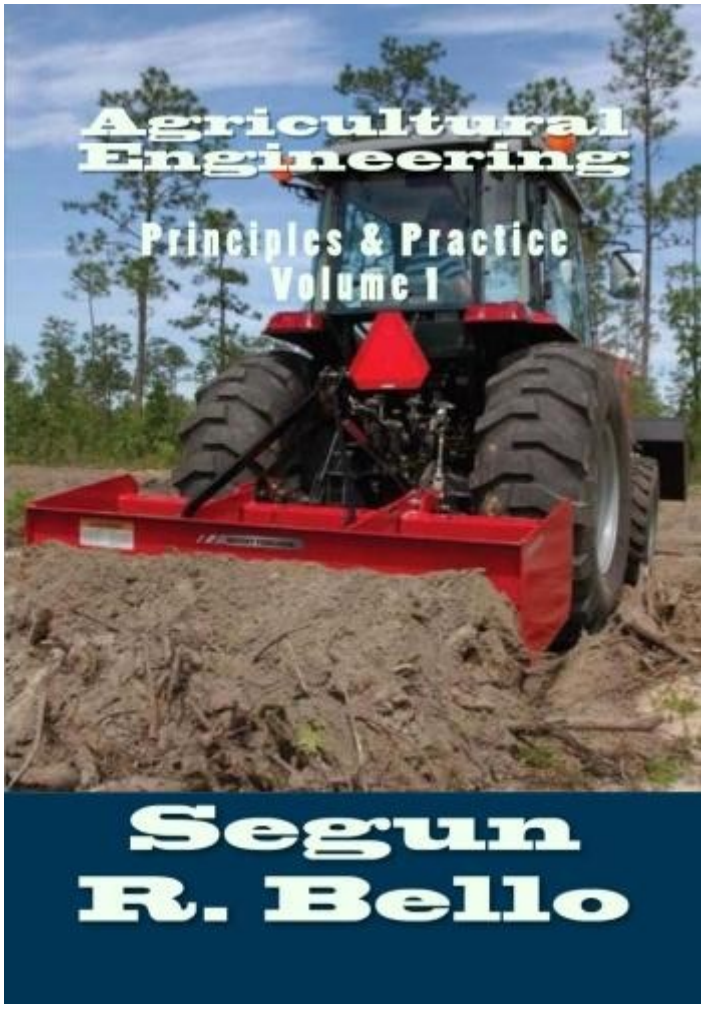
Introduction to Agricultural & Bio-Environmental Engineering



COURSE CODE: **ABE 101**

COURSE LECTURER: Engr. Segun R. Bello

Course objective

After completion of this unit, students should be able to describe the factors involved in selecting machinery and make calculations that facilitate the selection of machinery. This knowledge will be demonstrated by completion of assignment sheets and unit test with a minimum of 85 percent accuracy.

Specific objectives and competencies

After completion of this course, the student should be able to:

1. Understand
2.

Reference materials

1. Bello R. S., 2012: **Agricultural Engineering: Principles and Practice (Vol 1).** *Createspace Charl US.* ISBN-13: 978-147-931-614-4 URL:https://www.createspace.com/3996235 Sept 2012 (390 pages)
2. Bello R. S., 2012: **Agricultural Engineering: Principles and Practice (Vol 2).** *Createspace Charl US*. ISBN-13: 978-145-633-568-7 URL: https://www.createspace.com/3498612 Sept 2012 (390 pages)
3. Bello R. S., 2012: **Agricultural Machinery & Mechanization.** *Createspace Charl US.* ISBN-13: 978-145-632-876-4. https://www.createspace.com/3497673 June 2012 (388 pages)
4. Bello R. S., Adegbulugbe T. A. and Odey S. O., 2010: **Farm Power and Machinery** *Climax Printers,* Enugu Nigeria ISBN: 978-332-2-254-4-3 (466 pages)
5. Bello R. S., 2006: **Guide to Agricultural Machinery Maintenance, and Operation** *Fasmen Communications*, Okigwe Nigeria ISBN: 978 - 2986 - 90 – 9 (79 pages)
6. Bello R.S. and M.B. Bello, 2015. **Agricultural Machinery Management**. LAP LAMBERT Academic Publishing October 9, 2015 https://www.lap-publishing.com/

♣ All available @**:** http://www.amazon.com/Segun-R.-Bello/e/B008AL6RI0

Suggested activities

Locate someone (such as the school, a local business or a farmer) who is planning an equipment purchase and evaluate the situation as to what size of equipment should be obtained, whether it should be rented, purchased or custom hired, what the cost would be per year, etc.

Take an inventory of an average farm in the area to determine just how much money that farm has tied up in machinery.

Agricultural engineering and development

What is engineering?

Engineering is generally defined as the art or science of utilizing, directing or instructing others in the utilization of the principles, forces, properties and substances of nature in the production, manufacture, construction and operation of utilities.

The engineering family

You may ask who the members of engineering family are. The law regulating the practice of engineering in Nigeria (Laws of the Federal Republic of Nigeria, Decrees 55/70 and 27/92 (Now Acts 110)) makes provision for registration of four cadres of engineering professionals regarded as **the engineering family**: these are

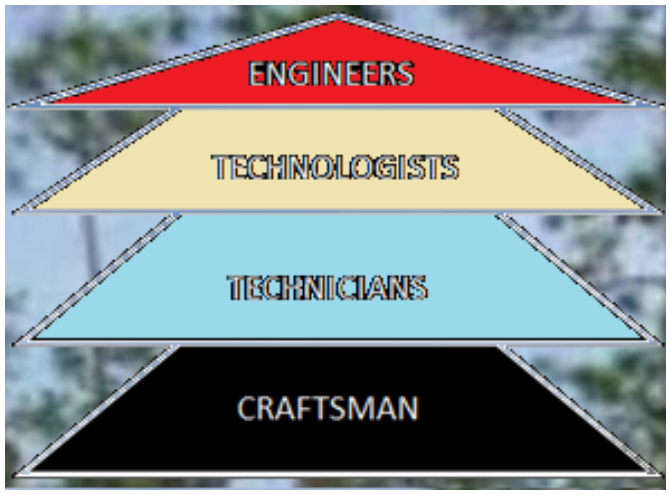
1. Engineers

2. Engineering technologists

3. Engineering technicians and

4. Engineering craftsmen

The structure of this family is shown below.



Hierarchy of engineering profession

Engineering profession is characterized by the three chains of command with specific functions.

Professional institutions: Professional institution provides a forum for members of a particular profession to interact among themselves. For instance, the Nigerian Institution of Agricultural Engineers (NIAE) provides a forum for Agricultural Engineers within the country to interact among selves.

Figure 1-2: Professional institution

The institution also set ethical standards and standard of professional conducts for members including benchmarks and best practices. They are quasi-regulatory agencies and can administer disciplinary actions for members' misconducts.

Professional society: This is an umbrella association formed by the coming together of several members of professional institutions with the primary objective of providing a forum where members of the profession can interact to share ideas. This body provides a wider platform for its operation than the professional institution.

Figure 1-3: Professional society

The Nigerian Society of Engineers (NSE) for instance is the umbrella association for all engineering disciplines in Nigeria which provides a bigger forum where they interact with each other, for example agricultural engineers can interact with other engineering professionals.

Professional regulatory body: Professional regulatory body is established by a decree or law whose primary function is to regulate the training of members of a particular profession such as engineering and the formulation of edicts of professional practice.

Figure 1-4: Professional regulatory body

There are many professional bodies in Nigeria that regulates the practice of different professions ranging from accounting to engineering. The professional regulatory body responsible for regulating the practice of engineering in Nigeria is the *Council for the Regulation of Engineering in Nigeria (COREN)*.

Code of engineering practice

The code of conduct of engineering practice is an obligatory norms (rules) guiding the conducts of every member of the profession. In Nigeria, the code of conduct of the society is clearly stated under article 80 of the memorandum of association. Every member is expected is expected to uphold and enhance the honour and dignity of Engineering profession and the reputation of the Nigeria Society of Engineer and to act always in consonance with that interest.

Agricultural engineering definition

Refreshing our minds, **agriculture** is defined as an art or science of raising crops and rearing of animals for human consumption and commercial purposes. Therefore, **agricultural engineering** in contextual meaning is simply defined as the introduction of engineering to solve agricultural problems.

However, from the view point of ethical practice, agricultural engineering can be defined from two perspectives; **the scientific perspective** and the **professional perspective**:

Scientific perspective: Agricultural engineering is expressed as the application of principles gained from the knowledge of basic (natural) sciences and mathematical modeling, to the solving of agricultural based problems involving primary, secondary and tertiary production processes.

*Professional perspective: A*gricultural engineering is the technological processes involved in the application of scientific principles for the optimal utilization of resources such as agricultural land, machinery, structures, processes, and systems for the utmost benefit of man.

Note: From the *professional perspective,* it can be said that *a*gricultural engineering is the **wheel-hub** of industrialization and the **lifeline** of all other professional development.

Areas of specialization in agricultural engineering

1. **Farm power and machinery engineering (FPME):** Concerned with the development and utilization of power and machinery in agricultural production. This option is divided into *farm power* and *farm machinery*: **Farm power** deals with various sources of generating power and its availability on the farm while **machinery** aspect deals with machines other than farm power meant for job delivery on and off the farm.

2. **Soil and water conservation engineering (SWE):** Soil and water conservation engineering employs principles of engineering in solving soil and water management problems. The conservation of these vital resources implies utilization without waste so as to make possible a high level of production, which can be, continued indefinitely.

3. **Irrigation and drainage engineering:** This field of agricultural engineering is concerned with the determination of crop water requirements and design irrigation systems. They are experts in agricultural hydrology principles, such as controlling drainage, and they implement ways to control soil erosion and study the environmental effects of sediment on stream quality.

4. **Postharvest systems engineering:** This field of agricultural engineering is concerned with the management of products of primary production processes which do not usually meet the needs of the consumers, neither has the desirable value addition to enhance its value on the international market, hence the need to further process them into more finished products which is the exclusive role of a post-harvest systems engineer.

5. **Structures and environmental engineering:** This field of agricultural engineering is concerned with the management of farm structures which include farmstead, settlements, animal houses, storage structures postharvest processing plant farm and allied products, machinery and processing equipment house etc. These structures need specialized designs. Control of environmental factors, external and within in the structures, waste disposal systems, biogas generation etc. are also involved.

6. **Wood products engineering:** This branch of agricultural engineering involves the study of engineering properties of woods, composite products from wood and associated wood products processing; design of machines required for forestation projects, exploiting forestry products and management of wood waste products.

Advancements in agricultural engineering specialization

Agricultural engineering have advanced in content to the extent that the scope had been widened to embrace various emerging technologies within the field and the following specialized fields have been identified:

1. Agricultural and environmental engineering

2. Power systems and machinery design engineering

3. Food and bioprocess engineering

4. Biological (Bioresources) engineering
5. Information and electrical technologies engineering
6. Forest engineering
7. Energy engineering
8. Aquacultural engineering
9. Nursery & greenhouse engineering
10. Agricultural safety and health engineering

Overall objectives of agricultural engineering

The overall objectives of agricultural engineering is to

1. *Reduction in farm hazards*: The causes of these hazards are identified and solutions given. This ensures that the farmers labour is not in vain.

2. *Reduction of drudgery in agricultural operations*: Agricultural engineering intervention is to develop machines and equipment that can be used in performing agricultural operations to reduce stress on farmers.

3. *Improved working environment*: Provide a conducive working environment for the farmer and assure him that there is dignity in farming,

4. *Food security*: Improve his economic situation and make food available in adequate quantity and quality at the right time of need and at a reasonable cost to consumers. These objectives are pursued

Historic emergence of Agricultural Engineering

The world outlook on agricultural engineering development historically started in the United States of America in the early 19th century. In 1906, a three-man forum attended by F. R. Crane of the university of Illinois, Jay Brownlee Davidson (referred to as the "*father of agricultural engineering*,") of Iowa State College and C. A. Ocock of the university of Wisconsin, met at the university of Illinois to discuss teaching techniques and development of instructional materials for the discipline marked the beginning of engineering knowledge to solving problems on the farm.

Early agricultural engineering training in Nigeria was substantially done overseas until about the early 1960s when local educational opportunities started to be available. Prior to the 1960s, the expertise and services of agriculturists and civil engineers were used to solve engineering problems on Nigerian farms. The interest and challenges of engineering services on the farm, made some of them to seek opportunities to retrain themselves in what today became the agricultural engineering curriculum.

Agricultural engineering education in Nigeria started in the few colleges of agriculture and polytechnics available in the then regional enclaves of Nigeria, with training in farm mechanization and special emphasis on tractorization which was later expanded to cover all aspects of agricultural engineering. This training started with the teaching of parts of the present day agricultural engineering curriculum to students in the schools and colleges of agriculture such as in Akure, Ibadan, Umudike (now FCA, Ishiagu) and Zaria, and faculties of agriculture in some universities. Some of such graduates were awarded degrees, diplomas and certificates in agricultural mechanization but not in agricultural engineering.

History of professional development of agricultural engineering in Nigeria

Agricultural engineering as a profession has developed under the platform of a professional institution just like any other profession. The professional institution overseeing agricultural engineering conduct and development in Nigeria today is known as the Nigeria Institution of Agricultural Engineers (NIAE). Attempts to have a forum for agricultural engineers in Nigeria dated back to 1965. That year, Professor Cargill of the University of Nigeria, Nsukka, Mr. Hewitt of BEWAC Nigeria Limited, Dr. Layide Onafeko, Engr. Deji Osobu and Professor F. O. Aboaba networked to start a professional society to be known as the *Nigerian Society of Agricultural Engineers (NSAE).*

The society took off with regular holding of meetings and held the first conference in Benin City in 1967. It was during the conference that the state of Biafra was declared which marked the beginning of the Nigerian civil war from 1967 to 1970. The Nigerian civil war prevented the society from functioning until 1975 when with the incoming of a crop of young and dynamic Nigerian agricultural engineers resuscitated the society with Professor Ayo Makanjuola becoming the president.

The society effectively took off once again with the following objectives:

i. To promote the science and art of engineering in agriculture.

ii. To encourage agricultural research.

iii. To foster and promote agricultural engineering education.

iv. To advance in every possible ways the standards of agricultural engineering.

v. To promote the intercourse of agricultural engineers among its members and with allied technologies.

vi. To encourage the enhancement of professional competence of its members.

Opportunities opened to agricultural engineers

Agricultural engineering graduates have in the past found jobs in the following areas of the economy;

1. *Government ministries and parastatals*: Federal/central and state government

2. *Public sector organizations/companies*: such companies as Tractor and Equipment (a division of UAC), SCOATRAC (a division of SCOA), Diezengoff, Leventis, etc.

3. *Banks and financial corporations:* Financial institutions requires the services of agricultural engineers in project evaluation, feasibility studies, undertake environmental impact assessment studies.

4. *Manufacturing industries:* In farm equipment manufacturing industries

5. *Educational institutions*: They are employed as lecturers, technologists, and instructors by federal, state, and local research, regulatory, and educational agencies.

6. *Research and development institutions:* Agricultural engineers work under the ministries of Agriculture and water resources and other government parastatals.

7. *Occupational health and safety organization:* Agricultural engineers are equally found competent to head health and safety projects in conglomerates.

8. *International organization*: Including the United Nations Development Promgrame (UNDP), Food and Agricultural Organization (FAO), United States Agency for International Development (USAID) etc.

9. *Self-employment*: notable engineers such as Sahara Engineers in Ibadan among several others have impact in this area.

10. There is also wide range of opportunities in storage, maintenance and sales of agricultural machinery etc.

Impacts of agricultural engineering in national development

Agricultural Engineering plays a pivotal role in the development of the country by helping to solve the following problems:

1. *Food security*: Food security is obtainable when food is abundantly produced above subsistence level keeping all other factors of production under monitoring.

2. *Agricultural stress*: Engineering input to agricultural has reduced drudgery considerably in agricultural operations.

3. *Development of rural infrastructure* through farmsteads development and socials

4. Conservation of natural resources such as soil, agroforest and water etc.

5. *Environmental management*: Environmentally friendly design considerations in machine design, construction and management has rapidly promote eco-friendly and sustainable environment

6. *Industrial development*: Agricultural engineering evolution has become a vital tool in both the agrarian revolution of the 18^{th} and 19^{th} centuries as well as the

industrial development witnessed in the world today through food security programmes, raw material research and development as primary input in industrial production and development.

7. *Subsistence agriculture*: This has largely been improved through equipment and machinery design and production.

Agricultural Mechanization

What is Mechanization?

Mechanization may be simply said to be

1. The increase in production per worker per hectare of farmland cultivated.

2. The development and introduction of mechanized assistance of all forms and at any level of sophistication in agricultural production to improve human efficiency, timeliness of operation and labour involvement.

3. The use of any machine to accomplish a task or operation involved in agricultural production.

4. The application of engineering principles and technology in agricultural production, storage and processing; where these activities and applications are not limited within the boundaries of the farm units only.

5. An overall description of the application of agricultural inputs to production, processing and storage of farm products.

Why Mechanization?

Mechanization become imperative for the following reasons

1. Mechanization involves judicious application of inputs by using agricultural machinery/equipment e.g. Hand tools, bullock drawn equipment, power driven machines including the prime movers for performing various operations required for crop production activities.

2. Mechanization ensures precision in operation, time reduction, labour saving and reduction of drudgery associated with various farm operations

3. It economizes the utilization of inputs and thereby harnessing the potential of available resources.

What are the priorities of mechanization?

1. To enhance productivity and conservation of energy required for various operations involved in crop production, threshing, processing, transportation, value addition, storage etc.

2. To decide the actual requirements of various agro climatic zones and

3. To decide land preparation equipment; crop production techniques for cereal crops, for cash crops and horticultural crops etc.

4. To decide animal thermal environment, housing requirement etc.

5. To evolve new approaches to agricultural products processing and storage

Government efforts in promoting mechanization

With a view to enhance the pace of agricultural mechanization, Government have a vital role to play in promoting agricultural mechanization with emphasis laid on

1. Providing financial assistance to the farmers and other target groups for purchase of different kinds of farm equipment through subsidy,

2. Demonstration of new equipment among farmers for spread of new technology,

3. Human resource development in operation, maintenance/ repairs and management of agricultural machinery and

4. The quality improvement through testing and evaluation besides institutional credit & fiscal measures.

Benefits of mechanization

1. Improvement in crop yield per hectare and quality

2. Extension of cultivated area

3. Possibility of raising new crops and livestock which were not initially possible

4. Improvement in timeliness of farming operations, timely provision of suitable conditions and environment for plant and animal growth,

Constraints/problems in promotion of mechanization

The constraints in promotion of mechanization include

1. Huge cost of investment on equipment.

2. The varied requirement of equipment for each agro climatic zone,

3. The small and fragmented land holding,

4. Low investment capacity of the farmers,

5. Inadequate irrigation facilities,

6. Poor know how status of the farmers,

7. Poor repairs & maintenance facilities etc.

Mechanization and labour displacement /unemployment

Mechanization does not necessarily displace labour, rather it enhances labour employment particularly for paid employments through increase in cropped area, handling of more produce, expansion of marketing infrastructure etc.

Involvements of mechanization in agricultural production

The involvements of mechanization in agricultural operations and production include:

1. The process of selection of agricultural systems and inputs,

2. Handling/management of the selected systems and utilization of the inputs,

3. Operation of machines/equipment and optimization of operational time and

4. Maintenance of mechanical devices and systems involved in agricultural operations and production

Attachments required for effective mechanization programme

What implements you will need depends on what you intend to do with your tractor. When shopping for a used tractor, it is a good idea to try to find one with as many model-specific attachments as possible.

Guide to equipment lasting a longer time

Develop good maintenance habits. Also, follow specific manufacturers' maintenance recommendations to guarantee durability of your tractor and related equipment.

Types of mechanization

i. *Appropriate mechanization* is the practice of applying actual machinery and equipment to production process such that human involvement is minimal, production cost kept at minimum and output yield is optimum. (2 marks)

ii. *Optimum level of mechanization* is the degree of mechanization that produces the most beneficial production systems in terms of efficiency and economic returns (2 marks).

Indicators of mechanization

i. *Degree of Mechanization* (M) is described as the average energy input of work provided exclusively by different levels of mechanization technology (labour) per hectare

ii. *Levels of mechanization*: Levels of mechanization involves the gradual improvements in the power development for agricultural operation while Degree of Mechanization (M) describes the average energy input of work provided exclusively by different levels of mechanization technology (labour) per hectare.

iii. *Mechanization index*:

Mention the four levels of mechanization and the power source available

i. Hand tool technology (HTT) utilizing hoes, cutlass, axe, knife etc. Examples: human power, Solid fuels Charcoal

ii. Animal draught/draft technology (ADT) , Examples: horses, mules, oxen and bullocks

iii. Mechanical power technology (MPT) Examples: Agricultural Tractors, electric motor stationary engines generators truck/haulage tractors

iv. Renewable energy technology (RET) Examples: Solar energy wind energy biomass energy fossil fuels (petrochemicals) **geothermal energy fuel cells (batteries)** hydropower (**hydel) energy**

Farm power and machinery

Farm power

Farm power refers to all prime movers and power sources used for all stages of agricultural production, processing and distribution.

Major sources of power on the farm and examples of each

Sources: Human, animal, mechanical (engine) renewable resources

Examples

i. **Human power**: Examples: man,

ii. **Examples of animal**: horses, mules, oxen and bullocks

iii. **Examples of mechanical**: Agricultural Tractors, electric motor stationary engines generators truck/haulage tractors

iv. **Examples of renewable**: Solar energy wind energy biomass energy fossil fuels (petrochemicals) **geothermal energy fuel cells (batteries)** hydropower **(hydel) energy**

Define prime mover

A prime mover is any of the primary source of power available for producing energy for machinery operation

Define an engine and mention four types of engine classification

An engine is a mechanical system which transforms heat energy into mechanical energy using fuel. An engine is a machine that makes energy more usable. Engines usually turn heat energy into motion.

Engine classification:

i. External combustion engine e.g. steam engine

ii. Internal combustion engine e.g. petrol and diesel engines

iii. LP gas engine

iv. Hybrid engine e.g. alcho-gas engine

External combustion engine and internal combustion engine

i. The external combustion engine usually called EC Engine uses steam from a boiler to generate power in an engine. Some of the earliest engines ran on steam power, like steam locomotive.

ii. The internal combustion engine called IC engines uses the expansive force of burnt gases from an enclosed space called combustion chamber to generate output power in the form of motion called output power for other uses. Examples of IC engine are the diesel and petrol engines.

Operational differences between an internal-combustion engine (ICE) and external-combustion engine (ECE)

Operational differences between ICE and ECE

S/No	ICE	ECE
1.	Burn fuel internally	Burn fuel externally
2.	Compact in construction	Bulky in construction
3.	Burn fuel in 4 operations	Burn fuel in boilers

Sequence of operation in a two-stroke and four stroke operation

1. *First stroke*: Intake and compression take place simultaneously
2. *Second stroke*: power and exhaust take place simultaneously

Sequence of operation in four strokes**:**

1. *First stroke*: Intake
2. *Second stroke*: compression
3. *Third stroke*: ignition/power,
4. *Fourth stroke*: exhaust

Four definite series of events that must occur in sequence for an engine to operate

The four definite series of events that must occur in sequence for an engine to operate:

1. Fill cylinder with combustible mixture
2. Compress mixture into a smaller space
3. Ignite mixture causing it to expand and produce power
4. Remove burned gases from cylinder.

Four functional divisions in engine and their functions

1. *The power train*: The power train receives, exert and transmit the motion forces from burnt gasses

2. *The stationary parts*: The stationary parts to constrain and support moving part (power train)

3. *The engine operating systems*: The engine operating systems coordinates the functional performance of the engine.

4. *The auxiliary parts and accessories*: The auxiliary parts and accessories enhance the performance efficiency for smooth engine operation

Engine component parts and their function(s)

1. *Piston:* The piston converts rectilinear motion of the piston constrained by the cylinder walls to rotational motion on the crankshaft

2. *Connecting rod:* This connects the piston to the crankshaft.

3. The *crankshaft* transforms the reciprocating motion of the piston into rotary motion. The crankshaft

4. *Piston rings:* Their purpose is to form a gas-tight combustion chamber for all positions of the piston.

5. *The piston pin or wristpin* serves to fasten the piston to the upper end of the connecting rod. It can either be classified as stationery, oscillating or floating.

6. *The cylinder block*: This confines the expanding, gases and forms the combustion chamber. Serve as support for other engine components

7. *The cylinder head:* The cylinder head houses the valves and forms a cover to the cylinder and form the combustion chamber.

8. *The combustion chamber* consists of a cylinder, usually fixed, that is closed at one end and in which a close-fitting *piston* slides. The in-and-out motion of the piston varies the volume of the chamber between the inner face of the piston and the closed end of the cylinder.

9. *The crankcase* serves the purpose of supporting the shaft, mounting the cylinders, housing the running parts, and forming a reservoir for lubricating oil. *The Oil Pan* forms the lower part of the crankcase

10. The *inlet manifold* is attached to the side of the cylinder head or block and serves to conduct air mixture into the cylinders.

11. The *exhaust manifold* attached to the side of the cylinder head or blocks serves to conduct the burned gases away from the engine.

Engine operating systems and auxiliary systems

Engine operating systems include

a. The fuel supply system

b. Lubrication system

c. The valve system

d. Air intake system

e. Cooling system

f. Governing system

Engine auxiliary systems include

a. Ignition systems

b. Exhaust system

c. Turbocharging and intercooling system

Farm tractor

What is an agricultural tractor and their uses?

Agricultural tractors can be said to be

i. A self-powered work vehicle, designed for pulling or pushing special machinery or heavy loads over land.

ii. A vehicle for off-road and on-road operation, being able to carry, guide, pull and drive implements or machines – moving or stationary – and to pull trailers.

iii. Traction machine designed primarily to supply power to agricultural implements and farmstead equipment.

iv. A self-propelled machine that provides a force in the direction of travel to enable attached soil engaging and other agricultural implements to perform their intended standard functions.

Uses of tractor

A tractor is designed for pulling or pushing special machinery or heavy loads over land and are widely used in agriculture, building construction, road construction, and for specialized service in industrial plants, railway freight stations, and docks.

Two broad classification of tractor type and differences

Wheel (pneumatic i.e. tyre) tractors and crawler (chain) tractors.

Differences

Wheel tractors generally have two large rear wheels with pneumatic tyres or ground-gripping metal lugs; they operate much like an automobile with a gearshift drive.

Crawler tractors move on heavy, metal tracks that form a loop around large geared wheels; the wheels drive the metal tracks, and the tracks distribute the weight over a wide area

Types of tractor suitable for agricultural operations

Tractors suitable for farm operations include:

i. **Agricultural tractors:** These are large, heavy-duty tractors suited for commercial farming.

ii. **Utility tractors:** These are smaller, less powerful or both than agricultural tractors, but heavy duty and usually sufficient for private farms and small commercial farming operations.

iii. **Compact tractors:** (some manufacturers refer to these as sub-compact or compact-utility tractors). They are suitable for both on farm and off-farm operations and other specialty activities such as lifting loads and hauling.

Types of tractor drive

There are three types of tractor drives: 2-wheel drives, 4-wheel drives and power tillers

i. The *two-wheel drives* have two of its four wheels controlled by the steering. Examples are common with front wheel drives in which the two front wheels control the forward and reverse movement.

ii. *The four-wheel drive* has a drive shaft that transmits power between the front wheels and the rear wheels. Most old two-wheel drives have manual power transmission; the newly designed two-wheelers are power drive while all the 4-wheel drives are hydraulically driven.

iii. Power tillers: These are two wheeled push-behind or ride on-power tractor designed to power specialized equipment for specific operation

Functional divisions in a tractor and their functions?

Four functional divisions have been identified in tractors; the engine, transmission, differential, and auxiliary/front axle

i. *The engine*: The engine produces the power (known as brake power or output power) that is used by the tractor and this power is delivered to flywheel.

   The components: The engine systems components include; the cooling system, valve system, lubrication system, ignition system, air intake system, exhausts system and other auxiliary system such as turbo charging system that helps improve engine performance.

ii. *The tractor transmission:* The power delivered to the flywheel is transmitted through the transmission systems to the differentials, the final drives, the hydraulic control, the PTO and the drawbar.

   The: The components include the mechanical (friction drives) transmission systems such as: gear systems, belt and pulley, chain and sprocket, hydraulic and hydrostatic systems such as used in steering systems, brake systems and clutch systems.

iii. *The differentials:* The differentials are special features in tractor that provides independent braking systems and field operations maneuverability.

   The components: Component parts include the specially designed final drive wheel and gear systems for the rear of the tractor and also the PTO drive.

Farm machinery

Define farm machinery

Farm machinery refers to the machines used for production, which may or may not be powered by the power units.

Farm operations and functions

Selection of machinery depends on specific operation it is intended. The following farm operations and functions are considered for selecting suitable machinery.

1. *Land clearing*: Vegetation clearing and disposal
2. *Land forming*; Land leveling, land filling, ditching waterways
3. *Tillage*; suitable seed bed preparation and weed control
4. *Planting*; Seed establishment, propagation, fertilizer and chemical application and
5. *Weeding*; Weed control, disease and pest control,
6. *Harvesting*; crop harvest and handling preparatory for processing,
7. *Processing:* conversion of agricultural products into more stable, beneficial and refined forms for market satisfaction and storage purposes
8. *Transportation*; Farm products transport, distribution and marketing.

Machinery involved in farm operations

1. *Land clearing*: cutting blade, stumper, spliters, root rake, MA rake, burner etc.
2. *Tillage*: Ploughs, harrows, cultivators, ridgers etc.
3. *Land forming*: Excavator, ditcher, scraper, land plane
4. *Planting*: seed drills, root crop planters, transplanters
5. *Weeding*: rotary hoes, mowers, sickles,
6. *Harvesting*: combine harvester, fruit harvester, and
7. *Processing:* equipment for milling, size reduction, mixing, chopping, rolling, waxing, washing and packaging
8. *Transportation*: trailers, articulated vehicles, intermediate vehicles ATVs.

Land clearing

Land clearing is the development of land with potential for agricultural use. Land clearing requires the removal of vegetation from the surface of land. This includes the removal of roots and embedded rocks.

Factors affecting extent of land clearing

The extent of land clearing development programme depends on the following factors.

1. *Environmental factor*: land, weather, & vegetation **cov**er

2. Institutional and social factors

3. Cost factor and

4. End users factor

Methods of land clearing

Four methods are popularly identifiable with land clearing;

1. Complete removal of tree and stump by physically uprooting and moving to piles: This method involves *Bulldozing, Tree pushing and Chaining*

2. Cutting vegetation at ground level: cut off at or slightly above ground level tearing the stumps in the ground to decay or for later removal. This method involves *Hand clearing with hand tools such as hoe and cutlass, Power sawing, Sickle mowing, Blade shearing, and Tree shearing*

3. Knocking down and incorporating vegetation into the soil: The vegetation is knocked down by the brute action of the implement and buried under the weight of the moving earth. The operation is primarily a tillage operation involving the use of such implements as mould board plough, disc plough, and harrow or ridger/bedder.

4. Burning of vegetation in situ (in place): This method involves burning fallow vegetation or previous crop residues in order to clear the land or to scare away wild animals or snakes.

Power sources for land clearing

Basically, all land clearing machinery and equipment derived its power from two types of tractors:

Rubber tyre (pneumatic) tractors and Track layers/crawlers

Land clearing attachments

Land clearing attachments or detachable are pieces of equipment designed for specific land clearing operations and powered by field machine. Example of such detachable and attachments include:

1. *Cutting tools e.g. Fleco 'v' blade Rome k/g blades Backhoe*

2. *Brush piling equipment e.g. Buck rake, Brush rake Multi- application (ma) rakes Skeleton rock bucket Angle broom Grapple rake Grapple bucket Rock grapple bucket Stump bucket*

3. *Grubbing equipment e.g. Tree dozer Tree cutter Root cutter Pull-type root cutter Stumpers Stumper with splitter Tree pushers Stinger Juniper bit Rock/root rake Root plough Roller chopper Grapple shears*

4. *Canopies and cab guards*: These are used to ensure the safety of the operators.

Disposal of vegetation

Once the vegetation has been felled, usually it must be disposed off in some manner. The most economic measure must be employed in disposing rubbish. These operations include:

1. Racking:

2. Leaving in place: Leaving vegetation in place to dry and decay

3. Burning in place.

4. Piling the materials for firewood and charcoal

Landform development

Land forming is the process of cutting, movement and distribution of soils evenly on undulating land to obtain level surface. This includes leveling in preparation for agricultural operation.

Landform activities

Land forming activities include, soil movement, leveling, and conservation. Soil movement and leveling in agriculture is primarily limited to earthing-up and spreading in lowland or badly eroded surfaces.

Landform system and equipment

Different systems of land leveling require different field conditions and operating time. The following systems are used in land leveling:

1. *Use of draft animals and 2-wheel tractors using harrows and leveling boards:* These leveling techniques are require total in-field water coverage and require 7 to 8 days for a 2-wheeled tractor and 12 days per ha using draft animals

2. *Use of four-wheel tractor with a laser controlled bucket:* The use of laser controlled equipment results in a much more level field. Accuracy could be improved by up to 50% and the time required halved.

Tillage

Tillage definition

Tillage as an agricultural operation is simply described as the mechanical manipulation of soil to provide a condition suitable to the growth of crops. Tillage is aimed at modifying the state of the soil, mechanically or otherwise, in order to provide conditions favourable to agricultural production.

Functions of tillage

The main functions for tilling the topsoil are:

1. Development of a desirable soil structure for a seedbed by soil loosening
2. To facilitate the placement of surface residues through thorough mixing of trash with soil.
3. To minimize erosion problems and suppress evaporation
4. To improve water infiltration, and reduce evaporative water loss
5. Preparation of a level surface to facilitate other operations such as irrigation
6. To incorporate and mix fertilizer with soil.
7. Control of weeds and animals living in the soil, such as mice or slugs

Tillage practices

Two basic types of tillage have been identified in line with two identifiable agricultural practices and include:

1. *Conventional tillage practice*. This is further sub-classed into;
    a. Traditional tillage practice
    b. Conventional no till or zero tillage practice and
    c. Mechanical tillage practices
2. *Conservation tillage practice*: This is further sub-classed into;
    a. No-tillage system
    b. Minimum tillage
    c. Strip tillage
    d. Ridge tillage and
    e. Mulch tillage

Mechanical tillage practices

Mechanical tillage practices is further divided into primary and secondary tillage practices

Primary tillage:
Primary tillage implement
The implement most often used for primary tillage with tractors falls into one of these categories

1. *Plough implements*: These implements are further classified as
   a. Indigenous plough
   b. Soil turning ploughs such as:
      i. Mouldboard plough
      ii. Disc plough
      iii. Turn-wrest or reversible plough and
      iv. Blade plough

2. *Blade/tine implements*: These are special category of implement classified based on the depth of penetration and width of implement and include
   a. Chisel plough,
   b. Sub-soiler and
   c. Rippers.
3. *Rotary implements*: This category of implement include
   a. Rotary plough or hoe
   b. Power tillers mounted with a rotary cultivator or ploughing body.
4. *Hybrid implements*: This category of implement include
   a. Disc chisel implement
   b. Coulter chisel
   c. Disc ripper
   d. Coulter ripper
   e. Soil conditioner

Secondary tillage

Secondary tillage implies operations involved the preparation of a seedbed after the first initial primary tillage.

Functions of secondary tillage

Further tillage operation is carried out following the primary tillage for some of the following reasons;

1. To further develop a seedbed by pulverizing soil clod

2. To form top soil for better moisture movement

3. To cut up crop residue and mix vegetative matter or other materials into the soil

4. To destroy or control weeds.

Secondary tillage activities

a. Harrowing: This is a secondary tillage operation carried out to pulverize, smoothen and pack the soil in readiness for seed bed preparation and to control weeds.

b. Ridging: Traditionally, all crops are grown on ridges or mounds made by gathering up heaps of soil in continuously long span along a row or varying sizes of round mounds for the purposes of crop planting.

Secondary tillage implement

Secondary tillage implements falls into one of these categories

1. *Drawn implements:* These include such implements as'
   a. Floats chain implement
2. *Plough/disc implements*: These implements are further classified as
   a. Disc harrow
   b. Mouldboard ridger
   c. Disc ridger
   d. Border disc plough
3. *Tine implements*: This category of implement include
   a. Spike tooth harrow
   b. Coiled (spring) tine harrow
   c. Mulcher
   d. Cultivators and tillers
4. *Rotary implements*: This category of implement include
   a. Rotovator,
   b. Spiked rotors and
   c. Rotary spade harrow
   d. Power harrows

Planting

This is simply an act of placing seeds beneath the soil surface to provide a conducive environment for its germination or establishment. The number of plants established in the field relative to number sown is an indication of the final analysis of success of the planting operation.

Methods of planting crops

There are two methods involved in seed planting:

1. *Method of planting on flat surface*: Planting on flat surface implies planting directly after the initial land clearing operations or tilling the soil to obtain level surface without visible ridges being formed. This method of flat surface planting is achieved by the following seed distribution patterns: Broadcasting, and drilling patterns

2. *Method of planting on prepared ridges or beds and heaps*: In this method, distinct ridges or beds or heaps are formed with clear furrows created. Crops are either planted along bed side, on the ridge top or on both depending on the type of cropping system. Examples of ridges or beds planting patterns include; Row planting (precision planting, check row planting and hill drop planting) as well as dibble planting.

Advantages of conventional bed planting over surface planting

Conventional bed planting offers the following advantages over surface planting:

1. Improved weed control,

2. Efficient water management,

3. Better fertilizer management opportunities,
4. Less crop lodging
5. Reduction in tillage,
6. Possible improvement in yields above 10% with the proper variety
7. Possible reduction in production costs by 20 - 30%, and
8. Possible reduction in irrigation water requirements up to 35% compared to conventional planting on flat surface.

Functional requirement for crop planting equipment

Their general functions of *crop planting equipment* include

1. Transport materials meant for planting to the field
2. Open furrow for seed placement below the soil surface
3. Spread material randomly on soil surface or meter material from the seed hopper through a channel to the opened furrow
4. Place material appropriately in furrow
5. Cover material
6. Consolidate soil
7. Transport, meter, place and cover fertilizer
8. Transport, meter and place pest control chemicals
9. Remove unwanted seedlings
10. Supply missing seedlings

Crop planting implements on flat surface

The range of such equipment used in flat surface planting operations includes;

1. Hand held dibbers
2. Hand jab planters,
3. Animal-drawn planters,
4. Seeders and grain drills
5. Power tillers and

6. Planters for limited-powered tractors.

Crop planting implements

Examples of crop planters on ridge surface include

1. Root crop planter and

2. Stem planter

Seedling transplanting operation

The term transplanting is a method of establishing crops, for instance, paddy rice, sugar cane and cabbage etc. on specially prepared beds under a transparent cover in nursery/garden beds or in greenhouses

Methods of transplantation

Transplant operation is performed either manually (traditional or improved manual parachute technology) or mechanically.

Post planting operations

Every other farm related activities carried out after crop planting and preceding crop harvest is regarded as post planting operation. Post planting operations therefore include crop thinning, crop protection (pest and disease controls and management), and fertilizer application among others.

Thinning

Thinning is the term used for removal of excess or weak plants trees or some tree vines from a stand to give others more room (and resources) to grow and as a tool for improving timber value, making sites more productive, and – perhaps most commonly, for keeping trees healthy.

Types of mechanical thinners

1. *Down the row rotary thinner:*

2. *Oscillatory thinner*

3. *Flaming thinner:*

4. *Intelligent thinning using machine*

5. Row crop thinner (RCT)

6. *In-row thinner cultivator*

Crop protection

In agricultural production a pest is known to be anything that impedes or competes with the desired crop growth and yield. Pest may be other plants (weeds), insects, fungi or diseases. Crop protection is therefore the means of controlling these pests by some techniques such as chemical means, non-chemical treatments, or a combination of measures sometimes known as Integrated Pest Management (IPM).

Pest/weed control

In agricultural production a pest is anything that impedes or competes with the desired crop. The pest may be other plants (weeds), insects, fungi or diseases. Control of these pests is accomplished by chemical means, non-chemical treatments, or a combination of measures sometimes known as Integrated Pest Management (IPM). IPM strives for pest control using biological, chemical and physical (mechanical) means that are effective, economical and environmentally friendly.

Benefits of weed control programme

a. Weed control programme helps reduce competition between plant and weeds

b. It help reduce plant overcrowding and make more light available to crops for better performance

c. It help improves crop yield by reducing nutrient competition among weeds and crop plant

d. It eliminates some pests and help eradicate diseases that could use weeds as host

e. It reduces pathogenic effect on planted crops

Weed control practices

The various weed control or eradication practices in use today may be grouped into three general categories namely:

1. *Weed prevention measure*: - These are measures taken to prevent the introduction and or establishment of specified weed species in areas that are not currently infected with these species.

2. *Weed eradication*: This infers that a given weed species, its seed and vegetative part has been killed or completely removed from a given area and that the weed will not reappear unless re-introduced to the area.

3. *Weed control measure*: This encompasses those practices whereby weed infestation are reduced but not necessarily eliminated.

Chemical weed control

Chemical weed control functions on the basis that certain chemicals are capable of killing weed without significant injury to other plants (crops). Such chemicals could be selective or non-selective,

Chemicals are classified as either *contact* or *systemic*. Chemicals that control pests/weeds by contact must come in direct contact with the pest/weeds they are to control. Systemic chemicals are absorbed into the plant by roots and leaves, and cause interference with the ongoing growth process of the plant. Chemicals are applied to soil and crops in the form of granules, dust, or liquid sprays.

Types of chemicals, methods of application and equipment

Agricultural chemicals can generally be classified into two namely; dry chemicals and liquid chemicals.

Dry chemicals

Dry chemicals in the form of granules can be applied to the soil by spreaders while those in powdered form are applied as dust application. To apply the wettable powder,

1. Take the recommended amount of a given insecticide & add a little water to make it into a paste.

2. Add the required quantity of water slowly, simultaneously stir the liquid to make the spray solution

Dusters and agricultural aircrafts have been used extensively for the distribution of dry or powdery chemicals to large areas of land.

Liquid chemicals

Liquid chemicals are normally mixed with diluents such as water or diesel fuel and are applied as a spray or mist. Some chemical can be stored as liquid vapour e.g. anhydrous ammonia. Liquid chemical application can be applied direct to crop field by spraying at uniform rate and pattern or it can be injected into irrigation water by a process known as **chemigation**.

Common equipment for direct field application of liquid chemical is the sprayer.

Sprayers fall into three major categories:

1. *Low pressure sprayers*: These operate at pressure of 138 to 345kpa. They are relatively inexpensive and are used to control insect and plant diseases. Used for both pre-emergence and post emergence weed control, insect and fertilizer application.

2. *High-pressure sprayers*: There operates at pressures above 689kpa. The high pressure provides a driving force to penetrate more into the foliage of trees, the thick furs of animals and the crevices of building.

3. *Recirculating sprayers* (RCS): This is a very recent discovery in the category of low-pressure sprayers known as RCS. They are designed for specific purposes of applying contact herbicide in such a manner that unused spray is collected and returned to the supply tank thus avoiding waste.

These categories give rise to the following types of sprayers and sprayer applications

Categories	Types of sprayers	Examples
Low pressure sprayers	Hand held mist applicators	Small hydraulic applicator, Flit gun, Battery / ULV sprayer, Manual hand sprayers
High-pressure sprayers	Backpack sprayers	knapsack sprayers, motorized sprayers, Motorized mist blower sprayers, Hydraulic handgun sprayers, Airblast sprayers, Boom sprayers
Recirculating sprayers (RCS)	Low pressure sprayers	

Methods of liquid chemical application

1. Direct application though spraying equipment (as discussed above)

2. Indirect application though irrigation water (Chemigation)

Chemigation

Chemigation is the process of applying pesticides or agrichemicals through irrigation water by injecting the chemical into the irrigation water. Depending on the type of agricultural chemical being applied, chemigation may be referred to as fertigation, herbigation, insectigation, fungigation, etc.

How to spray emulsion

1. Calculate required quantity of chemical concentrate & water to obtain recommended strength.

2. Add little water to the emulsion poured into a container & mix well.

3. Add measured quantity of water slowly, simultaneously stirring the liquid till all the water is added.

Precautions for handling & mixing of pesticides and herbicides

1. Read the label & leaflet carefully & follow the instructions

2. Select the required equipment along with protective clothing & other safety devices

3. While opening the container do not spill contents on to body. Care should be taken to use safety gloves

4. Mix chemicals in open ventilated areas

5. Use a wooden stick for mixing the chemical. Never use the hand for stirring

6. Always stand with wind on your back while mixing & filling pesticides

7. Never allow children to handle or mix pesticides

8. Never eat, drink or rub your eyes or face while working with pesticides

9. Clean up spills immediately. If body is accidentally contaminated, wash immediately with plenty of water & change clothes if required

Spraying

1. Check up the sprayer to be used for any defects & proper working

2. Pour spray material in the sprayer tank using a funnel to strain the solution. Do not spill it.

3. Build up pressure in the tank by about 18-20 kg /645 m2

4. Start spraying in the direction of the wind at right angles to it

5. Keep the nozzle about 15 cm above the crop to be sprayed

6. Cover the leaf surface & other parts of the plant evenly & also on under surface of
leaf.

Precautions to be taken while spraying

1. Wear personal protective clothing & other aids like mask, gloves etc. While spraying

2. Ensure that no animals or persons are there in downward wind direction

3. Apply pesticides only when needed. Do not drag the sprayer on roads, pathways etc.

4. Do not blow out blocked nozzles with the mouth

5. Apply at correct stage for efficacy, to avoid residues in harvested produce

6. Never spray against the wind

7. Apply the correct dosage to avoid wastage & phytotoxicity

8. Exercise care not to contaminate any nearby ponds, streams and tanks

9. Do not eat, smoke or chew tobacco while spraying

10. Never leave used spray, equipment unattended

11. Wash the equipment, measuring cups, containers to avoid accidental poisoning

12. Take bath with plenty of clean water & soap

13. Wash contaminated clothes separately

14. Never empty unused spray solution into irrigation canals, ponds, wells etc.

When to spray?

1. To obtain best results, proper chemical in recommended concentration must be sprayed at right time

2. Do not spray or dust when there is too much of wind. Do not spray/dust during hottest part of day

3. Observe the stage of the pest. For externally feeding insects, borers, it is larval stage. For

4. Stage for control is when activity of moths is observed & when they begin to lay their eggs on the underside of leaf.

5. Use an insecticide of a long residual action before eggs hatch or larvae bore into stem, flower buds or fruits.

6. Do not spray or dust when the crop is nearing harvest. All spraying & dusting should cease a fortnight before harvest.

Do not flush the plants with spray fluid as if a bath is given. Pesticides do not stick on leaf surface but falls down on the soil. Apply spray in such a way that fluid falling on leaf resemble minute dew drops. This can be achieved by controlling trigger. Cover both sides of the leaves.

Non chemical treatment

These are other measures taken to control pests and weed other than application of chemical substance. Basically, non-chemical weed control measures include

a. *Mechanical weeding*: This involves *Burying weeds completely, Cutting weeds at ground level or Uprooting weeds*

b. *Biological*: This involves the introduction of beneficial organisms or plants that has potential to compete favorably with existing weed in a field. Such methods include the use of parasite, predators and pathogens. A bio-herbicide, a virus, bacterium, fungus, insect, or other organism that can weaken or kill weeds carries out biological control of weeds.

c. *Thermal weed control*: Thermal weed control involves the use of mild heat from heating sources to make weed cells inactive. Common example of this process include flaming, infra-red weeding and steaming.

d. *Pneumatic weeding*,

Fertilizer application

Methods of fertilizer applications

The following methods are in common use in fertilizer application to the field:

1. Broadcasting and mixing into the soil before or after ploughing
2. Broadcasting by placing at ploughing depth
3. Deep placement into the soil with chisel type cultivator
4. Direct placement or application during planting operation
5. Side dressing application on growing row crop during cultivation period
6. Top dressing application on planted crops
7. Drilling into established pastures and other sobs with special equipment.

Fertilizer application techniques

Application techniques for fertilizer distribution include

i. Injection techniques for dry and

ii. Injection techniques liquid fertilizers.

Dry fertilizer application equipment

The most common application equipment for distributing dry mineral fertilizer by direct injection of granule fertilizer is through a spreader or distributor.

Fertilizer distributors/spreaders

Fertilizer spreaders can be subdivided into two major types: variable width and fixed working width spreaders.

Examples of variable width spreaders:

Spinning disc spreader: A spinning disc spreader consists of one or more vanes mounted on the rotating disc which scattered the grains as it drops on it.

Oscillating spout spreaders: The oscillating spout spreader has an oscillating spout to distribute the fertilizer. The fertilizer flows, with the aid of an agitator, from the hopper into the spout.

Examples of fixed working width spreaders

Boom spreaders: Boom spreaders are tractor mounted equipped with booms for wide area coverage with mechanical lateral distribution.

Worm-auger spreaders: The fertilizer is delivered from the hopper by scraper floor chains, rubber auger belts or honeycomb floor belt chains to the spreading auger booms.

Venturi spreaders: This consists of an air entry section, a throat and material entry gate, a vane expansion and re-direction section.

Star-wheel and rotating bottom spreaders: It is a feed mechanism which consists of a toothed wheel, rotating in a horizontal plane and conveying the fertilizer through a feed gate below the star wheel.

Aerial spreaders: In some crops and under certain conditions, for example, rice, dry fertilizers and other chemicals are spread with aircraft.

Liquid fertilizer application

Liquid fertilizer application technique includes various ways of supplying dissolved fertilizer to crop field. Both organic and anhydrous fertilizer can be applied by this process by dissolving it in water to form slurry and directly applied to the field or to be dissolved and injected into irrigation water by a process known as fertigation.
Typical equipment for liquid fertilize application include;
Tank trailers also known as slurry tankers, are used to haul dissolved organic wastes from animals, plants or sewerage and other organic liquids for direct application into the field before or after cultivation.
Equipment for the i*njection of dissolved fertilizer through irrigation water (fertigation)*

Crop Harvesting

Harvesting simply mean the removal of an entire economic product, or its economic parts such as be grain, seed, leaf, root or the entire plant, after maturity from the field.

Methods of crop Harvest

Two method are generally employed in crop harvest; manual and mechanical harvest

Manual harvesting practices

Manual harvesting practices involves careful picking of matured products with hand or picking aid.

Manual picking tools

Majority of crops harvested by hands are done using sickles, cutlass, secateurs, clippers, knives or diggers. Some fruits such as citrus, grapes and mangoes, need to be clipped or cut from the plant.

Advantages and disadvantages of manual harvesting

The primary advantages manual harvesting includes:

a. Harvesting of fruit or vegetable can be done at appropriate maturity.

b. The produce will suffer minimum damage.

Disadvantages of manual harvesting

a. It is a time consuming process.

b. More labour is required during harvesting season.

Mechanical harvest

Various mechanical means have been developed for harvesting of crops. Common among them are tree shaking, mechanical aids and mechanical harvesters.

Mechanical harvest machines

Combine harvester machines are specially designed for harvesting, processing, conveying (transporting) and delivery for storage of grain crops such as rice, corn, millet, etc. when picking with hand, harvesters should grasp the product firmly but gently and pull upward Gentle digging, picking and handling will help reduce crop losses.

Crop processing

Crop processing is an agricultural technological operation that agricultural materials are subjected to in attempt to improve their quality for direct consumption or for further processes. A wide range of processes, machinery and equipment are required in this processes, some of which include;

Crop drying process: Drying is the reduction of moisture content to a given final value at which the material can be stored.

Drying systems

Selection systems for drying grains range from thin layer drying in the sun or a simple maize crib to expensive mechanized systems such as continuous flow driers. The choice is governed by a number of factors including: rate of harvest, total volume to be dried, storage system, cost, and flexibility. Drying systems falls into three principal groups: *natural drying, artificial drying and solar drying.*

Cooling of agricultural materials: The methods adapted to cool grain after drying are dependent on the drying system used. Sun-dried grain can reach high temperatures while in the direct sunlight. If it is to be stored in any container through which air cannot freely pass, it should at least be left shaded for an hour or more before storing. Failure to cool grain that has just been dried with heat may cause an increase in moisture content great enough to seriously shorten its storage life.

Densification of agricultural materials

Densification is the use of mechanical pressure to reduce the volume of agricultural matter and the conversion of this material to a solid form, which is easier to handle and store than the original material. Densification of agricultural residues may be used as fuel for the generation of energy. Four methods of achieving densification using commercial machines include: baling, cubing, pelleting, and briquetting.

Cutting of agricultural materials

Cutting is used frequently during harvesting of agricultural material, separation and subsequent comminution of plant components. Cutting is also the main operation in fodder preparation. During cutting, a cutting edge (knife) penetrates into the material, overcoming its strength and cutting thereby separating it. Four basic methods of cutting employed in agricultural operations as identified include:

1. *Counter moving blades*: Two sets of blades participate in this cutting (Figure 5-22). The knives move in opposite direction with the material in-between the moving blades.

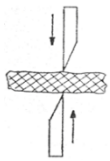
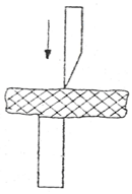
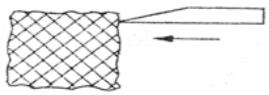


Figure 5-22: Counter moving blades

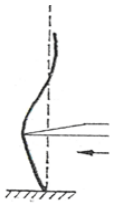
2. *Cutting by means of a resting and moving blade*: The resting blade supports the material while the moving blade slices the material against the stationary blade (see figure).



3. *Cutting of thin layers:* The stress distribution around the cutting blade (edge) is significantly distorted by the free surface found close to the cutting plane (see figure). The material may be fixed rigid e.g. beet cutting.



4. *Free cutting*: One end of a relatively long stalk is fixed and counter support is ensured by the moment of inertia of the stalk (see figure). The velocity of cutting edge is high; 20-40m/s.



Size reduction of agricultural materials

Size reduction of agricultural materials the breaking down of such materials into smaller and handlable sizes. Particle size reduction increases the surface area of agricultural materials like grains, thus allowing for greater interaction with digestive enzymes. It also improves the ease of handling and mixing characteristics

Size reduction methods

There are four main size reduction methods identified and is in common use: impacting, grinding, crushing and sawing Impacting is suitable for hard and brittle raw materials, such as maize feed; sawing is better for large and fragile feed; and crushing and grinding are used for tough feeds.

Mixing of agricultural materials

Mixing involves the putting together of two or more substances so that the particles of each are diffused among those of the others. It is one of the processes involved in feed preparation and must be attended to with care because improper mixing of feed ingredients result in unbalanced rations that undernourished livestock.

The objective of the mixing process is to produce feed in which nutrients and medication are uniformly distributed. Well mixed feed enhances animal performance

Transportation of agricultural materials

Transportation of agricultural materials is simply the conveyance of man to and fro the farm and farm products/ materials to processing centers. Farm transportation is thus the movement of agricultural products and other related materials such as machinery, inputs etc. from the farm to the markets or from the source to the farm.

Categorization of farm transport

There are two categories of farm transports viz:

On-farm transport: These are equipment for moving goods between field, store and household. On small farms this will include collection of wood and water for domestic purposes.

Off-farm transport: For the movement of goods between farm market. Loads are generally greater, distance longer.

Farm vehicles

The physical characteristics of the material to be handled must be known before the appropriate conveying system can be selected. In particular, the following properties are relevant for agricultural products: moisture content, average weight per unit volume, angle of repose, and particle size

There exist a wide range of low cost vehicles for moving, farm goods, which can be categorized as follows.

1. *Single equipment*: These are single unit carrying aids for agricultural materials such as:

- *Carrying aids for head*, shoulder, or back loading e.g. baskets, bags, sacks etc.
- *Wheel barrows and hand carts* Lifting inputs around the farm can really be burdensome without carrying aids such as wheelbarrows or carts. Wheelbarrows and carts are indispensable farm tools. Distribution of plants, soil and compost around the farm may be cumbersome without the help of such aids. The size of your cart will depend on the size of your farm.

- *Pedal driven vehicles* such as bicycles. Compared to other forms of transportation, the conventional bicycle is among the most efficient means of human locomotion.

- *Back of animals* such as ox, donkey, horse, cow etc as well as animal drawn carts.

2. *Intermediate equipment*: These are low power assisted transport equipment driven by human or animal assistance that attempts to merge the health and environmental benefits of a bicycle with the convenience of a motorized vehicle such as:

    - *Motorcycles and converted motorcycles*: These developed more power than the human locomotive bicycles. For instance, to travel one kilometer by bike requires approximately 5-15 watt-hours (w-h) of energy, while the same distance requires 15-20 w-h by foot, 30-40 w-h by train, and over 400 w-h in a singly occupied car (Justin, 2004).

    - Trailers for bicycles and motorcycles

    - Tricycles

3 *Advanced equipment*

- Basic motorized vehicles

- Dual-purpose agricultural transport equipment.

All these vehicles have different advantages and disadvantages in terms of load bearing capacity, suitability for route conditions, running costs, speed range and capital cost which enable them to

meet a broad spectrum of transport requirements. Many low cost forms of transport are used only in certain local areas and remain unknown even in other areas.

Trailers

Trailers are farm transport equipment powered by either a tractor or any other farm vehicles. Trailers are either open back or enclosed compartment meant to keep farm products under controlled atmosphere storage condition. Trailers are either single axle or doubled and are pulled by row crop or power tillers (Figure 9-40). The large trailers pulled by semi tractors have their own rear suspension and wheels, the front of the trailer being supported by the fifth wheel on the tractor.

Trucks

Trucks play an important role in many farm operations. They are a prime form of transportation. They are also used to transport a large variety of materials and livestock. Trucks may be used outside regular working hours when required in critical farm operations such as harvesting a crop or tending livestock.

Aircrafts

Fixed wing aircrafts are used to apply seed, fertilizer and pesticides to some commodities. Ensure that application by aircraft are specifically listed on pesticide labels and check with the local office of the Ministry of Water, Land and Air Protection for any further restrictions before application.