability and mixed gender (where appropriate) groups to enhance collaboration and eliminate stereotyping. More confident learners should be given additional tasks such as peer-teaching to help other learners.

ASSESSMENT SUMMARY

The assessment strategy for this section allows teachers to deploy methods that are fair and cater for the variations in learners' ability and the expected depth of their knowledge. The assessment approach focuses more on formative assessment, promoting continuous improvement and all-inclusive learner development. The assessment tools include individual responses to oral questions on the meaning and types of modern irrigation systems and group presentations in the plenary on the merits and demerits of various irrigation systems. These approaches should enable learners to think and communicate their ideas and findings hence improving their skills of communication and critical thinking. Written responses to questions or tasks will enable learners to form their thoughts and enhance their writing skills. Learners' performance in the assessment activities should be part of the continuous assessment process and recorded in the transcript system. Prompt feedback should be given to learners on their performance and additional help should be provided for some learners.

Week 8

Learning Indicator: *Describe the modern and efficient methods of crop irrigation.*

Theme/Focal Area1: Modern and efficient irrigation systems in vegetable crop and ornamental plant production

Irrigation

It is defined as the artificial application of water to the soil to supplement rainfall and ground water, for the purpose of crop production.

Methods of irrigation

1. Surface
2. Sub-surface
3. Pressurised irrigation

1. Surface irrigation method

This is the oldest and most common method, suitable for low to moderate infiltration rates and level lands. It is labour intensive. Surface irrigation can be either border irrigation, check basin irrigation or furrow irrigation.

The following information, on the various types of irrigation with their advantages and limitations, should be considered as background information for teachers. It will help in any discussion of the topics with the learners and might help them in answering their questions.

a. **Border irrigation:** The land is divided into a number of long parallel strips called borders. These borders are separated by low ridges. The border strip has a uniform gentle slope in the direction of irrigation. Each strip is irrigated independently by turning the water on at the upper end. The water spreads and flows down the strip in a sheet confined by the border ridges.

Picture of border irrigation on a rice farm

b. **Check basin irrigation:** It is the most common surface irrigation method. The field is divided into smaller units so that each has a nearly level surface. Bunds or ridges are constructed around the area forming basins within which the irrigation water can be controlled. The water applied to a desired depth can be retained until it infiltrates into the soil. The size of the basin varies from $10m^2$ to $25m^2$ depending upon soil type, topography, stream size and crop.

A picture showing check basin irrigation

c. **Furrow irrigation:** It is used for row crops. The furrows are formed between crop rows. The dimension of the furrows depends on the crop grown, equipment used and soil type. Water is applied by small running streams in furrows between the crop rows. Water infiltrates into soil and spreads laterally to wet the area between the furrows. In heavy soils, furrows can be used to dispose of the excess water.

A picture showing furrow irrigation

2. Subsurface irrigation

In subsurface irrigation, water is applied beneath the ground by creating and maintaining an artificial water table at some depth, usually 30-75cm below the ground surface. Moisture moves upwards towards the land surface through capillary action. Water is applied through underground field trenches laid 15-30m apart. Open ditches are preferred because they are relatively cheap and suitable for all types of soil. The irrigation water should be of good quality to prevent soil salinity.

3. Pressurised irrigation systems

(a) Drip or trickle irrigation

Drip or trickle irrigation is one of the most modern methods of irrigation. It is suitable areas of scarce water and saline soils. Water is applied to the root zone of the crop.

Types of drip irrigation systems

Advantages of drip irrigation:

i. More efficient water use – Soil evaporation, surface runoff and deep percolation are greatly reduced (~95 %, compared to less than 50 % in surface irrigation).
ii. It has the ability to apply small amounts of water leading to a smaller fraction of the soil volume being wetted thus reducing unnecessary water loss.
iii. Low interference with cultivation.
iv. Reduced nutrient and chemical leaching into subsoil.
v. Enhanced plant growth and crop yield.
vi. Improved plant health – Less disease and fungal pressure occurs due to drier and less-humid crop canopies (prevention of leaf wetting). The system can also be used for some types of soil fumigation.
vii. Improved fertiliser and pesticide management – Precise and more timely application of fertiliser and pesticides through the system can result in greater efficacy and, in some cases, reduction in their use.

Limitations of drip irrigation

i. High investment is needed.
ii. High level of knowledge needed for optimal and economical operation.
iii. Smaller wetting pattern – The wetting pattern may be too small on coarse-textured soils, resulting in too small an amount of water at the crop root zone.
iv. Reduced upward water movement.
v. Restricted plant root development.
vi. Row spacing and crop rotation limitations – Since the systems are fixed spatially, it may be more difficult to accommodate crops of different row spacing.

(b) Sprinkler irrigation system

Sprinkler irrigation system is another modern technique which is widely used. The sprinkler (overhead or pressure) irrigation system conveys water to the field through pipes (aluminium or PVC) under pressure with a system of nozzles. This system is designed to distribute the required amount of water uniformly, which is not possible in surface irrigation. Water is applied at a rate less than the infiltration rate of the soil hence the runoff from irrigation is avoided.

Types of sprinkler irrigation systems

Advantages of sprinkler systems:

i. Sprinkler irrigation systems are suitable for sloping fields and sandy soils.
ii. They use less water compared with other traditional methods **and therefore conserve water,** (35-40%) compared to surface irrigation methods.
iii. Fertilisers and other chemicals can be applied through the irrigation water.
iv. Such fertilisers are evenly distributed and avoid wastage.

v. They cover a large area of land in a relatively short time.
vi. They save time and labour as they can be automated to run on a schedule, reducing the need for manual watering.
vii. Sprinkler irrigation systems can be adjusted to different types of crops, soil and weather conditions, thus providing flexibility.

Limitations of sprinkler irrigation

i. They can be costly to install, especially for larger farms or orchards.
ii. Sprinkler irrigation systems can lead to water runoff, leading to nutrient loss.
iii. **The** systems can create a humid environment that is favourable for the growth of certain pathogens leading to disease and pest issues.
iv. There is high evaporation loss in spraying water.

Learning Tasks

1. Learners discuss the meaning of crop irrigation and its importance in agriculture.
2. Learners discuss various modern irrigation systems for producing vegetable crops and ornamental plants and at least three merits and demerits of each of them.
3. Learners search for information on modern and efficient crop irrigation methods using URL(s) provided and write a detailed report.

Pedagogical Exemplars

Talk for learning: The teacher provides background information about the various irrigation systems and guides learners in groups to think through them and discuss their views. The teacher helps learners with probing questions to bring out the meaning and importance of crop irrigation. Alternatively, a resource person could be invited to have an interactive discussion with learners about the irrigation systems including their merits and demerits

Collaborative learning: In groups, learners discuss the merits and demerits of the different means of supplying water to vegetable crops and ornamental plants.

Experiential learning: Embark on field trip (where possible) with learners to visit farms in the school community or nearby where irrigation systems are used to enable them to see the systems in action. Alternatively, learners watch documentaries on modern irrigation systems for producing vegetable crops and ornamental plants and write a report.

Key Assessment

Assessment Level 1: List two modern irrigation systems and state the merits of each.

Assessment Level 2: Explain the importance of irrigation systems in producing crops.

Assessment Level 3:

1. Prepare and present a report on the field trip to an irrigation site
2. Compare the drip irrigation and sprinkler irrigation methods for crop production.

WEEK 9

Learning Indicator: *Use appropriate irrigation system to produce vegetable crops and ornamental plants.*

Theme/Focal Area 1: Criteria for selection of an appropriate irrigation method.

Choosing the appropriate irrigation system for producing vegetable crops and ornamental plants involves a systematic approach by carefully considering the physical, financial and environmental factors before choosing the most appropriate irrigation system. This helps to optimize resource utilisation, plant growth and yield for both vegetable crops and ornamental plants. The important factors to consider are:

a. **Water needs:** Determine the water requirements of your specific vegetable crops and ornamental plants. Some plants need more frequent watering, while others prefer less frequent but deep watering. Understanding their individual needs is crucial in selecting the right irrigation system.

b. **Water source and availability**: Assess the water source and its availability. If water is scarce, consider more water-efficient systems like drip irrigation to minimise waste.

c. **Soil and drainage:** Evaluate the soil type and its drainage capabilities. Sandy soils drain faster and may require more frequent irrigation, while clay soils retain water longer. The irrigation system should match the soil's characteristics to avoid waterlogging or drought stress.

d. **Topography:** Sprinkler or drip irrigation are preferred over surface irrigation on steeper or unevenly sloping lands as they require little or no land levelling.

e. **Climate conditions:** Consider the local climate, including temperature, relative humidity and rainfall patterns. In arid regions, a more efficient irrigation system might be needed, while in areas with frequent rainfall, a simpler system would be sufficient.

f. **The crop:** Surface irrigation can be used for all types of crops. Sprinkler and drip irrigation are mostly used for high value cash crops, such as vegetables and fruit trees because of their high capital investment. Drip irrigation is ideal for irrigating individual plants or trees or row crops such as vegetables but it is not suitable for close growing crops like wheat, rice, sorghum, groundnuts and pulses.

g. **Financial strength:** Determine your budget and available resources for installing and maintaining the irrigation system. Some systems may have higher upfront costs but can lead to long-term savings in water usage and labour.

Learning Tasks

1. Learners list types of irrigation systems used in crop production.
2. Learners design simple irrigation plans for named vegetable crops or ornamental plants.
3. Learners create a chart or database of the watering frequency of various crop species commonly grown in their locality.
4. Learners are assigned projects to produce one vegetable or ornamental plant using a chosen irrigation system.

Pedagogical Exemplars

Initiating talk for learning: The teacher should put learners in groups to discuss and prepare a list of various crop species commonly grown in their locality, as well as the different irrigation systems used in crop production. Teacher should ensure that all learners participate in the discussion.

Digital learning: In the same groups, the teacher guides learners to search information from the Internet on the water needs of the various crop species commonly grown in their locality.

Project-based learning: Learners in small groups, select a simple irrigation procedure and use that to produce a vegetable or an ornamental plant.

Key Assessment

Assessment Level 1: List the various types of irrigation used in the production of vegetable crops.

Assessment Level 2: Explain why it is necessary to irrigate crop plants.

Assessment Level 3: Sketch a simple irrigation system that supplies water directly to the root zone of crops.

Assessment Level 4: Discuss why different plant species have unique water needs and how these requirements can vary based on factors like growth stage and climate conditions.

Section 4 Review

This section was devoted to the various types of irrigation systems, surface, sub-surface and pressurised irrigation. It also considered the types of vegetable crops and ornamental plants and their water needs, source and availability of irrigation water, as well as topography of the growing areas, all of which are necessary in choosing the appropriate irrigation system to produce the vegetable crops and ornamental plants.

Additional Reading

1. Advantages and Disadvantages of Sprinkler Irrigation, https://en.wikipedia.org/wiki/Irrigation_sprinkler
2. Advantages and disadvantages of subsurface drip irrigation by Dr. Freddie R. Lamm, Professor and Research Irrigation Engineer, Northwest Research-Extension Centre. Kansas State University. Colby, Kansas, flamm@oznet.ksu.edu (Chapter 8 of Advantages and disadvantages of SDIs)
3. Criteria for choosing a Suitable Irrigation Method | Irrigation | Agronomy Article shared by: Renuka G. Criteria for Choosing a Suitable Irrigation Method Irrigation Agronomy.html
4. Factors to Consider When Selecting an Irrigation System. Wikifarmer
5. Food and Agriculture Organisation; https://www.fao.org › ...
6. Furrow irrigation, Department of Earth Sciences/Integrated Water Resource Management - from traditional knowledge to modern techniques
7. Irrigation Engineering, [BTAI 2201], Prepared by: Birabhadra Rout, Assistant Professor, Dept. of Agricultural Engineering. SoABE, CUTM, Paralakhemundi Lec-10_Methods-of-Irrg.pdf
8. Shock, C.C. and Welch, T. (2011). Surge Irrigation; Ext/CrS 135 Sustainable Agriculture Techniques

9. Stem Agricultural Science Curriculum 1.X.1.3.LO.1; I.X.1.3.CS.1

10. South Eastern University of Sri Lanka, https://www.seu.ac.lk› Principles of Irrigation, BSE 11042 Principles of Irrigation. Furrow Irrigation

11. Surge Irrigation, United States Department of Agriculture (.gov), https://efotg.sc.egov.usda.gov › *public › surge-i...*

SECTION 5: PRODUCTION AND MARKETING OF VEGETABLE CROPS AND ORNAMENTAL PLANTS

Strand: **Farming For Jobs and Income**

Sub-Strand: Economic Production of Crops

Learning Outcome: *Produce vegetables and ornamental plants for profit.*

Content Standard: Demonstrate knowledge and understanding of market-oriented production of vegetable crops and ornamental plants.

INTRODUCTION AND SECTION SUMMARY

This section helps learners to appreciate the cultivation of ornamental plants as a way of improving their income and livelihoods. Many Ghanaians grow vegetable crops, predominantly in the suburban areas. Hence, introducing learners to ornamental plant production, will introduce them to a new and lucrative venture for the future. The broad aim of the section is to help learners acquire prerequisite knowledge and skills needed to plan, organise, produce and market vegetables and ornamental plants successfully. Learners are also expected to have basic practical skills in managing post-harvest operations as they are taken through this section. It is essential to help learners establish the link between the concepts in this section and related subjects such as economics and business studies. They need basic knowledge such as principles of production, managing and marketing of produce which are directly linked to economics and business studies. Learners will, therefore, be exposed to pedagogical exemplars such as experiential learning**,** collaborative learning, talk for learning**,** project based learning and digital learning. Both formative and summative assessment techniques should be used to promote inclusiveness and cater for the differences in the ability of learners.

The weeks covered by the section are:

Week 10: Identify market needs for vegetables and ornamental plants.

Week 11: Organise and produce selected vegetable crops and ornamental plants.

Week 12: Carry out required post-harvest practices and market the produce.

PEDAGOGICAL SUMMARY

Teaching the concepts under this section requires a blend of pedagogical strategies that will stimulate discussion among learners, develop digital learning skills and provide hands on learning. Teachers should deploy talk for learning, collaborative learning and digital learning approaches to enable learners discover market needs for vegetables and ornamentals. To help learners understand how to organise and produce selected vegetables and ornamentals, project based and experiential learning strategies should be used. The concepts of post-harvest practices and marketing of vegetables and ornamentals are to be taught by using talk for learning, digital learning and project-based learning. Teachers should consider mixed ability and mixed gender (where appropriate) groupings when using these pedagogical strategies to encourage team work and collaboration among learners. When assigning tasks and assessment activities, teachers should consider the variations in learners' ability to ensure they all participate fully in the process. For the highly proficient learners, additional tasks should be assigned to them and they should also be encouraged to help colleague learners.

ASSESSMENT SUMMARY

Assessment strategies that will promote inclusiveness and take care of the differences in the ability of learners should be deployed. This should help to motivate them to participate fully and contribute meaningfully to learning concepts. Both formative and summative assessment techniques should be used in this section. While the former should be used during the instructional process to check learners' progress, the latter should be used at the end of the section to measure learners' achievements. Teachers should use assessment tools such as individual responses to oral questions on activities carried out before and during crop production to allow learners to develop or enhance communication skills. Group presentations should be used in the plenary on post-harvest operations and marketing strategies to help learners think and communicate their ideas and findings. Written responses to questions or tasks on the market needs of vegetables and ornamentals will enhance their critical thinking and writing skills. Practical work and visits to the community and markets should be assigned to learners to enable them practise the production and marketing of vegetables and ornamentals. Teachers are expected to give prompt feedback on learner' performance and update the transcript system with learners' assessment records.

WEEK 10

Learning Indicator: *Identify market needs for vegetables and ornamental plants.*

Theme/Focal Area 1: Market-oriented production of vegetables and ornamental plants.

Vegetables

Vegetables refers to the group of edible plants or plant parts that are eaten either raw or cooked. Vegetables are classified botanically, either based on their life cycle, edible parts or common characteristics such as families. Vegetables can be grouped according to edible parts either as leafy, fruit, root or tubers. They can also be described as annuals, biennials or perennials when classification is based on their life cycle. They are also grouped into families like Solanaceae (tomatoes, peppers, eggplants and potatoes) and Brassicaceae (broccoli, cauliflower, and cabbage). See Tables below for the classification of vegetables based on edible parts and life cycle.

Classification of vegetables based on edible parts

SN	Leafy vegetables	Fruit vegetables	Root vegetables	Tuber vegetables	Flower vegetables
1	Lettuce	Tomato	Carrot	Ginger	Broccoli
2	Cabbage	Okra	Radish	Irish potato	Cauliflower
3	Spinach	Garden egg	Turnip	Sweet potato	
4	Kontomire	Aubergine			
5	Onion	Cucumber			
6		Pepper			

Classification of vegetables based on plant life cycle

SN	Annuals	Biennials	Perennials
1	Tomato	Aubergine	Broccoli
2	Okra	Pepper	Ginger
3	Cucumber		Asparagus
4	Cabbage		
5	Lettuce		
6	Carrot		

Ornamental plants

Ornamental plants are the group of flowering and non-flowering plants that are grown for their aesthetic values. They come in groups according to their purpose or function as ground covers or spreaders, herbaceous annuals and perennials, hedges, shrubs, trees, avenue plants and potted plants.

Marketing

Marketing is the activity or business of promoting and selling products or services including market research and advertising. Marketing is the term used to describe the act of buying and selling of a commodity between the producers, retailers and consumers. This is an act of physical exchange of commodity for money. The processes involved in marketing of vegetables and ornamental plants include assembling, sorting, grading, processing, packaging, storage, distribution, advertising and risk management.

The market requirements before taking on a vegetable or ornamental plant business.

1. Financial and personal goals:
   a. How much income is needed from the vegetable and ornamental plant business?
   b. How much is needed for the start up?
   c. How much time can be invested in the vegetable and ornamental plant business?
2. Identify crops to grow: Analyse crop options based on:
   a. Profitability
   b. Market demand
   c. Resources needed and resources available
      i. Capital
      ii. Land
      iii. Labour
3. Analyse market outlets based on:
   a. Volume to sell
   b. Crop diversity
   c. Price premium
   d. Special requirements (packaging, certifications, farmers agronomic preferences)
4. Identify when to sell and at what price:
   a. Seasonal factors
   b. Extending production season (greenhouse or high-tunnel production)
   c. Consider production and marketing costs
5. Production planning:
   a. Seedling and planting schedule
   b. Harvesting schedule

Planning

This is the key to success when one is ready to start a vegetable and ornamental plant production business. Poor management and lack of planning are, in many cases, the primary causes of business failure. It all starts with planning and goal setting. Draw up a plan to help with accountability. In any business enterprise, it is necessary to identify a market for the products. Given the perishable nature of vegetables, one needs to know where one will be selling the crop even before planting. It is important to secure customers or buyers for the product before making any significant financial investment. Other elements that must be evaluated beforehand are infrastructure and capital requirements for producing, harvesting, handling and marketing of the produce. Postharvest handling activities are very important to maintain the freshness of the product. Proper infrastructure must be in place, especially when going into large scale production and distribution.

Goal setting

First, identify the financial and personal goals. It is important to determine how much income is obtainable from the vegetable or ornamental enterprise to cover farm and living expenses. Plan the farm size according to the resources available. Even if the plan is towards a large enterprise, start with a modest size and develop a sustainable growth plan.

Marketing plan

Considering the perishable nature of vegetables and the slow demand for ornamental plants in Ghana, one must have a marketing plan that outlines what, where, when and at what price to sell vegetables and ornamental plants.

What to sell?

Some factors that can help determine what crops are best suited are product profitability, skills required for its cultivation, level of care needed, labour cost and startup capital required. Some crops may be very profitable, but they may also be labour-intensive. Consider different crops that can be produced at different times of the year. At any rate the market needs should determine the type of crops to grow.

Where to sell?

Depending on the size of the operation, there are various marketing options:

a. Direct-to-consumer marketing

b. Farmers' markets

c. Community-supported agriculture (CSA)

d. Roadside stands

e. Direct sales to restaurants or local supermarkets

f. Food hubs

g. Wholesale markets

First, know the buyers and their preferences. Some buyers have stricter requirements. For example, hospitals, wholesalers and some supermarkets may require specific agricultural practices and quality certifications. Volume, product diversification, handling, packaging, and product transportation requirements will also depend on the type of buyer

When to sell?

Seasonality is an important factor in vegetable production. Prices are lower during the typical production season and higher during the offseason. Alternative production methods such as greenhouse production or high tunnels allow the harvest season to be extended and thus get higher prices.

At what price?

Prices vary across market channels. Prices in direct-marketing channels such as farmers' markets are generally higher than wholesale prices. It is also important to negotiate prices. In order to negotiate the price, there is the need to be informed about price trends and prices received by other producers.

Production planning

There is the need to establish what to produce and the market avenue for disposing the produce, before developing a production plan. Some factors to consider in developing the production plan include:

1. **Capital needs:** Identify all the investment and cash operating needs and how much needs to be borrowed.
2. **Infrastructure and equipment:** Identify what equipment you need for the crops being produced. In addition, depending on packaging and handling requirements, identify what type of infrastructure will be needed.
3. **Management:** Identify the production, management and marketing skills necessary to make the enterprise successful. If those skills are lacking, hire additional labour.
4. **Planting and harvesting schedule**: Plan the best timing for planting and harvesting the crops, based on plant variety and availability of labour.
5. **Postharvest and sanitation:** Post-harvest needs (sanitation, handling, and refrigeration) are important aspects that need careful thought. Cooling is necessary to delay produce spoilage and keep it fresh. When the product is not sold or disposed off immediately after harvest, a cold storage option may be needed.
6. **Enterprise record keeping:** Keep good production and financial records to help you make good decisions in the future. Use records to identify challenges that need to be addressed.

Market needs for vegetable crops and ornamental plants

1. Producers must meet the market needs in terms of choice of vegetables and ornamental plants.
2. Fresh and quality produce (clean, fresh and disease-free).
3. Affordable pricing of products.
4. Convenient market location.
5. All yearlong supply of products.
6. **Certification and branding:** Develop a brand and slogan that reflect the quality and unique selling points of the produce and products.
7. **Packaging:** Attractive and informative packaging can help catch the attention of potential consumers
8. **Advertising:** Electronic and print media including television, radio, newspapers and magazines are effective advertising channels.
9. **Social media:** A strong online presence through social media helps to reach consumers.

Learning Tasks

1. Learners assess the market needs for the production of vegetables and ornamentals through surveys, interviews and online research on market trends, consumer behaviour and potential target audiences.
2. Learners identify and evaluate existing businesses that are already serving the vegetable and ornamental plant market. In particular, they need to consider the products, pricing strategies, marketing approaches and customer (re)views and identify potential gaps in the market that can be exploited.

3. Learners develop a comprehensive marketing plan for the vegetable and ornamental plant business. This task should involve defining their target market, positioning their products and developing strategies to reach and attract customers.

By completing these tasks, learners will gain a deeper understanding of the market needs, preferences, and opportunities within the vegetable and ornamental plant industry. This knowledge will enable them to make informed decisions and develop effective strategies for a successful business venture.

Pedagogical Exemplars

Initiating talk for learning: Teacher provides enough background information to guide learners on how to gather data through surveys, interviews and online research in assessing the market needs of vegetables and ornamentals.

Experiential learning: Learners visit the local community and work places to observe types of ornamental plants used for hedges and home decoration and visit the local markets, to collect data for comparative analysis.

Collaborative learning: Learners in their groups discuss their findings from the market and community survey and present reports to the class. Teacher should encourage teamwork with team members providing support where necessary.

Key Assessment

Assessment Level 1: List the factors that determine the market needs for the production of vegetables and ornamental plants.

Assessment Level 2: Explain the market needs for types of ornamental plants and vegetables you plan to grow.

Assessment Level 3: Examine the market demands and preferences for various types of ornamental plants and vegetables in the locality.

Assessment Level 4: Analyse the market requirements and trends for a named ornamental plant and vegetable, considering factors like consumer preferences and emerging demands and submit a detailed written report.

WEEK 11

Learning Indicator: *Organise and produce selected vegetable crops and ornamental plants.*

Theme or Focal Area 1: Organise and produce a selected vegetable crop and ornamental plant.

The organisation stage for crop production involves gathering all resources necessary for the production such as land, capital, seeds or planting materials, tools, implements, agro-inputs and labour. Production involves knowing the kind of crop and ornamental plant, the available varieties the kind of soil, climatic requirements, methods of raising or planting the selected crop, knowing the planting distances of seedlings, management practices such as pest and disease recognition and control, harvesting and post-harvest operations such as processing and marketing and storage of the vegetable and ornamental plants. Some crops require special land preparation methods and special nursery attention.

A. Organisation/planning stage (factors to consider)

1. Availability of capital
2. Land
3. Kind of vegetable crop and ornamental plants to grow
4. Seeds/planting materials
5. Purpose of production (home/subsistence gardening or commercial gardening).
6. Source of labour
7. Tools and equipment for production
8. Favourable season for production
9. Technical know-how of production of the selected crop and ornamental plant
10. Market demands

Steps in the production stage

1. Site selection
2. Land preparation
3. Nursing and nursery practices
4. Transplanting
5. Irrigation
6. Weed control
7. Fertiliser application
8. Pest and disease control
9. Harvesting and post-harvesting processes (marketing, processing and storage).

Factors to consider in selecting a site for crop production

a. Topography of land
b. Soil type

c. Existing vegetative cover

d. Organic matter content

e. Permanent water source

f. Proximity of site to human settlement

g. Road access and availability of market

Factors influencing the choice of vegetable crop and ornamental plant production

1. Producer and consumer choice
2. Type of soil
3. Crop response and adaptability to locality
4. Technical knowledge about the production of the vegetable crop and ornamental plant.

Steps in the production of vegetable crops and ornamental plants

1. Determine the type of vegetable to be grown based on market demand, climate and soil type.
2. Secure a suitable land or greenhouse facility for production.
3. Develop a planting schedule based on the expected market demand.
4. Procure the necessary supplies for production such as seed, fertilisers, and pesticides.
5. Establish a pest control programme.
6. Implement a crop rotation plan to manage soil borne pests and diseases.
7. Hire and train workers to handle tasks such as planting, cultivation, and harvesting.
8. Establish a marketing strategy to identify potential buyers and secure sales channels.

Learning Tasks

1. Learners organise materials, select and prepare the site and construct beds and ridges for vegetable production.
2. Learners use planting materials and a guided activity plan to produce vegetables or ornamental plants on their garden plots and determine factors influencing the choice of crop.
3. Learners discuss the process of producing the vegetable or ornamental plant and keep records of activities regularly in a field note book.

Pedagogical Exemplars

Talk for learning: Learners in groups discuss the major factors necessary for growing selected vegetable crops and ornamental plants. The teacher should use probing questions to guide learners, especially those requiring support. More confident learners should be allowed to do independent work.

Collaborative learning: Learners in groups analyse the steps involved in the production of vegetables and ornamental plants. More confident learners should be encouraged to assist other learners.

Project based learning: Learners in groups select some of the vegetables and ornamental crops to grow in the school garden/farm in beds or in boxes, sacks, pots or plastic bottles using a chosen irrigation system. They should make regular visits to the garden to care for the plants and take records for discussion.

Key Assessment

Assessment Level 1: List the materials needed to produce selected vegetable crops and ornamental plants.

Assessment Level 2: Describe the stages of production and related challenges of selected vegetable crops and ornamental plants.

Assessment Level 3: Outline the production of selected vegetable crops and ornamental plants to meet identified needs.

WEEK 12

Learning Indicator: *Carry out necessary post-harvest practices and market the produce.*

Theme or Focal Area 1: Post-harvest operations for vegetable crops and ornamental plants

Post-harvest operations refer to the series of processes and practices that harvested vegetables and ornamental plants are taken through before marketing them to avoid spoilage and add value to the produce. The activities include washing and cleaning, sorting and grading, packaging, advertisement of products and taking the product to the consumers.

A. Post-harvest practices for vegetables and ornamental plants

1. **Post-harvest practices for vegetables**
   a. **Cleaning and washing:** Remove dirt and debris from vegetables to maintain their hygiene and appearance.
   b. **Sorting and grading:** Sort vegetables based on size, weight, quality and appearance to ensure uniformity of the produce.
   c. **Cooling and storage:** Rapidly cool vegetables to appropriate temperatures and store them in controlled environments to extend their shelf life.
   d. **Packaging and handling:** Use suitable packaging materials to protect and handle vegetables carefully during transportation and display.
   e. **Transportation**: Use appropriate vehicles (such as controlled temperature vans) to transport vegetables from production sites to storage and consuming centres to minimise physical damage.
   f. **Ripening:** For certain crops like tomatoes or bananas, controlled ripening may be carried out to optimise their quality before reaching the market.

2. **Post-harvest practices for ornamental plants:**
   a. **Pruning and trimming:** Trim excess leaves and branches to improve the appearance and health of ornamental plants.
   b. **Watering:** Ensure proper watering to keep plants fresh and hydrated during storage and transportation.
   c. **Temperature and humidity control:** Maintain suitable environmental conditions to prevent wilting and stress on the plants.
   d. **Packaging and handling:** Use protective packaging and handle plants with care to prevent damage to them.
   e. **Transportation:** Use appropriate vehicles (such as controlled temperature and humidity vans) to transport the ornamentals to storage and sales points to minimise breakage and deformation.

B. Marketing sites and strategies for vegetable crops and ornamental plants

1. **Marketing sites and strategies for vegetable crops**
   a. **Local farmers' or farm-gate markets:** Participate in farmers' markets to directly connect with consumers seeking fresh produce.
   b. **Grocery stores and supermarkets:** Establish partnerships with local grocery stores and supermarkets to distribute vegetables.
   c. **Online sales platforms:** Utilise online platforms to reach a broader customer base and offer doorstep deliveries.

d. **Promotional offers:** Offer discounts or promotional deals to attract customers and increase sales.
e. **Certification**: If vegetables are produced organically, obtain organic or sustainable farming certificates to appeal to organic produce enthusiasts.

2. **Marketing sites and strategies for ornamental plants:**
   a. **Garden centres and nurseries:** Collaborate with garden centres and nurseries to display and sell ornamental plants.
   b. **Landscaping companies:** Partner with landscaping businesses that may require bulk orders of ornamental plants.
   c. **Online market:** Utilise e-commerce platforms to reach customers interested in buying plants online.
   d. **Social media and visual content:** Utilise social media platforms and showcase visually appealing images of ornamental plants and engage with potential customers.
   e. **Plant care guides**: Produce plant care guides to educate customers and build trust in your products.

Effective marketing often involves understanding the target audience, highlighting the unique selling points of the products and adopting multiple channels to reach potential customers.

Learning Tasks

1. Learners visit markets in their community to gather information on post-harvest processes, current prices and market availability for vegetable crops and ornamental plants.
2. Learners collect some fresh unwashed tubers and vegetables from the school kitchen or from home to demonstrate washing, cleaning and sorting.
3. Learners provide detailed oral or written descriptions of the various post-harvest activities and marketing strategies for some selected vegetable crops and ornamental plants and reasons for performing those post-harvest activities.

Pedagogical Exemplars

Talk for learning: The teacher uses probing questions to guide learners to bring out the meaning of post-harvest operations and identify examples of these activities in marketing vegetable crops and ornamental plants.

Digital learning: The teacher guides learners in their groups to search the Internet to identify the marketing strategies used to sell vegetable crops and ornamental plants and discuss their findings with other groups. Learners who are computer literate should assist other learners.

Project based learning: The teacher leads learners in their groups to find out from farmers and marketers in their communities about the various post-harvest activities they carry out on some selected vegetable crops and ornamental plants and present oral or written reports to the class.

Experiential learning: Learners use items from the school kitchen or from home – vegetables and fruits – to learn how to clean, wash and sort items.

Key Assessment

Assessment Level 2: Describe the post-harvest practices carried out for a selected vegetable crop or ornamental plant.

Assessment Level 2: Outline the marketing strategies used to market selected vegetable crops and ornamental plants.

Assessment Level 3: Examine the reasons for performing post-harvest activities in marketing of vegetable crops and ornamental plants.

Section 5 Review

In this section, learners were introduced to factors that determine market-oriented production and processing of vegetables and ornamental plants for the market. Learners went to markets in the community to gather information on post-harvest processes, current prices and market availability for vegetable and ornamental plants and provided detailed written description of the various post-harvest activities for some selected vegetable crops and ornamental plants and reasons for performing those post-harvest activities.

Additional Reading

1. Food and Agriculture Organisation of the United Nations (2009). Growing vegetables for home and market; Diversification booklet No. 11 by Mike Nichols and Martin Hilmi; Rural Infrastructure and Agro-Industries Division; Rome.
2. https://www.marketnews.usda.gov/mnp/fv-report-config
3. https://www.agecon.msstate.edu/whatwedo/budgets.php.
4. Mississippi Department of Agriculture and Commerce website at http://www.mdac.ms.gov/bureaus-departments/farmers-market/markets-mississippi/.
5. Stem Agricultural Science Curriculum
6. www.ams.usda.gov