CROP SCIENCE REVIEW MANUAL

CROP SCIENCE REVIEW DASHBOARD								
	Main Topic	**#**	Subtopic	**Days left**	**Schedule**	**URC Lecture**	**Review Manual**	**Status (Done, ongoing)**
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CROP SCIENCE

1 BASICS OF AGRICULTURE AND CROP SCIENCE

Agriculture – the science and art of cultivating useful plants and raising livestock to meet human needs. It is concerned with plant and animal production for food and fiber, the provision for agricultural supplies and services and the processing, marketing, and distribution of agricultural products.

WORLD POPULATION AND LAND UTILIZATION

2019 world population	----------	7.7 Billion
World's total land area	----------	150M km^{2-}
Arable land	----------	10% of the total area
Permanent crops	----------	1%
Meadows and pastures	----------	24%
Forest and woodland	----------	31%
No vegetation such as urban area, Antarctica, deserts, mines	----------	34%

PHILIPPINE POPULATION, FOOD SUPPLY AND AGRICULTURE

- 2019 Philippine population – 108.61M
- Agricultural land – about 32% of the total land area
- In 2008, agriculture accounted for 18% of the gross domestic product (GDP)

The increase in food supply is about 2% per year, just enough to keep up with population increase. About 20% of this increase is due to the expansion of new production areas; 80% is due to technological advances in production like improved irrigation, crop protection, better cultivars, improved crop nutrition, post-harvest handling, etc.

PHILIPPINE AGRICULTURE

Agriculture and Fisheries Modernization Act (AFMA) or Republic Act 8435, mandated the modernization of the country's agriculture sector, signed into law in 1997

THE CONCEPT OF CROP SCIENCE

Crop Science is concerned with the observation and classification of knowledge concerning **economically cultivated crops** and the establishment of verifiable principles regarding their growth, development, and reproduction to derive optimum benefit from them.

Divided into the following areas:

- **Agronomy** – principles and practices of managing field crops and soils
- **Horticulture** – gardens and plants within an enclosure, which includes
  a. **Olericulture** (vegetables)
  b. **Pomology** (fruits)
  c. **Floriculture** (flowers)
  d. **Nursery management**
  e. **Landscape gardening**

CROP PRODUCTION AS A SCIENCE, ART, AND BUSINESS

- It is a **science** is based on the basic sciences of chemistry, mathematics, physics, and breeding and genetics.
- It is an **art** requires skills to produce crops even with little or no scientific training.
- It is a **business** because plants are grown not simply to satisfy the needs of man but to realize some profit.

Agricultural research in the Philippines is carried out in schools and research centers in both private and public sectors. These are:

A. State colleges and universities offering degree programs in agriculture and related fields
B. Department of Agriculture research networks
C. National commodity research centers

Philippine Rice Research Institute (**PhilRice**)
National Tobacco Administration (**NTA**)
Fiber Industry Development Authority (**FIDA**)
Philippine Coconut Authority (**PCA**)
Sugar Regulatory Administration (**SRA**)
Philippine Root Crops Research and Training Center (**PRCRTC**)
National Abaca Research Center (**NARC**)
Northern Philippines Root Crops Research and Training Center (**NPRCRTC**)

D. Specialized discipline-oriented research centers

Institute of Plant Breeding (**IPB**)
National Crop Protection Center (**NCPC**)
National Plant Genetic Resource Laboratory (**NPGRL**)
National Institute of Molecular Biology and Biotechnology (**BIOTECH)**
Postharvest Horticulture Training and Research Center (**PHTRC**)

E. Private seed companies
- Syngenta
- East West
- Pioneer
- Monsanto
- Allied Botanicals

The following are major international research organizations mandated to do research and development in crop species important to food and agriculture:

International Rice Research Institute, Philippines (**IRRI**)
International Center for Semi-Arid Tropics, India (**ICRISAT**)
Centro Internacional de Mejoramiente de Maize y Trigo, Mexico (**CIMMYT**)
International Institute for Tropical Agriculture, Nigeria (**IITA**)
Centro Internacional de Patatas, Peru (**CIP**)
Centro de International de Agricultural Tropical, Colombia (**CIAT)**
International Center for Agricultural Research for Dry Areas, Syria (**ICARDA**)
International Center for Research on Agroforestry, Kenya (**ICRAF**)
Asian Vegetable Research and Development Center, Taiwan (**AVRDC**)
Biodiversity International – for International Plant Genetic Resources Institute, Italy

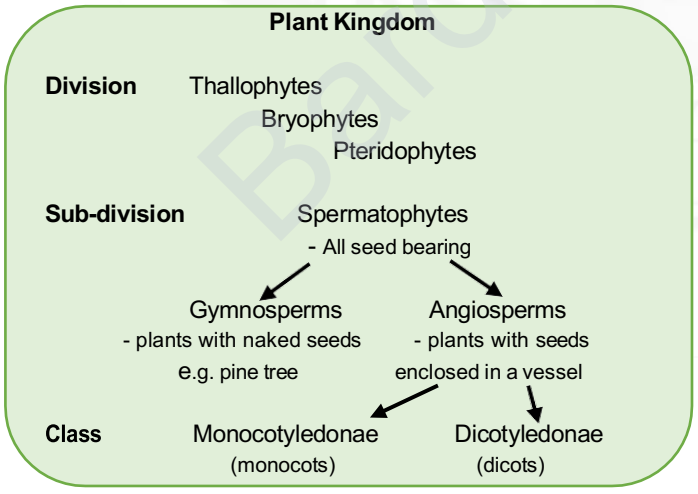
2 CLASSIFICATION OF CROPS

WHY CLASSIFY CROPS?

- For order and organization because agricultural crops are diverse in nature
- For logical naming. The use of common name is not adequate because it varies from one locality to another, whereas the scientific name is constant worldwide.

Systems of Classification

BOTANICAL CLASSIFICATION SYSTEM



Classification	
Scientific name	*Zea mays*
Kingdom	Plantae
Division	Spermatophyte
Sub-division	Angiospermae
Class	Monocotyledonae
Order	Graminales
Family	Graminae
Genus	Zea
Species	mays

Artificial system – based on convenience in which a structure or feature serves as a basis of grouping
Natural system – uses the most prominent and most peculiar morphological structure of the plant with the intention of grouping together those that are most familiar in a number of structures
Phylogenetic system – classifies plants according to their evolutionary status

GENERAL CLASSIFICATION OF CROPS

ACCORDING TO GROWTH HABIT

- **Herbs** – succulent plants with soft but self-supporting stems
- **Vines** – succulent or woody plants without self-supporting stems
- **Shrubs** – with no trunk and may have several main branches; rarely grows higher than five meters
- **Trees** – with single central stem to which branches are attached, usually taller than shrub

ACCORDING TO LIFE CYCLE

- **Annuals** – complete their cycle in 1 year or less e.g. squash
- **Biennials** – require 2 years or at least part of 2 growing seasons and a dormant period between growth stages to complete their life cycle e.g. carrot, cabbage, celery
- **Perennials** – do not die after flowering but live from year to year e.g. asparagus

ACCORDING TO MODE OF REPRODUCTION

- **Sexual** – develops after undergoing meiosis and fertilization in the flower to produce a viable embryo in the seed
- **Asexual** – produced by any vegetative means not involving meiosis and fertilization

BASED ON TEMPERATURE TOLERANCE

- **Tropical –** grown in the tropics and could not withstand chilling
- **Subtropical or semi-temperate crops –** can withstand slight chilling and relatively high temperature
- **Temperate –** can withstand chilling or low temperature

BASED ON PHOTOPERIODIC RESPONSE

- **Long-day –** requires about 14 or more hours for the formation of inflorescence; remain in vegetative stage if daylight is shorter
- **Short-day** – requires less than 14 hours to initiate flowering

SPECIAL TYPES

- **Parasites** – parasitic, sucking roots
- **Epiphytes** – grow upon other plants (orchids) but not parasitic
- **Saprophytes** – grow in places rich in decaying organic substances

BASED ON PURPOSE

1. **Cereals/Grain crops** – grown for their grains
   e.g. rice, corn, wheat, sorghum
2. **Legumes** – grown for pods and seeds
   e.g. cowpea, mungbean, sitao, peanut
3. **Root crops** – grown for enlarged roots/tuberous roots
   e.g. cassava, ube, arrow root
4. **Fiber crops** – grown for their fibers used in textile, cordage, twines, sacks, bags, etc.
   e.g. cotton, ramie, kenaf, jute
5. **Oil crops** – grown for their oil content
   e.g. soybean, peanut, sunflower, castor, coconut
6. **Sugar crops** – grown for their sugar content
   e.g. sugarcane, sugar beet
7. **Pasture/Forage crops** – used for roughage source for animals
   e.g. Para grass, napier grass, ipil-ipil, *Stylosanthes*
8. **Beverage crops** – used for brewing non-alcoholic drinks
   e.g. coffee, cacao, tea
9. **Spices, condiments, essences** – used to provide special flavor, scent, and color to food, perfumes, soaps, and body dressing
   e.g. black pepper, vanilla, citronella, ilang-ilang, annatto
10. **Latex and resins** – used for extracting sap from the trunk/stem
    e.g. rubber, chico, pili, rimas, papaya
11. **Medicinal and poison crops** – with curative, laxative and pesticidal properties
    e.g. lagundi, sambong, tobacco
12. **Vegetables** – usually eaten with staple crops and further classified based on similarities in the method of culture
    A. **Root** – radish, carrot
    B. **Leafy** – spinach, lettuce
    C. **Stem** – celery, asparagus
    D. **Flowers** – squash, katuray
    E. **Fruit** – okra, tomato, eggplant
13. **Fruits** – edible botanical fruits used for dessert and may be eaten raw, cooked or in processed form e.g. pineapple, cashew, mango
14. **Ornamentals** – cultivated mainly for aesthetic value, further classified according to special uses
    A. **Cutflowers** – grown for their flowers
       e.g. roses, orchids
    B. **Flowering pot plants** – grown in containers for their flowers, usually for display
       e.g. poinsettia
    C. **Landscape plants** – for landscaping purposes
       e.g. blue palm, white grass, song of India
    D. **Foliage plants** – for attractive foliage, grown indoor or outdoor for decoration
       e.g. begonia, philondendron

E. **Cut-foliage** – foliage used to provide background in floral arrangement
e.g. ferns, fortune plant, palmera
F. **Turf** – used in lawns or greens
e.g. bermuda grass, carabao grass, blue grass

SPECIAL GROUPS

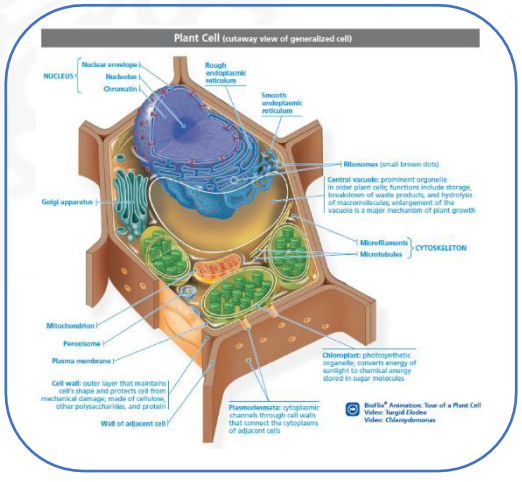
1. **Green manure** – crop plowed under while still green and growing to improve the soil
e.g. sesbania
2. **Companion crop** – crop sown with another crop and harvested separately. The combination benefits either or both crops
e.g. Ipil-ipil planted with black pepper
3. **Cover crop** – any crop grown to provide soil cover, prevent soil erosion by wind or water, improve soil and control weeds
e.g. centrosema
4. **Catch crop** – short season crop grown immediately after the failure of the main crop to utilize residual resources e.g. rice as the main crop may have been destroyed by typhoon therefore pechay or mustard is planted immediately
5. **Trap crop** – crop planted to protect the main crop from pests by attracting the pest and later destroying it
e.g. main crop is rice and sweet potato is planted to trap some rats
6. **Soilage** – grass grown, cut and directly fed to animals
7. **Silage** – grass grown, cut, fermented and preserved before being fed to animals

3 NATURE AND COMPOSITION OF PLANTS

PLANT CELLS, PARTS, AND FUNCTIONS

Cell - The smallest structure in the universe capable of growth and reproduction. It is the basic unit of every living organism.

- an autonomous living system capable of independent existence and propagation
- the fundamental morphological unit of plant body



DIFFERENCES BETWEEN PLANT AND ANIMAL CELLS

- Plant cells contain chloroplast(s) that carry out photosynthesis
- Plant cell is surrounded by a rigid cell wall. The walled cell and its adjacent wall are cemented together by middle lamella.
- Plant cells develop a large central vacuole
- Animal cells contain centriole and lysosomes that are involved in cell division and digestion, respectively. Embryonic cell can migrate from one location to another.

STRUCTURE	ANIMAL CELL	PLANT CELL
Cell Wall	Absent	Present
Chloroplast	Absent	Present
Vacuole	Absent	Present
Lysosome	Present	Absent
Centriole	Present	Absent

Three main components of plant cell: **Cell wall**, **Cytoplasm,** and **Nucleus**

CELL WALL

- Provides mechanical protection and rigidity to the plant cell
- Consists of cellulose that overcomes pressure due to its elastic property
- Composed of cellulose, hemicellulose, pectic substances, organic and inorganic substances, lignin, enzymes, protein and water

Three layers of cell wall:

- **Middle lamella** – where pectin cements adjacent cells together
- **Primary wall** – thin, not rigid, stretched as the cell grows; layer formed before and during growth of the plant cell; consists of cellulose microfibril; has primary pit fields, thin areas that are transversed by numerous protoplasmic strands called plasmodesmata
- **Secondary wall** – rigid, thick, formed after cell completes growth

CYTOPLASM

- All living matter of the cell apart from the nucleus
- Gel-like material or fluid which suspends the ce=-ll's organelles and internal membrane system
  Distributes substances absorbed from outside and released by the nucleus and other organelles (through cytoplasmic streaming/cyclosis – flowing movement of cytoplasm)

Cytoplasm consists of the following:

Plasmalemma/Plasma membrane – has selective permeability and with the following functions:

- allows some substances to cross easily and completely block others
- accumulates the ions or the molecules in the cytosol through the action of transport proteins that consume metabolic energy
- coordinates the formation of cell wall microfibrils

Endoplasmic Reticulum – flattened disks or tubular sacs, with the following types:

- rough endoplasmic reticulum (with numerous ribosomes)
- smooth endoplasmic reticulum (lack ribosomes)

Functions:

- **Rough ER** – involved in the synthesis of lipid
- **Smooth ER** – involved in the synthesis of membrane proteins and secretory proteins

Golgi Apparatus – collective term for all dictyosomes (consists of stack of flattened hollow disks called cisternae) or golgi bodies, with the following functions:

- involved in the synthesis of polysaccharides and glucose units for cell wall formation
- secretes protein and carbohydrates from the cell to the exterior part (ex. nectar coming out from the flower)

Mitochondria – small cylindrical organelles enclosed by two unit membranes:

- **Outer membrane** – permeable to smaller particles; contains the respiratory chain component and enzymes for ATP synthesis
- **Inner membrane** – impermeable and folded into numerous cristae, and the site of respiration (energy source for plant's body maintenance, growth, and development)

Plastids – differentiated into system of membrane (2 units) and ground substance, the stroma and with the following types:

a. **Chloroplast**
   - site of photosynthesis
   - involved in amino and fatty acid syntheses
   - provides space for temporary starch storage

b. **Chromoplast**
   - responsible for the yellow, orange or red colors of many flowers and other plant part attracts insects and other animals

c. **Leucoplast** – nonpigmented plastids but once exposed to light, may develop into chloroplasts
   - Amyloplast – starch
   - Proteinplast – proteins
   - Elaeioplast – fats and oils

Microbodies – spherical organelles bounded only by one membrane, about 0.5 to 1.5 mm in diameter and with the following functions:

- Peroxisomes (terms to some microbodies) with an important role in glycolytic acid metabolism associated with photorespiration
- Lyoxysomes (other microbodies) contain enzymes needed for the conversion of fats into carbohydrates during germination in many seeds

Cytoskeleton – an organized cytosol into a three-dimensional network of fibrous protein

Types:

Microtubules – long, thin, cylindrical structures about 24 mm in diameter and of varying lengths; each is made up of subunits of the protein called tubulin

Functions:

- involved in the orderly growth of the cell wall, especially the control of cellulose microfibril alignment
- formation of cell plate (the initial partition of dividing cell)
- involved in the movement of flagella and celia of which microtubules are important components

Microfilaments – consist of two actin chains (similar to that of muscle tissue) that maintain in a helical fashion and play a causative role in cytoplasmic streaming

Ribosomes – small particles about 17-23 nm in diameter containing an equal polyribosome or polysomes

Vacuoles – enclosed by a unit membrane called tonoplast. They are the dumping house of the cell, and contain water and other substances.

Functions:

- Absorb toxic products
- Store various metabolites
- Break down macromolecules and recycle their components within the cell

NUCLEUS

Contains the genetic information indispensable for the cell's life and metabolic function. Its functions are:

- Controls the activities of the cell by determining which protein molecules are produced and when they are produced
- Stores the genetic information

Anatomical Regions of a Plant Body

- The plant body has three organs: leaf for photosynthesis; stem for support; and root for anchorage and absorption of water and minerals
- Flowering plants (angiosperm – 250,000 species) cover almost the earth's vegetation
- The seed contains embryo and cotyledon (endosperm) protected with a seed coat
- The seed grows under favorable condition (moisture, temperature, oxygen and sometimes light)
- From the embryo, the root and shoot develop
- The seedling grows due to cell division in the meristematic tissues
- After juvenile stage, plant produces flowers and fruits (after pollination and fertilization)
- Fruits contain seeds, thus completing the life cycle of the plant

Tissue

- composed of cells usually similar in structure and function
- simple if it contains one cell type
- more complex if it is made up of several types of cell

Organ

- composed of several tissues with distinct structures and functions

System

- composed of interacting organs that coordinate as a functional complex in the life of the organ

PLANT TISSUES AND TISSUE SYSTEM

Meristematic tissue – where cell division (mitosis) occurs

- **Apical meristem** – tip of stem and roots (shoot or root apical meristem); gives rise to primary meristem
- **Lateral meristem** – stem and roots
  - Vascular cambium
  - Phellogen (cork cambium)
- **Intercallary meristem** – internodes and bases of young leaves

Permanent tissue – derived from meristems that have attained maturity form, thus perform specific function or functions

- **Epidermis**
  - Outer covering of plant body
  - Modified to form stomata and hairs
    - Stomata
      - openings in the epidermis mainly on lower leaf surface
      - regulate gas exchange
    - Hairs
      - protection
      - absorption
      - excretion
- **Parenchyma**
  - Found in all tissue systems
  - Living cells capable of further division
  - Provide new cells for growth (meristematic)
  - Function for food production and storage (mesophyll cells)
- **Collenchyma**
  - Thickened tissue in the cortex of the stem and petioles or along the veins of the leaves
  - Alive at maturity and have only a primary wall

- Mature from meristem derivatives that initially resemble parenchyma, but differences quickly become apparent.

- **Sclerenchyma** (from the Greek skleros, hard)
  - Hard and tough cells with a function in mechanical support
  - Scattered throughout the plant, found in both primary and secondary tissues

Types of Sclerenchyma Cells

- **Fibers** – known as bast fibers; long, thin cells with very thick walls often dead at maturity
- **Schleroids or stone cells** – similar with **root cap** – protects the tender apex (absent in aquatic plants); fibers, thick walled and lignified; may be living or dead at maturity
- **Cork** – outermost tissue; impregnated with suberin (waxy substance)

COMPLEX PERMANENT TISSUE/TYPES OF VASCULAR TISSUE

Xylem

- Carries water and mineral salts upward the plant body
- Vessel elements – main conducting cells
- Xylem parenchyma cells – transport selected solutes into and out vessel elements

Phloem

- Distributes the dissolved food materials between the source and sinks; consists of
  - **sieve tube element** – chief food conducting element
  - **companion cells** – parenchyma cells always found beside the sieve tubes; move food in and out of the sieve-tube member
  - **phloem parenchyma** – like ordinary parenchyma cells
  - **phloem fibers** – like sclerenchyma cells

MAJOR PLANT TISSUE SYSTEM

- **Ground**
  - Packing and supportive tissue that forms much of the bulk of young plants
  - Functions in food manufacture and storage
  - Contains three main cell types: parenchyma, collenchyma, and sclerenchyma

- **Dermal tissue**
  - The plant's protective outer covering in contact with the environment
  - Facilitates water and ion uptake in roots and regulates gas exchange in leaves and stems

- **Vascular tissue**
  - Together with phloem and xylem, form a continuous vascular system throughout the plant
  - Conducts water and solutes between organs and provides mechanical support

PLANT ORGANS

Root, Stem, Leaf, Flower, Fruit, Seed

ROOT

Regions

- **Region of cell division** – one to few mm above the root cap; has small cells with thin walls, dense with protoplasm; undergo repeated cell division (meristematic region)
- **Region of elongation** – lies above the meristematic region; extends to 1-5 mm; undergoes rapid elongation and enlargement; responsible for growth in root length
- **Region of maturation** – lies above the meristematic region of elongation; produces root hairs

Types of Root

- **Tap root system**
  - **Primary root** grows vertical downward
  - **Branches** (2nd, 3rd, etc.) grow downward or horizontally outwards
    Functions:
    - absorb water, minerals, and salts from soil
    - anchorage – can be modified to perform other functions
  - **Adventitious root system** – roots that grow from any part of the plant body other than radicle (base of stem, node, internode, branch, leaf: special circumstances)
    Types of adventitious roots
    - **Foliar root system –** from leaves, mainly petiole or vein (spontaneous or due to injury)
    - **Fibrous root system –** in monocots (with all adventitious roots)
    - **Adventitious** – from nodes or internodes (from cuttings)

STEM

- Organ that support and conduct, initially developed from the epicotyl
- Major parts: **bark**, **pith** and **wood** (composed of xylem made up of vessels, fibers and parenchyma cells)

Types of stem

- **culm** – flowering stem of grasses and sedges
- **offset** – like runner, originates from leaf axil as a short and thickened branch away from the mother plant
- **rhizome** – horizontal underground stem
- **runner or stolon** – indeterminate above-ground stem with internodes and new plantlet at the tip
- **sucker** – shoot arising below the ground from old stem

- **tendril** – slender coiling branch for climbing
- **tiller** – shoot produced from the base of the stem or culm
- **tuber** – thick storage underground stem
- **corm** – enlarged solid fleshy base

Forms:

- **Erect or strong stem – u**nbranched; erect; cylindrical; stout; slim jointed stem with solid nodes and hollow internodes
- **Weak stem**
  - **weak trailing stem** – on ground without rooting at the nodes
  - **creeping stem** – runner, stolon, offset or sucker
  - **climbing stem** – attaches or climbs objects (vines)

LEAF

- **Types of Leaf**
  - Simple
  - Compound
- **Functions**
  - food manufacture (Photosynthesis)
  - exchange of gases (Photosynthesis and Respriration)
  - evaporation of water (Transpiration)
- **Parts**
  - **Leaf base** – part attached to stem
  - **Petiole** – stalk of leaf
  - **Leaf blade** or **lamina** – green expanded portion of the leaf
- **Venations**
  - **Parallel** – veins parallel to each other
  - **Reticulate** – network type of veins

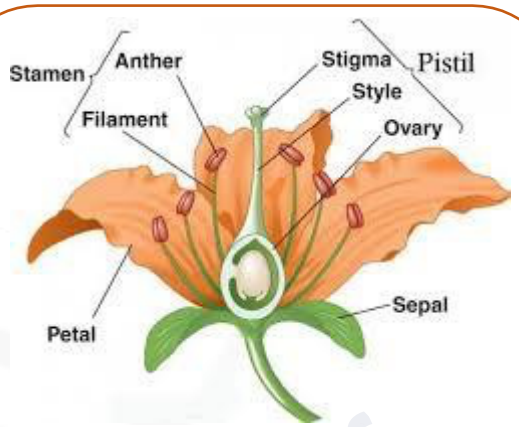
PLANT HABIT

- **Herbs** – with soft stem
- **Shrubs** – medium-sized plants with hard and woody stems**;** branch profusely (bushy habit)
- **Trees** – large plants with single stout trunk; hard wood and woody branch profusely formed
- **Climbers** – thin and long stem with diffuse branches; develop tendrils and climbing roots

FLOWER – reproductive structure of flowering plants

Classification

- **Complete Flower** – has all four parts (sepals, petals, pistil and stamen)
- **Incomplete Flower** – lacking sepals, petals, pistil or stamen



Complete Flower

Flowerhttps://www.studyrankersonline.com/3200/what-is-complete-flower

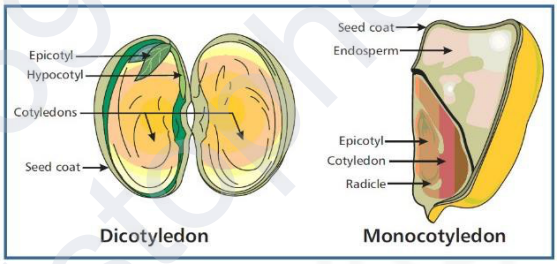
MAJOR PARTS

- **Calyx** – lowermost whorl of modified leaves, also known as sepals
- **Corolla** – whorl of petals above the sepals
- **Gynoecium or pistil** – group of carpels in the center or at the top of the flower
- **Gynophore** – stipe of a pistil or carpel
- **Pedicel** – stalk of a flower
- **Perianth** – combined calyx and corolla
- **Petal** – a unit of corolla
- **Sepal** – a unit of calyx
- **Stamen** – male sporophyll within the flower

SEED

A ripened ovule which, when shed from the parent plant, consists of embryo and stored food supply, both enclosed in a seed coat or covering.

Dicotyledon – embryo lies within an axis of two cotyledons
Monocotyledon – consists of seed coat, endosperm, and embryo



http://societynatureo.blogspot.com/2016/06/seed-parts.html

PARTS

- **Embryo** – developing plant inside the seed; has cotyledons (embryonic leaves), a root cap, a food source and a plumule (shoot)
- **Hilum** – the scar on a seed coat at the location where it was attached to the plant's stalk during development
- **Micropyle** – small pore in a seed that allows water absorption
- **Root (Hypocotyl)** – the part of the stem of a sprouting plant that is above the root and below the stalk of the cotyledon (seed leaves)
- **Seed coat (Testa)** – outer protective layer covering the seed
- **Seed leaf (Cotyledon)** – embryonic leaf within a seed
- **Plumule** – shoot of an embryo

TYPES

- **Orthodox** (e.g. rice, corn, beans, vegetable seed, pili, etc.)
  - dries out naturally on mother plant to a low MC (≤ 20%)
  - can be dried to low MC (<5%) without damage
  - can be stored at low temperature

- **Recalcitrant** (e.g. seeds of aquatic species, large seeded species, wild rice, tropical fruit crops, jackfruit, cacao, rambutan, lanzones, etc.)
  - does not dry out normally on mother plant; shed in moist condition (50-70%MC)
  - seed larger than orthodox – embryo is only 15% of orthodox
  - killed if MC is reduced below critical level (12-30%)
  - susceptible to freezing (below 0°C) or chilling (10-15°C)

- **Intermediate**
  - ➢ can withstand desiccation to about 10-12% MC and can be stored under hermetic condition
  - ➢ loses viability more rapidly at low temperature (<10°C) than at warm temperature (12-21°C)

FRUIT

- mature, ripened ovary
- contains the seed (ripened ovules) and pericarp (the tissue that surrounds the seeds)

Classification

- **Simple fruit –** one fruit develops from single ovary of a flower with or without accessory parts e.g. corn, peanut
- **Aggregate fruits** – collection of simple fruits developing from apocarpus pistil of a flower e.g. strawberry
- **Multiple or composite fruits** - develop from a number of flowers from an inflorescence e.g. pineapple, peach fruit

Types

- Fleshy fruits are juicy.
  - ➢ **Berry** – with entirely fleshy ovary e.g. tomatoes, dates, blueberries, bananas, peppers and cranberries
  - ➢ **Hesperidium** – with leathery rind e.g. oranges, grapefruits, lemons and limes
  - ➢ **Pepo** – with hard rind and a fleshy inner matrix e.g. watermelons, cantaloupe, squash and pumpkin
  - ➢ **Drupe** – fruit with fleshy exterior and a single hard, stony pit surrounding the seed e.g. cherries, peaches, olives, mango, raspberry, coconut, plums
  - ➢ **Pomes** – with fleshy exterior and a center with papery carpels e.g. apples and pears

- Dry fruits may be indehiscent or dehiscent.
  - ➢ **Indehiscent fruits** – do not split open at maturity and are usually one- or two-seeded.
    - ❖ **Achene** – single-seeded fruit with seed attached to the pericarp at only one place e.g. sunflower, strawberry, buckwheat
    - ❖ **Caryopsis** – similar to an achene; however, the pericarp sticks or clings to the seed e.g. corn, rice, barley, rye, amaranth, sorghum, oat and wheat
    - ❖ **Samara** – usually single-seeded with a membranous wing e.g. maple, elm and ash
    - ❖ **Nut** – hard, one-seeded fruit e.g. oak, walnut, filbert and hickory
    - ❖ **Uricle** – like achene, but the ovary wall fits loosely around the seed e.g. finger millet and pigweed
    - ❖ **Nutlet** – small version of a nut e.g. birch and hornbean

- **Dehiscent fruits** – split open upon maturation.
  - **Legume** (pod) – composed of a single carpel and has two longitudinal sutures e.g. soybeans, green beans and peas
  - **Follicle** – composed of a single carpel and splits open along one suture e.g. milkweed
  - **Capsule** – composed of more than one carpel that are united and form many-seeded fruits e.g. okra and cotton.
    *silique – a specialized form of capsule in the mustard
  - **Pyxis** – a type of capsule with a lid that falls from the fruit e.g. purslane

PARTHENOCARPY

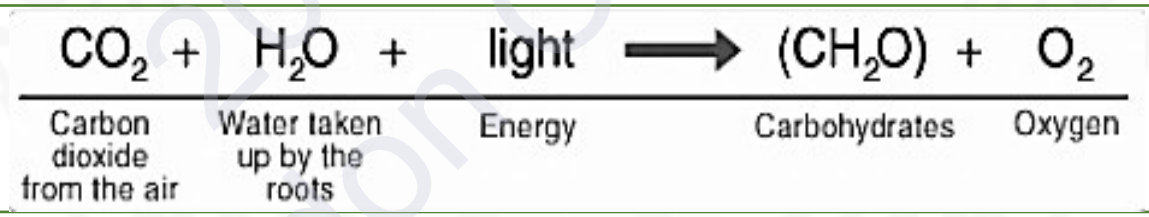
- Greek parthenos, virgin; and carpos, fruit – literally means virgin fruit
- the production of fruit without fertilization; fruit is therefore seedless
- ancient origin – oldest parthenocarpic fig first grown at least 11,200 years ago

Types of Parthenocarpy

- **Stimulative parthenocarpy** – pollination or other stimulation is required for parthenocarpy e.g. banana and watermelon
- **Vegetative parthenocarpy** – does not require pollination or other stimulation to produce parthenocarpic fruit e.g. cucumber, citrus and pineapple

4 PLANT LIFE PROCESSES

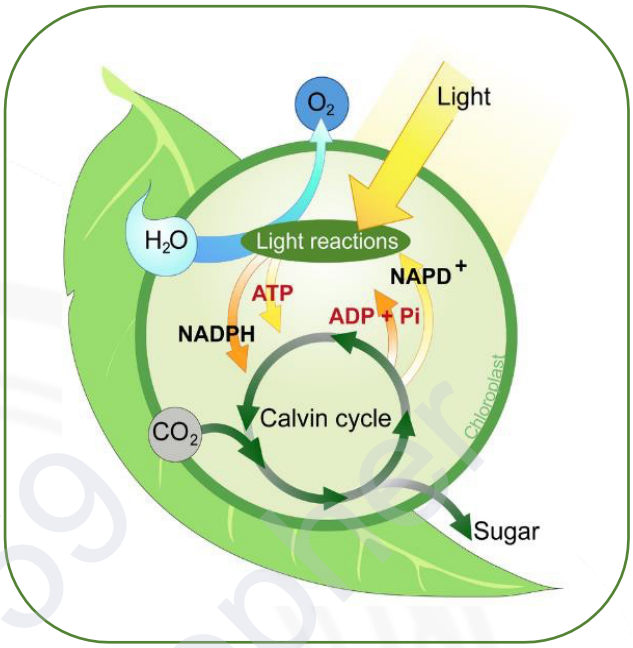
PHOTOSYNTHESIS



- Manufacture of sugars and their precursors by green plants in the presence of light and chlorophyll
- Carbon dioxide is taken from the air through the stomata, while water is absorbed from the soil by the roots and is transported in the xylem to sites of photosynthesis
- Leaf is the main organ for photosynthesis
- Chloroplast is the main organelle involved.
- Leaf features that make it an ideal organ for photosynthesis:
  - It is typically expanded form
  - It is usually perpendicular angle to incident light
  - It is extensive internal surface with an efficient vascular system for channeling the reactants and end products of photosynthesis
  - its pigment for light absorption

CHLOROPLAST

- usually lens-shaped, bounded by a double membrane
- the inner membrane invaginates parallel to the surface and becomes organized into specialized cytoplasmic body consisting of a stack of thylakoids called granum which are embedded in a proteinaceous matrix called <u>stroma</u>

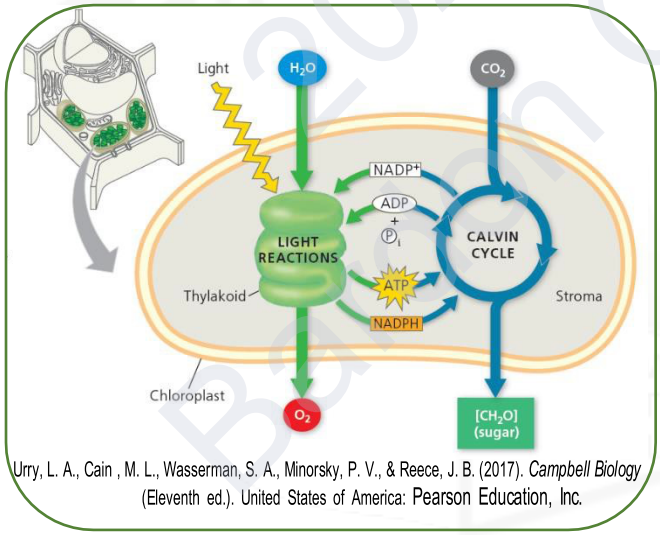


CHLOROPHYLL

- principal pigment in photosynthesis located in the partition between two adjacent thylakoids
- chlorophyll a occurs in all higher plants, but other isomers like chlorophyll b, c, d etc. may also be found
- in higher plants, the two main isomers are chlorophyll a and chlorophyll b, in a 3:1 ratio
- its basic unit is the porphyrin ring system, a structure made up of four simpler pyrrole nuclei joined by carbon linkage
- the center of porphyrin is occupied by a single magnesium atom

SIGNIFICANCE OF PHOTOSYNTHESIS

- converts light energy into chemical energy in the form of organic nutrients
- supplies oxygen to the atmosphere
- produces food



Urry, L. A., Cain , M. L., Wasserman, S. A., Minorsky, P. V., & Reece, J. B. (2017). *Campbell Biology* (Eleventh ed.). United States of America: Pearson Education, Inc.

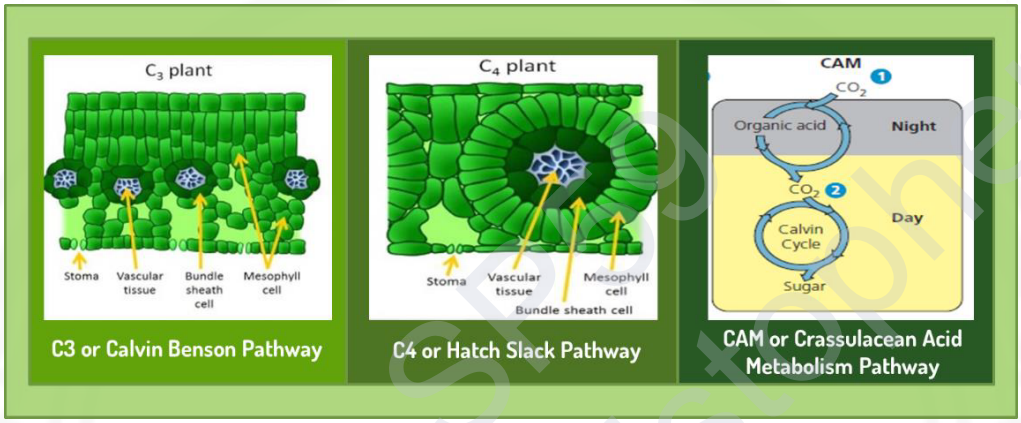
COMPONENT REACTIONS OF PHOTOSYNTHESIS

Light/Light Dependent/Photochemical Phase

- Light energy is harvested by two photosystems
- Oxidation of water and generation of NADPH and ATP by the chloroplast thylakoids
- The lights induce the splitting of H_2O to produce oxygen and the NADPH and ATP (reducing power)
- Rapid process and requires the presence of light
- **Composed of:**
  - Non-cyclic photophosphorylation
  - Cyclic photophosphorylation
- The end products of light reaction, ATP and NADPH, are used to fix CO_2

- **Dark or Light Independent/Biochemical or CO_2 assimilation phase or photosynthetic carbon reduction cycle**
  - Primary process by which inorganic carbon is converted to organic compounds
  - Use of reducing power to reduce CO2 to carbohydrates and water
  - Occurs both in the presence or absence of light
  - A slow process
    - Uses ATP and NADPH

THREE PATHWAYS IN THE FIXATION OR REDUCTION OF CO_2 INTO CARBOHYDRATES:



1. CALVIN BENSON CYCLE/REDUCTIVE PENTOSE PATHWAY

- fixation and reduction of one molecule of CO_2 requires three molecules of ATP and 2 NADPH (coming from light reaction)
- occurs in the mesophyll cell chloroplast
- CO_2 acceptor is RUBP
- RUBP carboxylase enzyme is needed
- the first product is 3-PGA

2. C_4 OR HATCH SLACK PATHWAY

- occurs in the mesophyll cell
- CO_2 acceptor is PEP, catalyzed by PEP carboxylase enzyme
- products are 4-carbon organic acids (oxaloacetic acid at the mesophyll cells)
- oxaloacetic acid is converted to malate and aspartic acid
- malic acid is decarboxylated to produce CO_2
- the 3-carbon compound goes back the mesophyll cells
- the CO_2 released enters the Calvin cycle for sugar/starch production
- the 3-carbon compound combined with 1-carbon from the atmosphere to form again into 4-carbon compound

3. CRASSULACEAN ACID METABOLISM (CAM) PATHWAY

- found in succulent plants (cactus, pineapple)
- during the night, CO_2 is fixed
- during the day, malic acid is decarboxylated where CO_2 is fixed through the C_3 pathway

GENERAL CHARACTERISTICS OF C3, C4, AND CAM PLANTS

	C3 plants	C4 plants	CAM plants
Characteristic	Temperate species can be seen in all photosynthetic plants	Tropical or semitropical plants adapted to high light, temperature, and semi-arid environments	Xerophytic species, can be seen in semi-arid condition
Cells Involved	Mesophyll cells	Mesophyll cells, bundle sheath cells	Both C3 and C4 same as mesophyll cells
Types of plants using the cycle	Mesophytic, hydrophytic and xerophytic	Mesophytic	Xerophytic
Leaf anatomy	Lack Kranz-type anatomy and peripheral reticulum; only one type chloroplast	Kranz type anatomy and peripheral reticulum are essential features	Lack Kranz-type anatomy and peripheral reticulum; only one type chloroplast
Initial CO_2 acceptor	Ribulose-1,5-bisphosphate (RuBP), a 5-C sugar	Phosphoenol pyruvate (PEP), a 3-C acid	PEP in the dark and RuBP in the light
First stable product	3phosphoglycerate (3(PGA), a 3-C compound	Oxaloacetate (OAA), a 4-C compound	OAA in the dark and 3-PGA in the light
CO_2 fixation	Only one CO_2 fixation pathway	Two CO_2 fixation pathways are separated in space	Two CO_2 fixation pathways are separated in time
Glycolate synthesis	High	Low	Low
Water-use efficiency/salinity tolerance	Low	High	High
Light saturation	At about 1/5 full sunlight	Do not readily photosaturate at high light density	Do not readily photosaturate at high light intensity
CO_2 compensation point	High	Low	High affinity for CO_2 at night
Calvin cycle operation	Alone	Along with the Hatch and Slack pathway	C3 and Hatch Slack pathway
Photorespiration	Present in high rate	Not easily detected	Detected in the afternoon
Optimum temperature for photosynthesis	15-25℃	30-40℃	>40℃
Stomatal opening	Open stomata by day	Open stomata by day	Open stomata by night
Example	Cotton, Sunflower, Spinach, Beans, Rice	Sugarcane, Sorghum and Maize	Cacti, orchids bromeliads and other succulents

FACTORS AFFECTING PHOTOSYNTHESIS

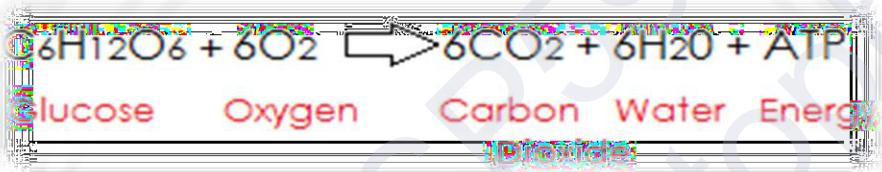
Internal

- Enzymes – biological catalysts/agents of life
- Genetic factor – chlorophyll, kind of plant, etc.
- Leaf age
- Demand of sinks for photosynthesis
- Water content of the plant
- Amount of plant regulates

External

- Light
  - Quality
  - Intensity
  - Duration
- CO_2 and H_2O availability
- Temperature
- Wind velocity

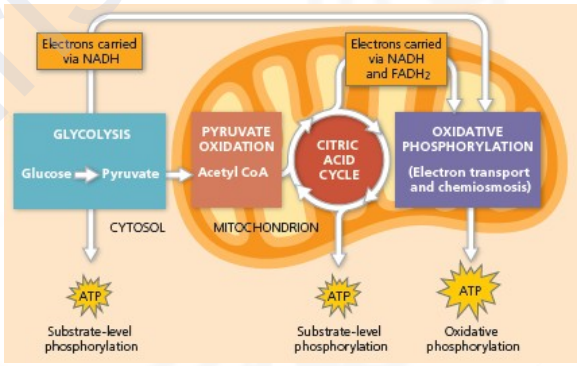
RESPIRATION



An enzyme-catalyzed reaction involving the transformation of organic substrate into carbon dioxide and water accompanied by energy release.

STAGES OF RESPIRATION

- **Glycolysis**
  - Occurs in cytoplasm
  - Partial oxidation of a glucose molecule (6C) yields two molecules of pyruvic acid (3C). In the process, substrate phosphorylation of the sugar molecule results in a net production of 2 ATPs



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- **Krebs Cycle**
  - Pyruvic acids produced in the cytosol during glycolysis are imported into the mitochondrial matrix, the site of Krebs cycle.
  - Pyruvic acid is first oxidized to acetyl co-enzyme A and subsequently converted to CO_2.
  - For every glucose molecule (2 pyruvic acids) entering the mitochondrion, the Krebs cycle generates 6 NADH and 2 FADH2 and yield 2 ATP via substrate level phosphorylation.

- **Electron Transport System (ETS)**
  - occurs in the inner mitochondrial membrane
  - NADH (from glycolysis and Krebs cycle) and $FADH_2$ (from Krebs cycle) are oxidized to yield ATP

- ATP is generated in ETS via oxidative phosphorylation

FACTORS AFFECTING RESPIRATION

- **Age and tissue type**
  - large, young tissues respire more strongly than old ones
  - developing tissues respire more than mature ones
  - tissues undergoing metabolic processes respire more than resting ones
- **Temperature**
  - enzyme activity doubles for energy; 10°C rise in temperature within certain limits
  - more rapid breakdown of respiration as temperature increases above 35°C due to heat destruction of enzymes
- **Oxygen**
  - presence of oxygen is essential for oxidative metabolism
- **CO_2**
  - high level (higher than normal atmosphere) inhibits respiration
  - high concentration causes the stomata to close
- **Physiological status of plant or plant parts**
  - dormant state respires less than active parts of the plant
- **Moisture content of tissues**
  - seeds with higher moisture content respire more than seeds with drier tissues

TRANSPIRATION

The loss of moisture from plants in the form of water vapor. This evaporative process is dependent on energy, the heat of vaporization (539 cal per gram) which is required to convert water from liquid state to gaseous state

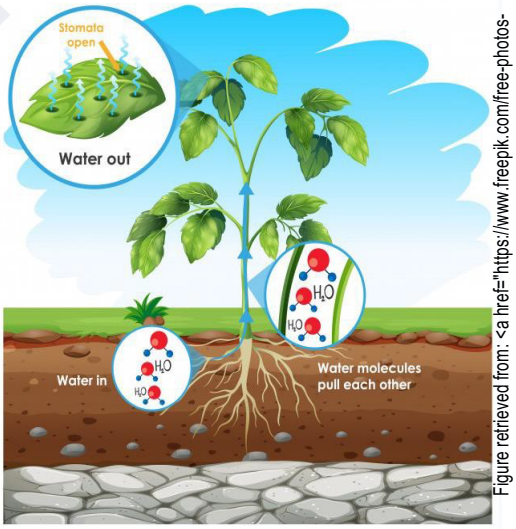


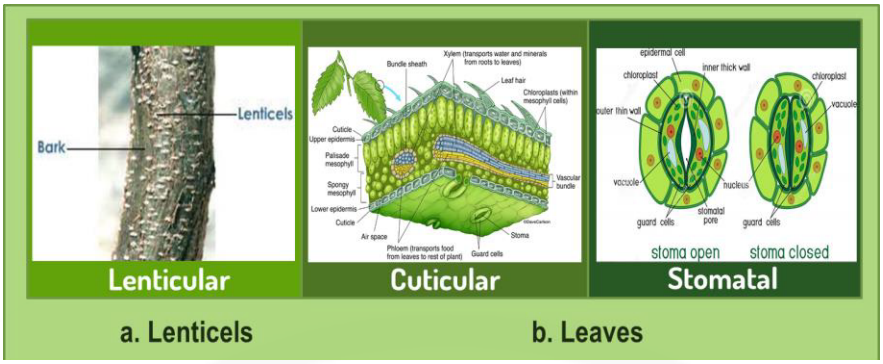
Figure retrieved from: Tree vector created by brgfx - www.freepik.com

Considered as "necessary evil"

a. it keeps the cells hydrated
b. it maintains favorable turgor pressure for the transport of nutrients absorbed by the roots from the soil
c. it serves as a cooling process

TYPES OF TRANSPIRATION

- **Cuticular transpiration** – loss of water through the epidermis, usually covered with a cuticle. In some temperate plants, about 5-10% of the water lost from plants may be lost through this pathway.
- **Lenticular transpiration** – loss of water through numerous pores in the outer layer of a woody plant stem, called lenticels. In deciduous species and in some fruits, water loss through lenticels maybe quite substantial.
- **Stomatal transpiration** – loss of water through the stomata, accounting for as much as 90% of water loss from plants



Two stages involved in transpiration

- **Evaporation of water** from the moist cell walls into the substomatal air space
- **Diffusion of water vapor** from the substomatal space into the atmosphere

FACTORS AFFECTING TRANSPIRATION

- Relative humidity
- Temperature
- Wind velocity
- CO_2 concentration – higher concentration will close the stomata
- Light intensity
- Morphology of leaf stomatal modification

SOIL-PLANT-AIR CONTINUUM OF WATER

1. **Movement of water from the soil to the root xylem**
   a. **Extracellular or apoplastic route** - water moves through non-living parts, e.g. capillary spaces of the cell walls and intercellular spaces
   b. **Intracellular route**
      - **Symplastic pathway** – plasmodesmata
      - **Transmembrane or transcellular pathway** - vacuolar membrane (tonoplast) and the plasma membranes

2. **Movement of water from root xylem to leaf xylem**
   - transpiration-cohesion-adhesion theory

3. **Movement of water from leaf xylem to the air**
   - influenced by RH and VPD
   - towards lower water potential (Ψ; expressed in MPa)

TRANSLOCATION

- long-distance transport of photoassimilates
- transport of solutes by the roots to the other plant parts passing the dead conduits or dead xylem vessels (apoplastic transport)
- transport of photosynthates in living conduits or phloem vessel (symplastic transport)
- transport of solution from the roots to the upper parts through the xylem of the stem (transpirational stream); transpiration or loss of water in plant is the cause of the movement
- tissues involved are the phloem and the xylem
- sucrose is the main photosynthates being translocated
- the translocation is from the sources to the sinks

SOURCE

- an organ or tissue that produces more assimilates than what it requires for its own metabolism and growth exporter organ

SINK

- importer or consumer of assimilate

FACTORS AFFECTING TRANSLOCATION

- **Temperature**
  - rate of translocation increases with temperature to a maximum and then decreases due to hazardous effect of high temperature
- **Light**
  - CO_2 assimilation increases as light intensity increases
- **Metabolic inhibitors**
- **Concentration gradient**
- **Mineral deficiencies**
  - sucrose movement can be aided by boron
- **Hormones**
  - associated with the active parts, hence growing parts (sinks) greatly influence translocation

ASSIMILATION

- The process of utilizing food (photoassimilates and other solutes) for growth
- During the early stage, food substances are converted into simpler compounds (enzymes are needed, nutrients are necessary for normal action of enzymes) and used as building blocks for more complex substances
- In the later stage, simple and complex compounds are integrated into the living substances of the cells

FACTORS THAT DETERMINE ASSIMILATE PARTITIONING IN A CROP

- **Sink strength** – ability of a sink to accumulate assimilates; a function of sink size and sink activity
- **Proximity of the sink to the source organ** – assimilates move preferentially toward sink leaves above and in line with the source leaf. Lower mature leaves feed mainly the roots, the higher mature leaves feed mainly the young leaves and the shoot apex
- **Stage of development** – developing flowers and fruits become dominant sinks during the reproductive stage of a crop. On the other hand, storage roots used as planting materials export assimilates to developing vegetative tissues.
- **Nature of vascular connections between source and sinks** – each leaf is connected to the main vascular system of the stem by a vascular trace, which diverts from the vascular tissue of the stem into the petiole.

5 PLANT NUTRITION

SOIL FERTILITY AND PLANT NUTRITION

SOIL FERTILITY

- the inherent capacity of a soil to supply nutrients to plants in adequate amount and in suitable proportions

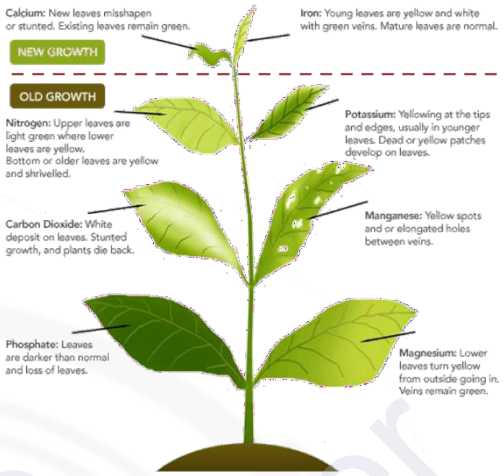
PLANT NUTRITION

- to the interrelated steps by which a living organism assimilates food and uses it for growth and replacement of tissue
- to the need for basic chemical elements for plant growth
- involves a complex balance of mineral elements essential and beneficial for optimum plant growth

CLASSIFICATIONS OF NUTRIENTS

1. **Based on subsistence**
   a. **ESSENTIAL**
      Criteria for an element to be classified as ESSENTIAL:
      i. Life cycle completion
      ii. Constituent of plant metabolite
      iii. Not replaceable
   b. **BENEFICIAL**
      - Can compensate for toxic effects of other elements
      - Can replace mineral nutrients in some other less specific function
      - Example: maintenance of osmotic pressure
      - Includes Na, Si, Al, Se, V

2. **Based on amount needed**
    a. **MACRONUTRIENTS**
        - Used by plants in large quantities
        - **C, H, O, N, P, K, S, Ca, Mg**
    b. **MICRONUTRIENTS**
        - Used by plants in small quantities
        - **Fe, B, Cu, Cl, Mn, Mo, Zn, Co, Ni**



3. **Based on mobility in plant**
    a. **MOBILE**
        - capable of being retranslocated from older tissues to younger tissues
        - **N, P, K, Mg, S, Mn, Cl, Ni**
    b. **IMMOBILE**
        - cannot be translocated from older tissues to younger tissues
        - **Fe, Ca, Zn, Cu, B, Mo, Co**

When a MOBILE nutrient is deficient:
- the nutrient already present in the plant will be remobilized to young tissues
- deficiency symptoms are manifested in older leaves

When an IMMOBILE nutrient is deficient:
- the nutrient is locked in place after assimilation
- deficiency symptoms are manifested in younger leaves

SOME TECHNIQUES USED TO DIAGNOSE NUTRIENT DEFICIENCY AND TOXICITY:

1. **Soil analysis or soil test**
    - Test for pH, exchangeable cations, available N, P, and K, and soluble salts
    - Not always give a reliable estimate of the amount of nutrients in the soil that are available to the plant

2. **Plant tissue analysis**
    - Concentration of the nutrient in the tissue increases with its availability
    - Best results obtained when values calibrated against actual growth of crops under field conditions

3. **Field or greenhouse experimentation**
    - Using solution culture technique
    - Modifying concentrations of the nutrient solution

6 GROWTH AND DEVELOPMENT

DEVELOPMENT

- denotes the attainment of size by virtue of growth and architectural style by the concomitant process of morphogenesis
- has three interrelated aspects: **growth, differentiation, and organization**

GROWTH

- Irreversible increase in size, weight (dry or fresh) or mass of plant organs and whole plants
- Irreversible increase in size by cell division, and enlargement and elongation
- Including synthesis of new cellular mater and organization of subcellular organelles

Measurements to quantify growth

- **Volume (size)** – measures expansion in only one or two directions
  - **Length** – stem height
  - **Diameter** – stem
  - **Area** – leaf area expansion
- **Mass**
  - **Fresh mass**
  - **Dry mass**

DIFFERENTIATION

- the outward sign of selective gene action, the reflection of change in the cell's biochemical program as a consequence of the release of information encoded in one-dimensional sequence.

ORGANIZATION

- orientation and integration of the differentiated cells in space together with regulated growth with the consequent attainment of form and structure of the complete organism

CORRELATION

- regulatory effect exerted by one part of the plant on the growth and development in another part

ENDOGENOUS RHYTHM

Recurring events or oscillations with properties not directly reflecting environmental fluctuations

a. **Annual** – reoccur every year
b. **Lunar** – reoccur every new moon
c. **Circadian** – recur every 24 hours

PLANT MOVEMENTS

THREE STEPS IN PLANT MOVEMENT:

1. **Perception** – recognition of the environmental stimulus
2. **Transduction** – biochemical and biophysical changes that occur in response to perceived stimulus
3. **Response** – changes in the organ affected by the perceived stimulus

TWO CATEGORIES OF PLANT MOVEMENT

1. **Tropic movements (tropisms)** – direction of the environmental stimulus determines the direction of the movement
    - **Phototropism** – response to light
    - **Gravitropism** – response to gravity
    - **Solar tracking** – flat blade of the leaf is always at nearly right angle to the sun throughout the day.

2. **Nastic movements** - maybe triggered by an internal timing mechanism (biologic clock) and the direction of the stimulus may not determine the direction of movement
    - **Hyponasty** – bending up of leaves
    - **Epinasty** – bending down of leaves
    - **Nyctinasty** – folding of some leaves in response to light, usually assuming a rhythmic pattern because of its interaction with the biological clock
    - **Hydronasty** – folding and rolling of leaves in response to water
    - **Thigmonasty** – response to touch or mechanical stress
    - **Seismonasty** – response to shaking without contact to the organism

CROP ADAPTATION

1. **Morphological adaptation**
    - shown by the presence of metamorphosed or specialized organs that perform non-typical functions
    - e.g. pneumatophores or modified roots of certain trees growing in marshes that serve as “breathing organs”
2. **Physiological adaptation**
    - shown by the closing of stomates of manyu bromeliads during the day to help conserve water and the abscission of leaves in deciduous plants to reduce the evaporative surface area thereby conserving moisture and lowering compensation point
3. **Biochemical adaptation**
    - biochemical changes with some bearing on certain survival mechanisms like the increase in proline and abscisic acid and osmolytes in plants during period of moisture stress to regulate increased water-holding capacity of tissues and stomatal closure to conserve water

7 PLANT GROWTH REGULATION

PHYTOHORMONES

- Organic substances other than vitamins and nutrients that are active in very minute (often <2μM) amounts
- Formed in certain parts of the plant and are usually translocated to other sites where they promote, inhibit, or otherwise modify physiological, biochemical, and/or morphological processes
- In general, PGRs are promotive at relatively low concentrations but become inhibitory at relatively higher concentrations
- Endogenous PGRs are called plant hormones or phytohormones

AUXIN

- Generic term applied to growth regulators with the special capacity to promote cell elongation
- Naturally occurring auxins are the indole-auxins represented by indole-3-acetic acid (IAA)
- IAA is synthesized from the amino acid tryptophan primarily in actively growing tissues. It is also produced in mature leaves and root tips albeit at much lower concentrations
- IAA transport is cell to cell and is polar in nature. The basipetal transport to the root and acropetal transport to the upper organs involve vascular and non-vascular tissues.

FUNCTIONS:

- promotes cell enlargement and cell division in the cambium in tissue culture
- stimulates phloem and xylem differentiation
- stimulates root initiation in cuttings
- induces ethylene biosynthesis at supra-optimal concentration
- mediates the tropic bending response of shoots and roots to gravity, light and touch
- promotes apical dominance
- delays leaf senescence and leaf and fruit abscission
- promotes fruit setting and fruit development in some plants
- can delay fruit ripening but may promote flowering in some plants (e.g. bromeliads)
- induces femaleness in dioecious flowers (via ethylene)
- induction of parthenocarpic (seedless) fruit development (e.g. tomato)
- popularly used as herbicides (e.g. 2,4-D, 2,3,5-T [agent orange], dicambaetc)

GIBBERELLIC ACID

- Belongs to a family of compounds based on the ent-gibberellane structure
- GA is synthesized from mevalonic acid in (1) elongating shoots, (2) young leaves of developing apical regions of roots
- The major conduit for the non-polar transport of GA is the phloem.

FUNCTIONS

- stimulates stem elongation (may reverse physiological and genetic dwarfism in plants)
- promotes bolting (rapid elongation of floral cytostem) in long-day plants
- induces germination of seeds that normally require cold treatment (stratification) or light (positively photoblastic seeds)
- stimulates *de novo* synthesis of α-amylase in germinating cereal grains
- promotes fruit set and fruit growth in some fruits e.g. grapes
- induces maleness in dioecious flowers of some species

CYTOKININ

- Adenine derivatives that induce cell division in tissue culture
- The most common CK base in plants is zeatin, the first natural CK isolated from corn endosperm.
- Synthesized through the biochemical modification of adenine
- The major site of CK biosynthesis is at the root apical meristem although seeds (embryo) and developing leaves have been shown to produce significant amounts of CK as well
- CK produced in the roots is transported to the upper organs via xylem

FUNCTIONS:

- regulates morphogenesis in cultured tissues (in synergy with auxin)
- releases lateral buds from apical dominance
- delays leaf senescence
- promotes cotyledon and leaf expansion
- promotes nutrient mobilization
- enhances stomatal opening in some species
- Enhances accumulation of chlorophyll as it promotes the conversion of etioplasts into chloroplast

ETHYLENE

- The only phytohormone occurring in gas state
- An unsaturated hydrocarbon synthesized from the amino acid methionine (primary precursor) in many tissues in response to stress
- Does not seem to be essential for normal vegetative growth but it is the only hydrocarbon with a pronounced effect on plants
- Synthesized in most tissues in response to senescence and stresses
- Being a gas, it moves by diffusion from the site of biosynthesis

FUNCTIONS:

- promotes ripening of climacteric fruits
- induces epinasty
- induces lateral cell expansion
- formation of adventitious roots
- induces flowering in pineapple and other bromeliads
- enhances flower, fruits, and leaf senescence
- induces femaleness in dioecious flowers of some species

- promotes shoot and root growth differentiation
- releases tissues/organs from dormancy
- promotes leaf and fruit abscission
- enhances flower opening in some species

ABSCISIC ACID

- Synthesized from mevalonic acid in mature leaves particularly in response to water stress. Seeds are also rich in ABA which may be imported from the leaves or synthesized *in situ*.
- ABA is exported from leaves in the phloem. There are evidences that ABA may circulate to the roots in the phloem and then return to the shoots in the xylem

FUNCTIONS:

- Counteracts the effect of gibberellins on α-amylase synthesis in germinating cereal plants
- Enhances stomatal closure (e.g. during water stress)
- Promotes leaf senescence
- Promotes storage protein synthesis in seeds
- Induces transport of photosynthates towards developing seeds and its subsequent uptake by growing embryos
- Induces and/or maintains dormancy in seeds and buds

8 CONCEPTS RELATED TO PLANT GROWTH

- **Liebig's Law of Minimum**
  - The growth in lowest supply (climatic, edaphic, biological or genetic) sets the capacity for yield
  - Otherwise known as the "barrel" concept. If a barrel has stages of different heights, the lowest one sets the capacity of the barrel.

- **Blackman's Theory of Optima and Limiting Factors**
  - When a process is conditioned as to its rapidity by a number of separate factors, the rate of the process is limited by the slowest factor

- **Mitscherlich Law of Diminishing Return**
  - When plants have adequate amounts of all but one limiting element, the growth response is proportional to the limiting element.
  - Plant growth increases with additional increments of a limiting factor but not in direct proportion.
  - The response is curvilinear contrary to Blackman's concept of linear response.

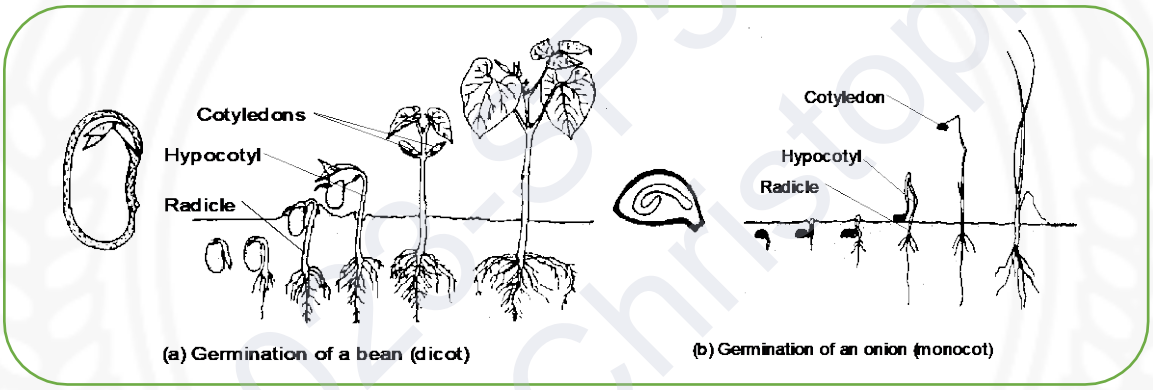
9 PLANT PROPAGATION

SEXUAL PROPAGATION

- Most common way plants reproduce in nature
- Most efficient and widely used method for cultivated crops
- Seeds arise from the fusion of male and female gametes to form a single cell (zygote) within the ovule of a flower

SEED GERMINATION

- Series of events that take place when dry quiescent seeds imbibe water, resulting in an increase in metabolic activity and the initiation of a seedling from the embryo
- Resumption of embryo growth



EPIGENOUS GERMINATION

- hypocotyl elongates and brings cotyledons above ground

HYPOGENOUS GERMINATION

- epicotyl emerges and the cotyledons remain below soil surface

SEED STORAGE: BEHAVIOR CATEGORIES

SEED DORMANCY

- physiological or physical condition of a viable seed that prevents germination even in the presence of otherwise favorable germination conditions.

SEED QUIESCENCE

- condition in which seed cannot germinate because of unfavorable conditions

TYPES OF DORMANCY

- **Primary**
  - **Exogenous or coat-imposed dormancy** – essential germination components not available
  - **Endogenous dorma**ncy – caused by environment during seed development and maturation
- **Secondary –** Imposed by temperature, light/darkness, abnormal amount of water, chemical and gases

DORMANCY TECHNOLOGY

- **Ecodormancy** – due to one or more unsuitable factors in the environment with non-specific effect
- **Paradormancy** – due to physical factors or biochemical signals originating externally to affected structure
- **Endodormancy** – regulated by physiological factors inside affected structure

REQUIREMENTS FOR GERMINATION

1. Sufficient moisture
2. Proper oxygen level
3. Favorable temperature
4. Medium or substrate
5. Light (optional)

Photoblastic seeds – seeds that require light to germinate e.g. lettuce, tomato

HASTENING SEED GERMINATION/BREAKING DORMANCY

SCARIFICATION - any treatment that removes the seed coat or alters it, making it more permeable to water and air. This can be done mechanically by rubbing into a rough surface or the use of chemicals such as hydrogen peroxide and muriatic acid.

- **Physical scarification** – soaking in water (tap, hot or boiling water) for a specific period
- **Mechanical scarification** – piercing, rubbing on sandpaper, filing, grinding with abrasives
- **Chemical scarification** – treatment with sulfuric acid and organic solvents

STRATIFICATION – placement of seeds between layers of moist sand, soil or sawdust at high or low temperature: the action of water and high and low temperature softens the seed coat.

VERNALIZATION – seed treatment to cold temperature prior to germination

EMBRYO CULTURE – aseptically removing the embryo from the seed and placing it in a sterilized culture medium to germinate

ASEXUAL PROPAGATION

- Reproduction from vegetative plant parts, possible because the vegetative organs of many plants have the capacity for regeneration.

PURPOSE OF ASEXUAL PROPAGATION

1. Means to reproduce plants that do not produce viable seeds
2. Perpetuate the desirable characteristics of the parent material.
3. Produce clones or true-to-type planting materials for uniformity.
4. Retain and reproduce the genetic trait of a hybrid.
5. Shorten time to fruit-bearing.
6. Control size and form of tree.
7. Incorporate environmental stress resistance.
8. Avoid seed-borne diseases.

PROPAGATION BY APOMICTIC EMBRYOS

Apomixis – from the Greek Apo, meaning "away from", and Mixis, which means "mingling"

- The production of viable seeds without pollination
- Involves the development of embryos containing the same genetic information as the mother plant and which are in effect clones
- Parthenogenesis in animals
- Reproduction of embryo without meiosis and fertilization, embryo arise from vegetative cells within the ovule

TYPES

- **Obligate Apomictic** – reproduces only by asexual reproduction
  e.g. lanzones, mangosteen
- **Facultative Apomictic** – reproduces either sexually or asexually
  e.g. mango, citrus

SEPARATION AND DIVISION

- **Separation** – separating naturally detachable organs from the mother plant
- **Division** – specialized vegetative structures are cut into section – **modified organs** – which may be separated and/or divided

1. **Bulb** – specialized underground organ consisting of a short, fleshy, usually vertical system axis (basal plate) bearing at its apex a growing point or a flower primordium enclosed by thick, fleshy scales e.g. tulips, lilies
2. **Bulbil** – aerial plantlet formed on the axil of the leaves or flower stalk e.g. agave
3. **Corm** – a swollen base of a stem axis enclosed by the dry scale leaves e.g. banana, gladiolus, gabi

4. **Cannel** – miniature corm that develops between old and new corms
5. **Crown** – pan of a plant at the surface of the ground from which new shoots are produced e.g. aster, Shasta daisy
6. **Offset** (syn. Offshoot) – a characteristic type of lateral shoot or branch that develops from the base of the main stem in certain plants (a shortened, thickened stem of rosette-like appearance e.g. *Pistia* sp.
7. **Pseudobulb** – specialized storage structure (enlarged, fleshy section of the stem made up of one to several nodes) e.g. *Cattleya* sp
8. **Rhizome** – a specialized structure in which the main axis of the plant grows horizontally at or just below the ground surface e.g. banana, bamboo, sugarcane
9. **Runner** – a specialized stem that develops from the axil of the left at the crown of a plant, grows horizontally along the ground, and forms a new plant at one of the nodes e.g. strawberry, black pepper
10. **Slip** – leafy shoot originating from axillary buds borne at the base of a plant or peduncle of the fruit e.g. pineapple, cabbage
11. **Stolon** – special modified stem, produced by some plants, that grows horizontal to the ground e.g. Bermuda grass
12. **Sucker** – adventitious shoot that arises from the underground stems below the ground e.g. banana, pineapple
13. **Tuber** – a modified stem structure that develops below ground because of the swelling of the subapical portion of the stolon and subsequent accumulation of reserve materials
14. **Tuberous root** – thickened root that contains large amounts of stored food e.g. cassava, sweet potato

- **Cutting** – cutting a portion of a stem, root, or leaf from the parent plant, placing in favorable environmental conditions, and including to form roots and shoots, thus producing a new independent plant.

  TYPES:

  Root cutting – ex. breadfruit, apple
  Stem cutting – hardwood, semi-hardwood, softwood, herbaceous cutting e.g. cassava, malunggay, coffee, rose
  Leaf cutting – e.g. snakeplant, begonia, African violet
  Leaf-bud cutting – e.g. black pepper, vanilla

- **Layering** – adventitious roots are included to form a stem while they are still attached to the parent plant

  TYPES:

  a. Simple layering
  b. Air layering or marcotting
  c. Compound or serpentine layering
  d. Mound or stool layering
  e. Trench layering

- **Grafting** – connecting plant parts together so they will unite and continue their growth as one plant

> **Scion** – short piece of detached shoot with one to several dormant buds and which is to become the upper portion of graft combination
> **Rootstock** – lower portion of graft which develops into the root system of the grafted plant
> **Interstock –** stem inserted between scion and rootstock (to avoid any incompatibility between scion and rootstock and/or to take advantage of its growth controlling properties)

TYPES OF GRAFTAGE

Approach Grafting or Inarching – selected shoots of the desirable plant are grafted with the stem or the stock grown in individual containers while the scions are still connected with the mother plant

Topworking – commonly used in changing the top of established inferior plants into more desirable ones.
Splice grafting - the detached scion used is leafless, usually with terminal leaf bud or well-developed dormant bud.
Cleft Grafting – a detached scion is directed grafted on top of the stock as in splice grafting, except that the types of cut used vary.
Side Grafting – the basal portion of a detached scion is joined at the side of the trunk of the stock.
Bark Grafting – especially useful in grafting a detached scion on a stumped stock whose stem is much larger than that of the scion.

- **Budding** – involves joining 2 plant parts such at the size of the scion is reduced to only one bud and a small section of bark, with or without wood.

TYPES OF BUDDING

Patch Budding – usually used in species having a thick bark which can be separated easily from the wood.
Shield or T-budding – usually made on an actively developing stem whose bark can be readily separated from the wood.
Chip Budding – used where the bark of the stem adheres closely to its wood, which may occur naturally to some species or arising from growing conditions.

- **Inarching (approach grafting)** – plants are made to unite while growing on their roots

- **Tissue culture techniques other than embryo culture** – plant parts which have cells capable of dividing are used e.g. shoot-tip culture, meristem culture, and endosperm culture

10 FACTORS THAT AFFECT CROP PRODUCTION

GENOTYPE AND ENVIRONMENT

GENOTYPE – genetic design of a plant that dictates the ceiling of how much a variety/cultivar can yield.

- Genes controlling a character (yield, plant height, taste, color, etc.)
- Varies among and even within species
- Sets the ultimate limit for plant variation

ENVIRONMENT – any factor external to the plant that influences its growth and development

- Maybe biotic or abiotic e.g. climate, soil, topography, pests and diseases

GENOTYPE x ENVIRONMENT INTERACTION

- A high yielding variety grown under poor environment will have low yield.
- A low yielding variety grown in optimum (good) environment will still have low yield.
- An ideal genotype is one that has a wide range of environmental adaptation
- An optimum environment is one that poses a minimum of constraints to crop growth and development
- Through G x E interaction, some particular elements of the environment may draw varying responses from different genotypes.

Practical implications:

- Development of management practices that can remove or avoid environmental constraints
- Continuously assess G x E interaction
- Need for continuous development of improved varieties

In a production system:

- **Inputs** – controllable, manageable resources e.g. seeds, fertilizers, pesticides, etc.
- **Output** – yield
- **Environment** – uncontrollable factors external to the system
- **System** – component crops, processes and activities

Practical implications:

- Man (management has only partial control of the system)
- Certain factors/conditions are given to which the system has to fit or adjust
- The design of the system emanates from man (his needs, objectives, knowledge and capabilities)

ENVIRONMENTAL FACTORS: ABIOTIC FACTORS

CLIMATIC FACTORS

- **Climate**
  - The seasonal pattern of a particular place occurring from year to year
  - A composite of day-to-day weather conditions described in averages and variability
- **Weather** – a momentary state of the atmosphere brought about by the combination of elements e.g. temperature, pressure, moisture content, air movements, radiation, etc.
- **Microclimate** – the climatic environment one meter below the canopy in the case of tall plants or the climate within the leaf canopy for short (below one meter) plants.
- **Macroclimate** – the climatic environment one meter above the plant canopy

The Climatic Elements

PRECIPITATION – any form of water particles falling on the ground in liquid or solid form (rainfall, hail, snow, etc.)

ROLE OF WATER IN PLANTS

- as a reactant in many biological reactions
- enters into the structure of biological molecules
- serves as medium of transport of nutrients and other substances
- helps regulate plant temperature

CATEGORIES OF PLANTS BASED ON NEED FOR MOISTURE

- **Xerophytes** – desert plants
- **Hydrophytes** – aquatic plants
- **Mesophytes** – land plants; mostly economically important plants

FACTORS AFFECTING AMOUNT OF DISTRIBUTION OF RAINFALL

- ***Topography*** influences the amount and distribution of rainfall
- ***Mountain ranges*** present barriers to clouds, causing them to rise to higher elevations and generally colder temperatures causing vapor to condense and water to fall on the windward sides as the clouds pass over, leaving the leeward side relatively dry. Examples are Los Baños in Laguna and Sto. Tomas in Batangas. Sto Tomas is drier than Los Baños due to the presence of Mt. Makiling.
- ***Air circulation patterns*** affect the seasonal distribution of precipitation

RAIN FORMATION REQUIRES

- high relative humidity (RH)
- sufficiently low temperature (below condensation point)
- condensation nuclei
- sufficiently low pressure

- **Drought** – insufficiently low rainfall/moisture which seriously affects plant growth.
  - **Absolute drought** – 29 consecutive days without rainfall of at least 0.25 mm
  - **Partial drought** – 15 consecutive days without rainfall of at least 0.25 mm

TEMPERATURE

- The degree of hotness and coldness of a body
- Every chemical, physiological and biological process in plants is influenced by temperature.

THREE (3) CARDINAL TEMPERATURES:

- **Minimum temperature** – temperature below which the velocity of the reaction becomes zero, due to the deactivation of enzymes.
- **Optimum temperature** – temperature where the velocity of the reaction is at maximum.
- **Maximum temperature** – temperature above which the velocity of the reaction becomes zero, due to the desaturation of enzymes.

Temperature of the environment depends upon:

- **solar radiation** – vertical rays are more energy efficient/unit area than oblique rays (in polar regions).
- **surrounding land masses or bodies of water**.
- **altitude** – for every 100m rise in elevation, there is a 0.6°C decrease in temperature.

In the Philippines:

- High elevation – 13.2 – 24.6°C
- Low elevation – 23.3 – 31.5°C

CLASSIFICATION OF CROPS ACCORDING TO TEMPERATURE REQUIREMENT

- **Cool season crops** - e.g. cole crops like cabbage, broccoli, cauliflower
- **Tropical** – e.g. coconut
- **Sub-tropical** – e.g. citrus

EFFECT OF TEMPERATURE ON CROPS

- Vernalization requirement of certain crops for flowering e.g. celery seed exposed to 4.4 – 10°C for 10 days under imbibed condition
- Effect on crop maturation (crops mature faster in hotter than in colder temperatures)

WIND OR AIR IN HORIZONTAL MOTION

- Normal wind speed in the Philippines – 7.2 km/hr
- At 30 km/hr – leaf tearing may already occur especially in banana and abaca

EFFECTS OF WIND ON PLANTS

- increases transpiration
- destructive effects of strong winds, typhoon e.g. crop lodging, grain shattering
- sterility due to loss of pollens
- disease spore dispersal
  - reduced CO_2 levels especially in enclosed spaces
  - affects plant form

- Air circulation in the atmosphere results from the sun's radiation falling more directly on the tropical regions than on polar regions, the warmer air rises and flows forward the poles, cools and sinks as cold polar air and then returns toward the equator as ground flow
- The interactions cause the establishment of regions, large and small, each with a different climate.

SOLAR RADIATION OR LIGHT – energy given out by the sun through radiation

THREE ASPECTS IMPORTANT TO PLANTS

- **Light intensity** – expressed in foot-candle or lux.
  - Plants are generally spaced so that maximum leaf area is exposed to sunlight
  - Some plants do not require high light intensity (shade-loving) because they have low light saturation point.
  - Some plants require subdued light to survive e.g. some ornamentals
- **Duration or day length** – expressed in hours per day
- **Wavelength** – expressed in Angstrom or nanometers or identified by color. Not all wavelengths of light are equally effective.
  - In photosynthesis – red and blue wavelength
  - In photoperiodism – far red and red wavelength

EFFECT OF LIGHT ON PLANTS

- **Photoenergetic effect** – direct effect on photosynthesis (intercepted radiation is important)
- **Photocybernetic effect** – effect on plant development
- **Photoperiodic effect** (response) – plant response as conditioned by daylength

CLASSIFICATION OF PLANTS ACCORDING TO LIGHT INTENSITY REQUIREMENTS

- **Heliophytes –** sun loving; light saturated at about 5000 ft candles e.g. banana, chrysanthemum, corn, cowpea, cucurbits, eggplant, papaya, peanut, sugarcane
- **Sciophytes** – shade loving;light saturated at about 500 foot candles e.g. ginger, African violet, ferns, philodendron, coffee

Plants belonging to the intermediate group may be converted through acclimatization into either heliophytes or sciophytes

CLASSIFICATION OF PLANTS ACCORDING TO PHOTOPERIODIC RESPONSE

- **Day neutral** – flowers over a wide range of daylength e.g. banana, citrus, coconut, corn, tomato
- **Short day plant** – does not flower when the dark period exceeds some critical length e.g. aster, castor oil, onion, radish

RELATIVE HUMIDITY

- Proportion/amount of moisture in the air
- Low relative humidity and high temperature will result in high evapotranspiration
- High relative humidity and high temperature will result in low evapotranspiration

GASEOUS ENVIRONMENT

- **Carbon dioxide –** critical in enclosed environments like greenhouses
- **Air pollution –** toxic substances like lead, sulfur dioxide, carbon monoxide, HF

Cloudiness – cloud including smog and fog affect the amount of radiation received by plants. Most solar radiation is reflected by clouds.

CLIMATIC STRESSES

TYPHOON AND WEATHER VARIATIONS

- Typhoon – strong winds with speeds greater than 21 kph

OZONE DESTRUCTION

- Ozone – protective shield against the harmful UV rays; it is 6-30 miles above the earth
- Harmful effects:
  - Depressed photosynthesis
  - Reduced levels of seed protein, lipids and carbohydrates

GLOBAL WARMING

- increased concentration of carbon dioxide in the atmosphere
- CO_2 concentration might double to around 600ppm in 30-75 years
- methane gas contributes to global warming

EL NIÑO/LA NIÑA

- El Niño phenomenon happens when there is a periodic ocean-warming and atmospheric disturbance characterized by deficient rainfall or prolonged drought in some areas, while heavy rains, storms or hurricanes occur in other areas of the globe

CLIMATIC INDICATORS OF EL NIÑO IN THE PHILIPPINES INCLUDE:

- Delayed onset of the rainy season
- Early termination of the rainy season
- Weak monsoon activity
- Weak tropical cyclones activity

EFFECTS OF EL NIÑO:

- fish kill especially cold-water fish – tuna and milkfish catch declines
- decrease in yield for most crops
- human death

ACID RAIN

- Sulfur dioxide produces S which is released from natural sources and human activities; oxides of S and water produce acid rain

LAHAR

- leads to a decrease in agricultural lands, resulting in low production

EDAPHIC FACTORS

- Soil as a factor in crop production
- **Soil** - mixture of organic and inorganic materials which developed on the earth's surface through rock and mineral weathering and whose properties are conditioned in various degrees by the influence of climate, living organisms and topography acting on the parent material over a period of time
  - medium of plant growth – physical support for anchorage of plant roots; supplier of water and nutrient
  - non-renewable resource – it takes about 100 years for natural processes to form an inch of soil.
  - natural body with dimensions of thickness and width with indistinct horizontal boundaries enabling it to blend with other soils and vertical boundaries of the air above it and the unweathered rocks below it.

SOIL PROPERTIES IN RELATION TO CROP PRODUCTION

SOIL TEXTURE

- relative proportion of sand, silt, and clay in a particular soil
- the ranges of diameters of the three separates are: sand, 2.0-0.05mm; silt, 0.05-0.002mm; and clay, <0.002mm

COMPARISON BETWEEN SAND AND CLAY SEPARATES

Sand	Clay
Low total porosity (more macropores)	High total porosity (more micropores)
Low water-holding capacity (droughty)	High water-holding capacity
Very good aeration	Poor aeration and drainage
Easy to till ("light" soil)	Difficult to till ("heavy" soil)
Non-sticky and non-plastic when wet	Very sticky and plastic when wet
Low nutrient-holding capacity (less fertile)	High nutrient-holding capacity (more fertile)

SOIL STRUCTURE

- the clustering of the soil particles into characteristic aggregates of various sizes, shapes, and stability

STRUCTURAL CLASSES BASED ON THE SHAPE OF THE AGGREGATES

- **Prismatic structure**: pillar-like with level tops
- **Columnar structure**: pillar-like with rounded tops; like prismatic structure, commonly occurs in subsoils and in soils of arid and semi-arid regions
- **Blocky structure**: cube-like and has more or less sharp edges with distinct rectangular faces
- **Sub-angular blocky structure**: with more or less rounded edges; like the blocky structure, typical in clayey subsoils particularly in humid regions
- **Platy structure**: has disc-like aggregates; commonly found in virgin soils and subsoils; generally makes the soil poorly drained
- **Spheroidal structure**: rounded, more porous aggregates; characteristic of surface soils especially those with high organic matter content
- **Granular/Crumb**: resembles cookie crumbs; commonly found in surface horizons where roots have been growing

IMPORTANCE OF SOIL STRUCTURE TO CROPS

- influences the infiltration of water through the soil
- influences soil aeration, critical during seed germination and seedling emergence

BULK DENSITY

- the mass (dry weight) per unit volume of soil
- mathematically, **B.D. = W_s/V_t**
  W_s = oven-dried weight of soil in g
  V_t = total volume of soil clod in cm^3 (includes solids and pore spaces)
- a measure of degree of compaction of the soil and an indicator of porosity
- the more compact the soil, the higher is the bulk density value and the less porous it is
- the range of bulk density values for sand and sandy loam soils is 1.20 to 1.80 g/cm^3
- the range of bulk density values for clay, clay loam and silt loam is 1.0 to 1.60 g/cm^3

Interpretation of some bulk density values	
1,0 to 1.3 g/cm^3	Normal soil
>1.3 g/cm^3	Compacted soil, poor soil structure
<1.0 g/cm^3	Very loose soil

SOIL CHEMICAL PROPERTIES

SOIL PH

- pH 6 and pH 7 are most favorable for growing most agricultural plants because the availability of nutrients and activities of beneficial microorganisms are at maximum at this range
- the range of soil pH in the Philippines is from pH 5.5 to pH 6.5
- with too low pH (<5.0, strongly acidic)
  - nutrients, particularly Ca, Mg, K, P, Mo and N, become less available to plants
  - N release may also be hindered when the symbiotic nitrogen fixation and nitrification are inhibited
  - Fe, Al and Mn become more soluble to the point of toxicity
  - P becomes complexed into insoluble forms with Fe and Al
  - P can also be precipitated as insoluble manganese phosphate compounds when the soil is rich in manganese oxides
- Soils become acidic with leaching out of the bases are leached and replaced with H^+ ions e.g. old soils in the humid tropics
- Soil acidity may develop from organic matter decomposition because of the formation of organic acids like fulvic acid, humic acid and carbonic acid.
- With too high pH (>8.0, strongly alkaline),
  - most micronutrients (except Mo) become unavailable
  - iron deficiency develops
  - P becomes complexed with calcium as precipitates of calcium hydroxyapatite or calcium phosphate dehydrate
  - K also competes with the now abundant Ca for plant absorption

CATION EXCHANGE CAPACITY (CEC)

- the ability of the soil to adsorb and exchange cations with those in the surrounding soil solutions and with the plant roots
- the sum of all adsorbed cations per unit amount of soil commonly expressed as milliequivalent per 100 g of soil (m3/100g) or $cmol_c$/kg soil
- reversible, instantaneous and stoichiometric process
- typical values range from 10m3/100 g to 30 me/100 g
- increases with increasing amount of clay and organic matter

SOIL ORGANIC MATTER (SOM)

- the totality of all carbon-containing compounds in the soil derived from either plants or animals
- organic constituents of plants:
  - cellulose (15 – 60%)
  - hemicellulose (10 – 305)
  - lignin (5 – 30%)
  - water-soluble fractions: amino sugars, amino acids (5 – 30%)
  - proteins

- fats, oils, and waxes
- accumulation is affected by temperature, soil moisture, vegetation, soil texture and cropping system
- cultivated soils contain an average of 2 to 3% organic matter
- Organic matter declines when the soil is cultivated because of the enhanced oxidation and microbial activity that go with the loosening of the soil.

EFFECTS OF ORGANIC MATTER ON SOIL PROPERTIES

PHYSICAL

- enhances soil aggregation and aggregate stability
- reduces plasticity, cohesion and stickiness of clayey soils
- Increases soil water retention, infiltration rate, water-holding capacity and aeration
- darkens soil
- reduces bulk density and compaction

CHEMICAL

- increases CEC of soils
- increases soil buffering capacity
- increases nutrient availability through solubilization of minerals by organic acids and by chelation of metal ions
- reduces Al toxicity by binding the Al ions in non-toxic complexes
- increases soil native supply of N, P, S, etc.
- adsorbs pollutants such as Pb, Cd and Cu
- inactivates toxin and pesticides

BIOLOGICAL

- provides C and energy to soil organisms and thus increases their diversity and activity
- enhances microbial functions such as N fixation, decomposition and nutrient transformations

SOIL BIOLOGICAL PROPERTIES

Soil organisms

- large and small plants and animals
- the larger organisms (insects, worms, moles, etc.) prepare the organic materials for further degradation by breaking them into smaller pieces
- the smaller organisms (bacteria, fungi, actinomycetes, algae, nematodes, protozoa) cause biochemical changes in the organic materials

Roles

- Responsible for biochemical changes
- Act as agents in the decomposition of plant and animal residues
- Improve soil structure through aggregation

BENEFITS FROM EARTHWORMS

- Burrowing – channels for drainage and aeration, entry of other animals, entry o water, nutrients, roots
- Mix the soil, "plows" the soil
- Incorporates crop residues
- Contribute to OM
- Humus enrichment
- Improves soil structure
- Control pests (e.g. leaf miner pupa, scub pathogen
- Nutrient recycling

ENVIRONMENTAL FACTORS: BIOTIC FACTORS

All living elements in the environment that affect crop production

a. **Beneficial organisms** – provide beneficial effects on crop production
b. **Pollinators** – plays an important role in the preservation of species and in biodiversity conservation
c. **Decomposers** – soil microorganisms specifically important in the maintenance of soil organic matter
d. **Natural pest enemies** – provide balance in a crop production system particularly in the control of pests
e. **Pests** – includes pests, diseases, weeds, invertebrates, and vertebrates

Genetic Factors – includes all factors internal to the plant

- **Genotype** – the genetic design/makeup of a plant that dictates the ceiling of how much a variety/cultivar can yield
- **Genome** – sets the ultimate limit for plant variation
- **Selection indices of major Philippine crops**
  - the choice of variety to plant is one of the most critical decisions in crop production
  - technologies required in growing a particular crop depend on varietal characteristics especially growth characteristics, quality of the product and market acceptability

EXAMPLES OF SELECTION INDICES

- **Corn** – early maturing (90-95 days) to medium maturing (102-105 days); yield – 5-7 tons/ha; yellow or white flint; moderate or highly resistant/tolerant to rust, corn borer, earworm, downy mildew, etc.; drought tolerant
- **Rice** – growth duration: early, 100-110 days; medium, 110-120 days; late, >120 days; yield, 5-6 tons/ha; plant height, 80-105 cm; amylose content, intermediate to high; gelatinization temperature: low, intermediate, high; grain size and appearance, medium to long slender

- **Mungbean** – maturity, 60 days; yield, 1.2-1.5 tons/ha; plant height, 30-75 cm; tolerant to cercospora leaf spot, downy mildew, water logging; shiny, yellow-green seeds
- **Coconut** – 1200-1500 nuts/harvest: 8x/yr or every 45 days; tree or plant should have a rounded crown; at least 60-80 nuts/tree/yr; at least 30-36 opened leaves; closer leaf scar; presence of inflorescence in every leaf; medium-sized, round shaped nuts; free from pests and diseases
- **Mango, dwarf** – fruit large with thin/small seed; regular bearer; resistant to major pests and diseases
- **Banana** – early maturity; high yielding; drought tolerant; resistant to pests and diseases; good fruit quality

Human Factors

- **Farmer's preference** (crop type, variety)
- **Farmer's capability**
  - depends on the farmer's resources and knowledge
  - most Filipino farmers are resource-poor
  - our culture is very rich in indigenous knowledge particularly about farming
- **Management**

11 CROP IMPROVEMENT AND SEED SELECTION

PLANT BREEDING

- Science, art, and business of crop improvement for human benefit
- Improves plant quality, disease, and insect resistance, change in maturity duration, agronomic characteristics, photosensitivity, synchronous maturity, non-shattering characteristics, etc.

ACTIVITIES IN PLANT BREEDING:

A. <u>CREATION OF VARIETY</u>

NATURALLY EXISTING VARIABILITY

- **Domestication** – process of bringing wild species under human management
- **Germplasm collection** – collection of a large number of genotypes of a crop species and its wild relatives
- **Introduction** – taking a genotype or a group of genotypes of plants into new environments where they were not being grown before

CREATION OF NEW VARIABILITY

- **Hybridization** – crossing genetically dissimilar individuals
  - Hybrid – product of hybridization
- **Inbreeding** – mating of plants related by ancestry; leads to production of homozygous progeny
- **Inbred** – a product of inbreeding, hence, a homozygous plant
- **Topcross** – cross between an inbred and an open-pollinated variety
- **Testcross** – cross between a plant or line and a tester (tester may be an inbred, hybrid, synthetic, or open pollinated variety)
- **Backcross** – a cross between a hybrid and one of its parents; also repeated backcrossing of F1 (first generation offspring of a cross) and the subsequent generations to the recurrent parent usually to transfer a major trait controlled by one or a few genes from the donor (as the non-recurrent parent) and the recipient (as the recurrent parent)
- **Polycross** – open pollination in isolation among a number of selected genotypes arranged in a manner that promotes random mating
- **Reciprocal cross** – mating of two individuals in which each is used as the male parent in one cross and the female parent in the other
- **Intraspecific cross** – crossing individuals belonging to the same species
- **Wide or distant cross** – crossing distantly related individuals
- **Introgressive hybridization** – repeatedly backcrossing interspecific hybrids to one of the parental species leading to the transfer of some genes from one species to another

Heterosis or hybrid vigor – superiority of the F1 hybrid over its parents

- Mid-parent heterosis
- Heterobeitiosis
- Standard heterosis

Combining ability – the ability of a genotype to transfer its desirable traits to its progeny

- **General combining ability** - average performance of a strain in a series of crosses
- **Specific combining ability** – deviation from performance predicted on the basis of general combining ability of parent lines

Inbreeding depression – loss of vigor due to inbreeding

MUTATION

- Heritable change in an organism
- Spontaneous – mutations occurring in natural populations
- Induced – mutations artificially produced by treatment with certain physical or chemical agents or mutagens

Chimera – an individual with one genotype in some of its parts and another genotype in other parts

Polyploidization – increasing ploidy level to more than two identical or distinct genomes

GENETIC ENGINEERING

- Production of transgenic plants
- Changing the genetic makeup of plants by direct introduction of genes from microorganisms, animals or other plant species; done when sexual hybridization between the recipient and donor is impossible

STEPS:

1. Identification of genes, construction of vectors
2. *In vitro* plant regeneration system
3. Gene introduction methods
4. Molecular analysis
5. Gene expression assays
6. Stability and transmission analysis

B. SELECTION

Identification of individuals or lines that are more desirable than others in a heterogenous population

- **Natural selection** – change in gene frequencies from one generation to another because of differences in survival and reproductive abilities of parent genotypes in natural populations
- **Artificial selection** – change in gene frequencies brought about by man as is done in plant breeding where certain individuals or genotypes are not used as parent of the next generation

MODES OF SELECTION

- **Stabilizing or normalizing selection** – when adaptive individuals in the populations are selected under a constant environment through the years; keeps the population constant and eliminates the deviants; reduces the variability in the population
- **Directional selection** – change towards a particular direction due to changing environments resulting in change of genetic contribution of the population; mode observed when breeders do artificial selection
- **Diversifying or disruptive selection** – opposite of stabilizing selection; leads to either formation of subpopulations differing in their characteristics or polymorphism in which each genotype is represented by a distinct phenotype.

TRAITS SELECTED FOR:

- **Qualitative traits** – monogenic or oligogenic traits; show discrete or non-continuous variation, controlled by one or few genes, less influenced by environment
- **Quantitative traits** – polygenic, metric or measurable traits; show continuous variation, controlled by many genes, highly influenced by environment

BASES OF SELECTION

- Phenotype (P) can be accounted for by the genotype (G), the environment (E) and the interaction between genotype and environment (GxE).

COMPONENTS OF PHENOTYPIC VARIANCE:

- **Phenotypic variance** – sum of genotypic variance, environmental variance and GxE variance
- **Genotypic variance** – sum of additive and non-additive types of gene action
  *Additive – due to individual effects of genes
  *Non-additive – due to intralocus and interlocus interactions
- **Environmental variance** – effect of environment on the phenotype and estimated by measuring variation in a genotypically uniform population growth in a certain location
- **GxE interaction** – change in ranking and/or performance of genotypes when grown in different environments; estimated by computing the variances of genotypes when grown in a number of locations which are environmentally diverse.

Heritability – a portion of the phenotypic variation among individuals that is due to genetic differences among them

- **Broad-sense heritability** – estimated from the ratio of the total genetic variance to the phenotypic variance
- **Narrow-sense heritability** – estimated from the ratio of the additive portion of the genetic variance to the phenotypic variance
- **Selection intensity** – the percentage of individuals selected in a population
- **Selection differential** – difference between the mean performance of genotypes selected from a population and the overall population mean
- **Gain from selection** – increase in mean performance of a population that is realized with each cycle of selection

C. EVALUATION

Assessment of the performance of newly developed lines of a crop through appropriate multi-location trials and tests

SEQUENCES IN THE CONDUCT OF YIELD TESTS:

1. **Observational yield test** – may test separate groups of experimental lines; uses incomplete block design or triple lattice design with 2-3 replications in one location
2. **Preliminary yield test** – evaluation including a check variety using incomplete block design with 2-3 replications in at least 2 locations
3. **General yield test** – uses randomized complete block design with 3 replications in at least 3 locations
4. **Advanced yield test –** elite lines from general yield tests evaluated using randomized complete block design with 4 replications in 6-10 locations

Superior lines are approved to be released as a variety by the National Seed Industry Council (NSIC); the variety must have passed the tests for distinctiveness (D), uniformity (U) and stability (S) or the DUS-test.

D. MULTIPLICATION

Seed multiplication of an entry after it is identified for release; the seed produced by the breeder after a strain is identified but before it is released as a variety is termed as the **stock seed**. The stock seed is known as **breeder seed** once the identified strain is released and notified.

Seed – any propagating material used in raising a crop

SEED MULTIPLICATION PROCESS:

- **Seed production** – proper isolation procedure is necessary to maintain the genetic purity of the variety
- **Isolation** – separation of a population of plants from other genotypes with which they are capable of mating
- **Seed processing** – drying, cleaning and grading, testing, treating, bagging and labeling of seeds

TYPES OF VARIETY

- **Hybrid** – first generation offspring of a cross between two individuals differing in one or more genes
- **Synthetics** – seed mixture of strains, clones, inbreds or hybrids, maintained by open pollination for a specified number of generations; the component units are propagated and the synthetic reconstituted at regular intervals
- **Composites** – mixture of genotypes from several sources, maintained by normal pollination
- **Inbreds** – purelines originating from self-pollination and selection
- **Multilines** – blends; composite of isolines
- **Isolines** – lines that are genetically similar except for one gene
- **Open-pollinated variety** – variety maintained through natural cross pollination
- **Landraces** – farmer-selected cultivated forms

HYBRID SEED PRODUCTION

- **3-line system** – male sterile line (A), maintainer line (B) and restorer line (R)
- **2-line system** – male sterile line, the expression of which is influenced by environment and any inbred variety as pollen parent
- **1-line system** – use of apomixes to produce the F1 seeds and maintain the genotype of the F1

E. DISTRIBUTION

CLASSES OF SEED

- **Breeder seed** – controlled by the originating plant breeder; starting point of all subsequent classes of seed; seeds obtained from uniform panicles by breeders; 100% pure
- **Foundation seed** – seed produced from breeder seeds; source of registered and/or certified seeds; carries a red tag
- **Registered seed** – produced from foundation or registered seeds and carries a green tag
- **Certified seed** – produced from foundation, registered, or certified seeds and carries a blue tag
- **Good seed** – produced from varieties not yet approved by NSIC

F. GERMPLASM CONSERVATION

- **Germplasm** – the sum total of hereditary material or genes present in a species
- **Plant germplasm** – genetic source material used by plant breeders to develop new cultivars
- **Germplasm storage**
  - as seeds in cold/refrigerated rooms
  - maintained as living plants in field or through slow growth *in vitro*
  - cryopreservation or freeze-preservation

13 SITE CHARACTERIZATION AND EVALUATION

The establishment of a crop production enterprise includes the following activities:

- finding a suitable site
- determining the suitable crop/s for that particular site
- evaluating the socio-economic, biological and physical conditions existing in the site

Site selection – affects future decisions related to production costs, farm operations, transportation, etc.

Socio-economic factors

- Peace and order
- Manpower development
- Market availability
- Farmers' preference
- Zoning and other regulations
- Land tenure situation

Biological factors

- Crops planted
- Crop pests and diseases

Physical factors:

- Area and Shape
- Soil Condition
  - Fertility
  - Structure
  - pH
- Location
- Climatic Condition
  - Rainfall pattern
  - Wind velocity
  - Climate type
- Drainage
- Present bodies of water

14 LAND PREPARATION AND PLANTING PRACTICES

LAND PREPARATION

- Done to provide a favorable soil environment for the germination and growth of a particular crop.
- Done in accordance with the requirements of the crops, whether they grow under dryland or wetland systems. The two systems of land preparation and water management (wetland and dryland) have contrast features in terms of the physical, biological, and chemical nature of soils.

TILLAGE – the manual or mechanized manipulation of the soil to provide a medium for proper crop establishment and growth.
JETHRO TULL - considered as the father of modern tillage.

TYPES OF LAND PREPARATION:

- **LOWLAND/WETLAND PREPARATION** – soaking, plowing, harrowing, leveling
- **UPLAND/DRYLAND PREPARATION** – plowing, harrowing/rotavation, leveling

TILLAGE AND PLANTING EQUIPMENT:

- **Plow** – animal-drawn moldboard, tractor-drawn moldboard, disc
- **Harrow** – disc, comb-tooth, spike-tooth
- **Rotavator**
- **Furrower** – animal-drawn ('lithao'), tractor-drawn
- **Planting hold digger**

CHARACTERISTICS OF A WELL-PREPARED UPLAND FIELD

- Soil is granular, friable, and compact enough to allow contact between seed and soil
- Sufficient moisture for germination and subsequent growth
- Level field to avoid water accumulation
- Free from weeds

DIFFERENCES IN TERMS OF PHYSICAL CHANGES BETWEEN UPLAND AND LOWLAND LAND PREPARATION

- **UPLAND** – no flooding, no puddling, macro- and micropores are maintained, water drains easily if there is no plowpan, tillage is easy especially at field capacity
- **LOWLAND** – flooding involved, puddling involved, macropores are lost while micropores are maintained, plowpan is formed, tillage is hard when soil is dried

DIFFERENCES IN TERMS OF CHEMICAL CHANGES BETWEEN UPLAND AND LOWLAND LAND PREPARATION

- **UPLAND** – root zone is well-aerated, aerobic organisms are present, no reduced zone, pH is stable, high N mineralization, P, K, Si and Mo are less available, Cu and Zn are not affected, less generation of gases (i.e. carbon dioxide, methane, nitrous oxide, hydrogen sulfide) and organic acids
- **LOWLAND** – thin oxidized layer and reduced layer in root zone, aerobic and anaerobic organisms are present, increase in pH in acid soils and decrease in pH in alkaline soils, slow N mineralization, P, K, Si and Mo are available, Cu and Zn are reduced, generation of gases and organic acids

TYPES OF TILLAGE OPERATION

A. **Primary tillage** – the most aggressive tillage operation, undertaken when the soil is wet enough to allow the field to be plowed and strong enough to give reasonable levels of traction; after the crop harvest or at the beginning of the next wet season; includes the plowing operation which is opening of the compacted soil

B. **Secondary tillage** – any work completed after primary tillage; shallower and less aggressive; includes the operations performed after plowing such as leveling, discing and harrowing

C. **Seedbed preparation** – carried out by using hand tools or implements like harrow, rollers, plank, and rider for seed germination

D. **Inter tillage** – work done in the standing crop; after sowing or planting and prior to the harvesting of crop plant; includes gap filling, thinning, weeding, mulching, top dressing of fertilizers, hoeing, etc.

FORMS OF TILLAGE OPERATION

- **CONVENTIONAL TILLAGE** – results in a residue-free soil surface at planting time

- **CONSERVATION TILLAGE** – entails practices in which some crop residue remains on the soil surface after the preparation. It maintains residue from previous crop on soil surface. Its chief goals are:
    1. to reduce soil erosion
    2. conserve moisture.

COMMON TYPES OF CONSERVATION TILLAGE

- **No tillage or zero tillage** – a crop is seeded directly into a seedbed not tilled since the harvest of the previous crop.

- **Mulch tillage** – leaves crop residue to serve as mulch, as in stubble-mulch tillage that aims to conserve moisture and to protect the soil from wind and water erosion by leaving crop residues on the soil surface.

- **Strip tillage** (also called strip-till or zone tillage) – entails the disturbance of narrow strips in the soil where seeding is done. The interrow zone remains undisturbed and covered with crop residue.

- **Minimum tillage** – involves considerable soil disturbance but to a lesser extent than conventional tillage. Some crop residue is left on the soil surface. Minimum tillage is also called reduced tillage.

- **Ridge tillage** – a small band of soil on the ridge is tilled. The soil from the top of the ridge is mixed with crop residue between ridges. The debris reduces soil erosion and increases water retention.

TILLAGE PATTERNS

Tillage patterns reduce the time spent in non-productive work; minimize the number of turns and maximize the length of the tillage runs

1. **Circuitous pattern** – used with moldboards, discs and offset discs; most animals are accustomed to working; ends up with a large cut out furrow in the center – difficult to drain and get an even depth of cultivation
2. **Up and back/Headland pattern** – runs parallel to each other; used for tired implements, rotavators, harrows and reversible plows; most field efficient system and if equipment is correctly setup and operated, it should not leave furrows in the field
3. **Land system** – plowing to begin in the center of the field and works out to the edges; requires measurement of the field to establish the center point; used with all types of plow

15 PLANTING MATERIAL, SELECTION AND PREPARATION

PLANTING MATERIALS – seeds, setts, seed pieces, propagules
SEEDING RATE – number of seeds to be planted in a given hill or linear meter
POPULATION DENSITY – the amount of seeds planted in a given area
FURROWS – an opening in the soil where the seeds are sown
BASAL FERTILIZERS – fertilizer materials before the seeds are placed

PLANTING MATERIALS FOR ROW PLANTING

SEEDS: all grain crops (legume and cereals), forage grasses and legumes; fiber crops (jute, ramie, and cotton)

VEGETATIVE MATERIALS:

- **Stem cuttings** – sugarcane, sweet potato, cassava, forage grasses
- **Tubers** – Irish potato, yams
- **Bulbs** – multiplier onions, garlic
- **Corms** – taro (gabi)
- **Rhizomes** – ramie, ginger

SEXUAL PROPAGATION AND NURSERY PRACTICES

TYPES OF FLOWER

- **Staminate** – male, only stamens
- **Pistillate** – female, only pistils
- **Hermaphroditic** – perfect, both stamen and pistil
- **Monoecious** – staminate and pistillate flowers on the same plant e.g. cucurbits
- **Dioecious** – staminate and pistillate flowers on different plants e.g. papaya
- **Andromonoecious** – perfect and staminate flowers on the same plant e.g. muskmelons

CLASSIFICATION OF CROPS ACCORDING MODE OF POLLINATION

NATURALLY SELF-POLLINATED

- beans, peas, lettuce, tomatoes
- not absolute; crossing usually occurs

CROSS-POLLINATED

- Crucifers (cabbage, cauliflower, radish)
- Root crops, carrots, beets, parsnips, onions
- Others like sweet corn, spinach, asparagus

PARTIALLY CROSS-POLLINATED

- Eggplants, peppers, celery, cucurbits (squash, pumpkins, muskmelons, cucumbers, watermelons)

HYBRID VS. OPEN-POLLINATED CULTIVARS

HYBRID – product of controlled pollination of two or more genetically distinct parental inbred lines; superior; crops uniformity; time-consuming; expensive

OPEN-POLLINATED – self/cross-pollinated; strict artificial isolation; less expensive

SEED QUALITY AND CHARACTERISTICS

- ✓ True-to-type
- ✓ High germination percentage
- ✓ High vigor
- ✓ No dormancy
- ✓ Free of foreign matter
- ✓ No disease or insect contamination

SEED CLASSES

a. **BREEDER'S SEED** (**WHITE TAG)**– initial source of cultivar produced by the plant breeder
b. **FOUNDATION SEED (RED TAG)** – progeny of the breeder's seed and handled to maintain the highest degree of purity
c. **REGISTERED SEED (GREEN TAG)** – progeny of foundation seed for the production of certified seed
d. **CERTIFIED SEED (BLUE TAG)** – final product produced by seed company or growers for commercial sale to crop producers

GOOD SEEDS – seeds produced from certified seeds which are widely available at village levels.

SEED PERFORMANCE

- **SEED VIGOR** – rapid, complete and uniform seed germination
- **SEED ENHANCEMENT** – done to improve seed vigor;
  - ➢ **CHITTING** – shorten time between sowing and seedling emergence, under ideal conditions until radicle emergence, sowing/transplanting in moistened media.
- **OSMOCONDITIONING/SEED PRIMING** – improves seedling vigor, germination rate and uniformity; involves seed imbibition in a temperature-controlled, dilute, aerated solution of an organic or inorganic osmoticum; all seeds will have exactly the same moisture content; seed metabolism is stimulated
- **USE OF COATED OR PELLETED SEED** – small-seeded vegetables like tomatoes can be handled and singulated in precision seeders more efficiently; thick layer of diatomaceous earth, montmorillonite clay, sand, etc. with a binder around seeds to increase size and uniformity; increased pestilence protection when fungicides/insecticides are incorporated
- **USE OF SYNTHETIC SEEDS** – disease-free plant tissue, somatic embryos produced asceptically *in vitro*, embryos can be removed from the culture media and encapsulated in synthetic gels that

replace endosperm and seed coat; chemicals for protection against pestilence can be incorporated in this gel.

TRANSPLANTING VS DIRECT SEEDING

TRANSPLANTING (plugs)

- extends a short growing season for late maturing crop
- improves land-use efficiency; saves cost of expensive hybrid seed
- force crop production for an early market
- assures complete stand and crop uniformity

DIRECT SEEDING

- most economical
- not satisfactory seed germination

HARDENING – acclimatization or adaptation to the harsher field environment by withholding moisture and reducing temperature for 7-14 days prior to transplanting; slows or retards seedling growth and allows accumulation of carbohydrates

CROPS USUALLY TRANSPLANTED

- cabbage, pepper, broccoli, cauliflower, celery, tomato, lettuce, eggplant

CROPS USUALLY DIRECT-SEEDED

- melons, bitter gourd, cucumber, beans, kangkong, hybrid onion, sweet corn

CROPS THAT SHOULD BE DIRECT-SEEDED

- radish, turnips, carrot, beets
- these crops are never transplanted because the tip of their taproots may be damaged in the process, resulting in forked roots

PLANTING DEPTH

- Too deep – exhausts energy reserves before reaching the soil surface
- Too shallow – will not be able to reach soil moisture, dry out and die
- not deeper than 10x the diameter of the seed
- epigeal emergence (soybean) – prone to crusting than hypogeal emergence (corn)
- seeds – sown deeper in sandy than clayey soils

SEEDING METHODS

- **Broadcasting** – even spreading of seed on top of seedbed; manual or mechanized
- **Drilling** – depositing seed in a row at a uniform depth in a seedbed using equipment; greater seeding precision
- **Dibble** – seeds are sown in more/less uniform distance. No land preparation is needed before planting. Only the area where the hole will be made is the one cultivated. Done in hilly areas.

METHODS OF RAISING RICE SEEDLINGS

- **WETBED METHOD** – seeds are sown on raised beds with continuous irrigation water; seedlings are ready for transplanting in 25-30 days

- **DAPOG METHOD** – pre-germinated seeds are sown in cemented or puddle soil covered with banana leaves or plastic sheet; seedlings are ready for transplanting in 10-14 days
- **DRY-BED METHOD** – only applicable in rainfed areas wherein seedbeds are prepared followed by sowing of seeds; seedlings are ready for transplanting in 20-40 days

SEED ANALYSIS/TESTING – a procedure for gathering pertinent information about a seed, its capacity for establishing a stand of seedlings.

METHODS OF SEED VIABILITY TESTING

STANDARD GERMINATION TEST

- **Rug doll method or rolled-towel test** – seeds are arranged in rows and rolled up. The rolled material is placed in a germinator at 90% RH at 26°C for 16 hours, then another 8 hours at 30°C for one to several weeks.
- **Seedbox method** – seeds are sown in previously sterilized soil.
- **Petri dish method** – seeds are placed in absorbent material in the dish.

TETRAZOLIUM TEST

- a colometric test in which the biochemical reaction causes the test solution to change color under certain conditions. Respiring and viable seeds will change color to red; dead or non-respiring seeds remain colorless.

SEED PURITY TEST - seed purity is the percentage pure seed (only the seed of the desired kind without contaminants) in the sample tested

ASEXUAL PROPAGATION AND NURSERY PRACTICES

NATURAL VEGETATIVE PROPAGATION

Vegetative propagation by roots

- tuberous and developed adventitious buds that grow into leafy shoots called slips
- radish, carrot, dahlia, tapioca

Vegetative propagation by stems

- when aerial weak stems like runners and stolons touch the ground, adventitious roots grow
- when the connection with the parent plant is broken, the portion with the newly struck roots develops into an independent plant

Vegetative propagation by leaves

- *Bryophyllum* plantlets are produced from the notches of the margin of intact leaves, still attached to the parent plant
- in other species of *Bryophyllum*, the leaves must be detached or injured before plantlets arise.

Vegetative reproduction from reproductive organs

- in Agave, the flower bud becomes modified structures called bulbils; bulbils are fleshy storage food in the floral leaves and drop from the parent plant to the ground, give out adventitious roots, and develop into new plants.

Artificial Vegetative Propagation

- combining the good qualities of two different varieties
- propagating the desirable variety of plants economically, with the least attention and in a comparatively shorter time.

16 SPECIAL PRACTICES IN CROP PRODUCTION

WINDBREAK – rows of trees or shrubs that protect crops from strong winds
SHADING – required for normal growth and development for sciophytes
HARDENING – exposing young plants slowly to the outdoor environment
PRICKING – transfer of seedlings from overcrowded container to another container
ROUGING – removal of off-type or diseased plants
MULCHING – placing mulch (a protective layer made of either organic or inorganic material) over the soil
PRUNING – removal of plant parts to attain a specific objective (preventive, formative, corrective)

TYPES OF PRUNING

a. **HEADING-BACK** – the cuts are made at the terminal portion of the plant; capitalizes on "apical dominance"
b. **THINNING-OUT** – the complete removal of any number of branches; the remaining branches retain their apical dominance, suppresses the development of the lateral buds and grow into sturdy boughs.
c. **FRUIT THINNING** – removal of some fruits to minimize inter-fruit nutrient and assimilate competition
d. **DEBLOSSOMING** – removal of flowers on the young woody plants to have full canopy development
e. **RATOONING** – growing of a new crop out of the shoots arising from the previous crop
f. **DESUCKERING** – removal of unnecessary slickers from the base (mat) of banana or abaca
g. **TRAINING** – bending, twisting, and tying of plants to support structures
h. **TRELLISING** – providing structural support to plants so that stems, leaves or fruits are kept away from the ground and plants are more exposed to sunlight; arbor or overhead type, fence type, pole type, T-type, A-type, teepee type
i. **PROPPING** – providing support to bunches or stalks which tend to bend due to heavy load of fruits' single pole, double pole, cable propping

j. **FRUIT BAGGING** – wrapping fruits either individually or as a group with newspaper, jute sack or PEB to prevent damage from pests, diseases, and strong winds
k. **LATEX STIMULATION** – use of Ethrel to stimulate latex production of old rubber trees
l. **FLOWER INDUCTION** – hacking (wounding trunk of mango tree to release ethylene); smudging (smoky fire below mango tree canopy); potassium nitrate (carabao, pico and pahutan mango cultivars); calcium carbide or Ethrel (pineapple)
m. **POLLINATORS** – increase percentage of seed setting
j. **CONTROL OF SEX EXPRESSION** – maleness (long days, high temperatures, gibberellins); femaleness (short days, low temperatures, auxin, and ethylene)
k. **DISTANCE ISOLATION** – maintain genetic purity and avoid seed variability especially in cross-pollinated plants
l. **TIME ISOLATION** – at least 3 weeks difference in time flowering

17 HARVESTING AND POSTHARVEST

HARVESTING

- separation of the economic yield (whole plant biomass or portion of the whole plant biomass when a crop has reached highest or optimum level of productivity (physiological maturity onwards)
- cutting or collecting of crops from the field which can either be done by hand, harvesting tools, machines, etc. depending on the technical and economic factors

TYPES OF MATURITY

- **PHYSIOLOGICAL MATURITY -** development stage of the crop when it has developed the ability to ripen normally after harvest
- **COMMERCIAL MATURITY -** the stage of development of plant parts preferred by the consumer

MATURITY INDICES

- signs or indications of the readiness of the plant for harvest
- used to determine maturity and predict harvest date
- used to assess quality of crop; ensure sensory quality (flavor, color, aroma, texture) and nutritional quality
- ensure an adequate postharvest shelf life
- facilitate scheduling of harvest and packing operations

METHODS OF DETERMINING MATURITY

1. **Subjective Method**

a. **Visual –** color, size, shape, angularity or fullness, change in appearance or drying of plant parts
b. **Physical –** use of taste, smell, touch, force, and sound to determine maturity

2. **Objective Method**
   a. **Chemical/Compositional -** measurement of chemical constituents like total soluble solids (TSS), titratable acid (TA), ratio between solids or sugars and acid, oil content and starch content
   b. **Physiological -** determination of rates of respiration and ethylene production
   c. **Phenological -** age of fruit in terms of number of days to harvest from a point of reference such as anthesis, shooting, flower induction
   d. **Physical -** measurement of dimensional fullness or diameter of fru

AGE-RELATED/PHENOLOGICAL

Number of days from planting to maturity

- Days from flower induction (mango)
- Days from anthesis (durian, beans)
- Days from shooting (appearance of false hands in banana)
- Head units/growing degree days (GDD)

MORPHOLOGICAL

- Change in peel color (pineapple, lanzones, tomato)
- Change in pulp color (mango, tomato)
- Drying of plant part (banana, onion, ginger, potato)
- Flattening of eyes (pineapple)
- Development of abscission zone (melon, durian)
- Greater prominence of netting (melon)
- Appearance of bloom (mango, grapes)
- Increase in size (eggplant, cucumber)
- Fullness of pods (cowpea, peas, snap beans)
- Change in shape (banana, mango)
- Compactness of curd/bud (cauliflower, broccoli)
- Bud opening (roses)
- Bud opening change in angularity of fingers
- Appearance of corky spots (banana)
- Development of waxy layer on the epidermis (plum, grape, melon)
- Formation of gel-like material surrounding the seeds (tomato)
- Prior to tip opening (asparagus)

METHOD OF HARVESTING

- pulling
- twisting
- using knife
- shaking of branches
- harvesting aids/tools
- ladder
- picking pole
- catching net
- rope

POSTHARVEST HANDLING – the movement of farm products or operations through which the commodities undergo from harvest to possession by the final consumer

POSTPRODUCTION TECHNOLOGY – practices and operations from harvesting to consumption; aim is to deliver good quality products

PRIMARY PROCESSING – original plant part can still be recognized

SECONDARY PROCESSING – conversion of produce into more stable forms that can no longer be changed into other forms

TYPES OF SECONDARY PROCESSING

- **Heat sterilization** – canning
- **Dehydration** – dried fruits and vegetables
- **Fermentation** – pickling, wine making, vinegar making
- **Freezing** – frozen fruits and vegetables

POSTHARVEST HANDLING

Types of crop based on postharvest characteristics:

- **Durables** – low moisture content (less than or equal to 14%); corn, rice, mungbean
- **Perishables** – high moisture content (80-95%); fruits, vegetables, ornamentals

KINDS OF PACKAGE

- **Flexible** – burlap or gunny sacks, mesh or net bags, PEBs, palm leaves, sacks of woven plastic fabric
- **Rigid and semi-rigid** – bamboo and rattan baskets, wooden crates, cartons, wood-paper laminated container, plastic crates, foamed plastic boxes

Shelf-life of perishables can be prolonged by

Evaporative cooling

- perishables give off heat during respiration and when a source of heat is within the vicinity, heat given off is used in evaporating water resulting in a drop in temperature and an increase in relative humidity

Modified atmosphere (MA) storage

- respiration of the produce modifies the atmosphere; uses any of low-density polyethylene (LDPE), polyvinyl chloride (PVC), polypropylene (PP), waxes, temperature-compensating packages, and vacuum or hypobaric packaging

Controlled atmosphere (CA) storage

- the supply and level of carbon dioxide and oxygen are manipulated through gas generators and appropriate control devices in properly designed storage structures

Biological factors involved in deterioration

a. Respiration
b. Ethylene production
c. Compositional changes
d. Transpiration or water loss
e. Condition of crops
f. Growth and development

Environmental factors involved in deterioration

a. Temperature
b. Relative humidity
c. Atmospheric composition
d. Ethylene
e. Light
f. Sanitation

- **CLIMACTERIC** – harvested at optimum maturity and ripened after harvest; show dramatic changes after harvest – apple, avocado, banana, mango, peach, pear, plum, tomato
- **NON-CLIMACTERIC –** continuously declining rate of respiration from maturation to the end of senescence; no burst of Rs during postharvest; harvested ripe and ready for consumption – bell pepper, cherry, citrus, grapes, pineapple, snap bean, strawberry, watermelon

Degreening – process of hastening the peel color change from green to orange or yellow of citrus fruits which have attained full flavor and aroma

Vapor pressure treatment - pressure exerted by water vapor in a given space or atmosphere; mangoes exported to Japan undergo this treatment

Aril – the fleshy edible pulp adhering to seeds of fruits e.g. rambutan, durian and lanzones

Commercial maturity of a commodity – the stage of growth when a commodity has developed sufficient desirable characteristics to make it marketable or desirable for its intended purpose

Curing – process of toughening and self-healing of bruises and skinned areas in root and tuber crops or the rapid closing of the neck of bulb crops under favorable conditions

Dehaulming – cutting or killing of potato vines a week before harvesting

Fumigant – chemical which, at required temperature and pressure, can exist in the gaseous state in sufficient concentration to be lethal to a given pest organism

Grading – classification into groups according to a set of recognized criteria of quality and size, each group bearing an accepted name and size grouping.

Horticultural maturity – commercial maturity

Internal breaking of mango – white starchy area in the middle portion of the pulp near the seed of a ripe fruit, sometimes with air pockets in the middle of the starchy areas

Precooling – the rapid cooling (48hr or less) of a commodity to a desired transit or storage temperature soon after harvesting before it is stored or moved in transit

Shelf life – post-storage market life

Sorting – classification of commodity into groups, designated by the person classifying the produce either according to a set criteria or whatever criteria he may desire

Standardization – formulation and issuance of grade standards in the country or industry

Vascular streaking – browning of tissues about a centimeter below the peeled surface of a cassava viewed cross-sectionally

Waxing – the application of a thin film of surface coating to fruits and vegetables; the coating may or may not be wax but usually the term wax is used synonymously with surface coatings or protective skin coating

Water elimination – the drying of surface moisture after washing or waxing or when commodities are harvested wet

Topping – the removal of leaf sheaths in abaca

Tuxying – the separation of the strong mechanical bundles from the weaker fibrovascular bundles

18 SUSTAINABLE CROP PRODUCTION

SUSTAINABLE AGRICULTURE

An integrated system of plant and animal production with site-specific applications that aims to:

- satisfy human food and fiber needs
- enhance environmental quality and natural resource base upon which the agricultural economy depends
- make the most efficient use of non-renewable resources and on-farm resources and integrate, where appropriate, natural biological cycles and controls
- sustain the economic viability of farm operations, and enhance the quality of life for farmers and society as a whole

SUSTAINABILITY

- a system's ability to maintain productivity despite major disturbance such as intense or large perturbation
- a system's capacity to maintain output at a level approximately equal to or greater than its historical average, with the approximation determined by its historical variability.

CHARACTERISTICS OF SUSTAINABLE AGRICULTURE

FLEXIBLE

- no defined set of practices, methods, techniques/technologies or policies
- recognizes local specificity

EXPERIENTIAL

- does not impose a simple model or package
- farmers and local communities must be able to adapt and be allowed to change

PARTICIPATORY

- farmers are active participants
- incorporates recent innovations originating from scientists, farmers or both
- relies on continuous innovation by farmers and local communities

PROACTIVE

- forward-looking
- concern for short and long-term sustainability
- dynamic and innovative

FEATURES/ATTRIBUTES/DIMENSIONS OF SA

- **Continuously Evolving**
  - non-permanent
  - dynamic
- **Gender-Sensitive**
- **Ecologically Sound and Friendly**
  - environmentally/ecologically friendly farming practices
  - dynamic relationship between man and environment
  - improved standard of living for farmers without negative effects on the environment
- **Culturally Appropriate**
  - culturally sensitive
  - documentation, validation, promotion and use of indigenous knowledge system
- **Economically Viable**
  - economically viable system and practice
- **Location Specific**
  - appropriate/practical technology
- **Resource-Based**
  - community-based management of resources
  - control of resources
  - enhance/protect what is available or remaining
  - use of indigenous technical knowledge
- **Social Equity**
  - socially just and humane
  - enhance community participation and harmony
  - socially acceptable
- **Holistic Approach**
  - holistic/integrated
  - diversified farming
  - location specific
  - system with no leak
- **Enhances Human Values**

FOCUS FOR ACTION IN SUSTAINABLE AGRICULTURAL FRAMEWORK:

- long term sustainability rather than short term benefits
- provide internal solutions to internal problems rather than external solutions to internal problems
- emphasis on management solutions to problems rather than merely on technological solutions to the problems
- responsive to feedback, belief in accountability and participatory rather than detachment
- low rather than high external input
- emphasis on systems approach rather than on individual commodities and monoculture
- relies on available indigenous resources and self-reliance rather than capital intensive

- use of technologies that preserve and enrich the natural resource base rather than the use of technologies that exploit and destroy the natural resource base
- recognize location specificity of technologies, use of appropriate and indigenous technologies

BIODYNAMIC FARMING OR BIODYNAMIC AGRICULTURE

- emphasizes on many of the forces within living nature, identifying many of these factors and describing specific practices and preparations that guide the decomposition process in manure and compost (spiritual insights of Dr. Rudolf Steiner)

BIOLOGICAL farming/Ecological farming

- minimal use of chemicals for the control of crop pests

NATURAL FAMING

- no tillage, no fertilizers, no pesticides, no weeding, no pruning and remarkably little labor by careful timing of seeding and combination of crops (polyculture)

KYUSEI NATURE FARMING

- (Developed by Terou Higa of Japan, which means saving the world) uses beneficial microorganisms and inoculants to increase the microbial diversity, health and yield of crops

PERMACULTURE OR PERMANENT CULTURE

- (coined by Bill Mollison in 1970) produces efficient low-maintenance integration of plants, animals, people and structure applied at the scale of a home garden, all the way to a large farm

ORGANIC FARMING

- (first used by Lord Northbourne) shuns the use of synthetically compounded fertilizers, pesticides, growth regulators and livestock activities

REGENERATIVE AGRICULTURE

- enhances regeneration of renewable resource to achieve a sustainable form of agriculture

PRECISION FARMING/AGRICULTURE/PRESCRIPTION FARMING/SITE SPECIFIC MANAGEMENT

- employs detailed site-specific information to precisely manage production inputs; to know the soil and crop characteristics unique to each part of the field, and to optimize production within small portions of the field that uses computers, telecoms and global positioning systems (GPS), etc.

19 FARMING SYSTEMS

FARM – a highly organized integrated set of operations that exists in a complex of natural, social, political and economic environment

FARMING SYSTEM

- the manner in which a particular set of farm resources is assembled within its environment by means of technology for the production of primary agricultural products, excluding postharvest handling/processing and marketing

- a farming pattern or mix of farming enterprises that a family allocates its resources (land, labor, capital) to efficiently exploit the existing environment (rainfall, soil properties, solar radiation, market, credit infrastructures and service institution) for the attainment of the family's goal (increase income, improve quality of life, etc.

- a complex, inter-related matrix of soil, plants, animals, implements, power, labor, capital and other inputs controlled in part by families and influenced to varying degrees by social, economic, institutional and social forces that operate at many levels

- the scientific integration of different interdependent and interacting farm enterprises for the efficient use of land, labor and other resources for a farm family which provides year-round income to the farmers especially located in marginal zones.

- Represents an appropriate combination of farm enterprises viz. cropping system, livestock, poultry, fisheries, forestry and the means available to the farmer to raise them for increasing profitability.

TYPES OF FARMING SYSTEM

- **Based on Enterprise Mix(es)** – monocropping or diversified farming (multiple cropping systems)
- **Based on the Dominant Crop(s)** that form the major enterprise (rice-based, coconut-based, etc.)
- **Based on Agro-environment**
  - Moisture regime/water source – rainfed or irrigated
  - Topography – lowland or hilly farming e.g. Agroforestry and SALT
  - Elevation/Altitude – high land, hilly land, lowland
- **Based on Use of Farm Inputs**
  - **High External Input (HEI) FS** – associated with modern agriculture (green revolution) characterized by the use of chemical fertilizers, pesticides and HYV seeds
  - **Low External Input (LEI) FS** – biodynamic farming, permaculture, nature farming, etc. which are purest and pursue farming chemical free
- **Based on the Central or Unique Feature of the Farm**
- **Evolving Type of FS**
  - Crop Centered
  - Livestock Centered (ruminants, non-ruminants)

- Integrated Crop + Livestock
- Integrated Crop + Aquaculture
- Integrated Livestock + Aquaculture

- **Specialized FS**
  - Production of high-value cutflowers (anthurium, orchids, etc.)
  - Aquaculture – fingerling production, aquarium fish, etc.

GENERAL TYPES OF FARMING SYSTEM

- **Lowland Farming System** – crop or animals (including fish) production in paddy fields or swampy areas, where there is a continuous or regular availability of water e.g. lowland rice

- **Upland Farming System** – growing of crops and/or animals in relatively flat or plain areas where water is not regularly available except through precipitation (rainfall) or irrigation

- **Agro-forestry** – culture of crops and animals in any combination, together with a woody perennial; includes areas that are flat or sloping.

- **Highland Farming System** – growing of crops and/or animals in agricultural areas that are at least 800-1000m above sea levels, characterized with relatively lower temperatures throughout the year; oftentimes interchanged with hilly lands because of their similar topographic features

- **Dry Farming or Dryland Farming System** – growing profitable crops without irrigation in areas that receive an annual rainfall of 500 mm or less

- **Dryland Agriculture** – crop cultivation entirely under rainfed condition, with three groups/classifications on the basis of annual rainfall

SHIFTING CULTIVATION SYSTEM

- the shifting of fields within a large area of wild vegetation results in the gradual relocation of the farming population. Consequently, cultivation shifts within an area that is otherwise covered by natural vegetation.

TYPES OF SHIFTING CULTIVATION SYSTEM

a. **ROTATION SYSTEM**
   - practiced by migrating and sedentary cultivators
   - cropping and fallowing are alternate, with regular or irregular pattern
   - with regular sequence, a definite number of cultivation and fallow years

b. **MIGRATION SYSTEM**
   - the continued movement of cropping results in a slow migration of the population

c. **VEGETATION SYSTEM**
   - based on vegetation between shifting cultivation of forest, savanna, and grassland in the area

d. **CLEARANCE SYSTEM**

- the type and order depend upon the vegetation to be cleared, rainfall distribution, the crops grown, the available tools and the cultural background of the population.

Forms of Clearance System

- **Burn and plant** – the thick and secondary vegetation are burned, then corn is planted and harvested before the secondary vegetation recovers from burning.
- **Cut, burn, plant** – the most common: the vegetation is cut, usually towards the end of the dry season, and allowed to dry. Towards the rainy season, the dry organic material is burned and the soil is prepared for planting.
- **Cut, plant, burn** – the vegetation residue in the field is burned when the crops are already growing, done only in forest areas. Usually, the crops grown are bananas, plantains or cassava. Little damage is inflicted on the growing crops when burning is done.
- **Burn, hoe and cut, plant** – done in savanna areas where fire effectively eliminates most of the vegetation. Cutting is limited to the remaining trees and bushes.
- **Cut, bury refuse in mounds, plant** – the cut vegetation is buried in mounds, or the debris is burned first and the ashes are buried.
- **Cut, add extra wood, burn, plant, hoe** – bush from a greater area than to be planted is cut to obtain a hotter fire and a large amount of ash on the land to be sown.
- **Cut, wait one season, plant (forest)** – the vegetation is partially cut and bananas are planted. A season is allowed to pass before the clearing operation and planting other crops among the established bananas are completed.
- **Killing trees by ringing, ridging, planting** – instead of clearing, the trees are ringed. The leaves shed off and vegetation on the ground are dug into the ridges. The trees are never felled, but left as dead, standing timber.

FALLOW SYSTEMS

- characterized by defined holdings with largely permanent field divisions; semi-stationary housing predominates, with families having registered ownership of the land. With hoe as the main tool, cultivation is often in the form of soil-conserving and yield-maintaining but labor-demanding ridge or mound culture.

TYPES OF FALLOW SYSTEM (ACCORDING TO FALLOW VEGETATION AND ALTITUDES)

BUSH FALLOW SYSTEM – common in humid and semi-humid tropical lowlands and often related to tree-crop development.

- **Evolutionary type** – evolved out of shifting cultivation if the planting of tree crops gives rise to stationary housing. More and more land are taken by permanent crops and by food crops, less and less remain for fallows.

- **Involutionary type** – developed out of the evolutionary type where subsistence cropping increases rapidly without adequate application of fertilizer. The competition for limited land between tree crops (for cash) and food crops becomes acute.

SAVANNA FALLOW SYSTEM

- In highly fertile alluvial or volcanic soils in tropical regions with high rainfall, the cultivator's problem is more in controlling weeds than low soil fertility. Consequently, fallow years may be replaced by more labor input, and cultivators change from shifting to fallow system wherever cash cropping or concentration of population demands more intensive land use.

- Fallow systems in badly leached soils in the savanna where the fallow vegetation is predominantly *Imperata cylindrica*.

FALLOW SYSTEMS AND UNREGULATED LEY SYSTEMS IN SEMI-ARID AREAS – as cultivation spreads at the expense of fallows, forest or bush vegetation gives way to the cultivation of large areas of grass fallow, often dotted with patches of bush.

Unregulated ley systems in high altitude areas – greatly reduced dependence on fallow is the outstanding feature of the agricultural system in temperate, high altitudes. Suitable parts of the grazing areas are cropped for few years and then left to go back to grass.

LEY SYSTEMS – "Ley" is used wherever several years of arable cropping are followed by several years of grass and legumes for livestock production.

- **Unregulated** – characterized by a natural fallow vegetation of various grass species, a certain amount of bush growth on the pasture, communal grazing and a lack of pasture management, which make such system often more like short term fallow systems than to regulated ley system.

- **Regulated** – characterized by individual grazing, fencing, pasture management and rotational use of the grassland.

Types of Ley Farming

- **Regulated ley system in smallholder areas** – a rotation that includes intensively grazed grass fallows and a grass-type crop producing seeds for human consumption and valuable straw for cattle feeding.
- **Regulated ley system in large areas** – most of the established ley systems are found in large mechanized farms where bush and stumps have been removed. Their profitability depends on modern systems of animal husbandry, which are more easily introduced in large than in small farms.
- **Regulated ley system in settlement schemes** – the organization of production within settlements is usually considered as an instrument for introducing the complete set of innovations required to cope with the demands of recent technology.

SYSTEMS WITH PERMANENT UPLAND CULTIVATION – a continuous expansion of arable farming at the expense of the fallow or ley leads to systems with permanent cultivation. Permanently cultivated upland areas are often a supplementary activity in areas predominantly devoted to irrigation farming or tree crops e.g. lowland rice in valleys combined with permanently cropped upland areas on the slopes.

TYPES OF PERMANENT UPLAND SYSTEM

- **Permanent cultivation in humid climates** – presents some problems in tropical agriculture, and the traditional solution is gardening especially where the population density is very high, labor is cheap, and there is access to market.
- **Permanent cultivation in semi-humid climates** – usually mixed, often in combination with irrigated plots. Fodder production, manuring, terracing and other soil-preserving measures are applied but are normally insufficient to maintain soil fertility at its original level.
- **Permanent cultivation in semi-arid climates** –permanent cultivation in the tropics is mostly in semi-arid areas where there is less serious leaching problem. There are areas that are cropped annually by rainfed agriculture. Almost all of it is production is at a low level of output with high drought and erosion risks.
- **Permanent cultivation in tropical highlands** – the evolution path of arable land-use in densely populated tropical highlands is similar to that in moderate climates: shifting cultivation --- unregulated ley systems --- permanent arable cropping.

SYSTEMS WITH ARABLE IRRIGATION FARMING – reduce the length and the frequency of the period in which a lack of moisture is the limiting factor to plant growth.

SYSTEMS WITH PERENNIAL CROPS – primarily tree and shrub crops

20 CROPPING SYSTEMS

CROPPING SYSTEM – pattern or arrangement of crops in time and space and the process of growing them.

POLYCULTURE FARMING SYSTEM – the mixture of annual crops with other annuals, annuals with perennials, or perennials with perennials, or perennials with perennials planted in spatial pattern

CROPPING PATTERN – the yearly sequence and spatial arrangement of crops or of crops and fallows on a given area.

A. MONOCROPPING – only one crop is grown annually in the same parcel of land (perennial monoculture and annual crop monoculture)

- **Monoculture** – only one crop is grown in a given area throughout the year

TYPES OF MONOCULTURE

- **PERENNIAL MONOCULTURE**
  - planting of trees especially on steep slopes and heavy clay soils; rubber, ipil-ipil and coconut are suitable trees under this system.
- **ANNUAL CROP MONOCULTURE**
  - utilizes both upland and lowland annual crops like rice, corn and vegetables

B. MULTIPLE CROPPING – growing of more than one crop on the same land in one year.

TYPES OF MULTIPLE CROPPING

The intensification of cropping in time and space dimensions, is growing two or more crops on the same field in the year.

- **SEQUENTIAL CROPPING**
  - two or more crops in a sequence on the same field within a 12-month period, with the succeeding crop planted only after the preceding crop has been harvested such that a farmer manages only one crop at any time on the same field. A sequential cropping is denoted by a hyphen (-) between two succeeding crops.
- **Double cropping**
  - two crops in sequence, seedling or transplanting one after the harvest of the other – also called sequential cropping
- **Triple cropping**
  - three crops in sequence, seedling or transplanted one after the harvest of the other

- **Ratoon cropping**
  - the development of a new crop without replanting from buds on the root system, stubble or stems of the preceding crops, a harvest not necessarily for grains. Under certain conditions, rice can be a ratooned crop.

C. INTERCROPPING

- the growing of two or more crops simultaneously on the same field such that the period of overlap is long enough to include vegetative stage. Intercropping is denoted by a (+) sign between any two crops grown simultaneously.
- the growing of two or more crops simultaneously on the same piece of land, base crop necessarily in distinct row arrangement, or with or without a row arrangement (row intercropping or mixed cropping).
- includes alley cropping, strip cropping, contour cropping, paired row cropping, skip cropping, parallel cropping, companion cropping, multi-storey cropping and synergetic cropping.

MAJOR INTERCROPPING SYSTEMS

- **PARALLEL CROPPING**
  - cultivation of crops that have different natural habitat and zero competition
    e.g. mungbean (30-35 days after sowing) + maize (50 days after sowing)
- **COMPANION CROPPING**
  - intercropping where the production of both intercrops is equal to that of its solid planning
    e.g. mustard/potato/onion + sugarcane
- **MULTI-STOREY/MULTILEVEL**
  - cultivation of two or more crops of different heights simultaneously on a certain piece of land in any certain period
    e.g. sugarcane + mustard + onion/potato
- **SYNERGETIC CROPPING**
  - the yields of both crops are higher than of their pure crop on unit area basis
    e.g. sugarcane + potato

D. RELAY CROPPING

- growing of two or more crops together, but seedling or transplanting the succeeding one after flowering and before the harvest of the former crop. If the planting of the second crop is done before the flowering stage of the first crop, the cropping pattern is intercropping. Relay cropping is denoted with a slash (/) between crops.

E. Other types of Cropping Pattern

- **STRIP CROPPING**
  - two or more crops simultaneously in separate plots arranged in strips that can be independently cultivated

- **SORJAN CULTIVATION**
  - crop cultivation in parallel beds and sinks wherein lowland crops are planted in the sinks and upland crops are grown in beds. Two successive upland crops can be grown in beds during the year and the rice crops in the sinks.

- **ALLEY CROPPING**
  - alternate succession of the strips or hedgerow cropping of perennial crops established along the contour of the slope and an open space or alley which is devoted to annual agricultural crops.

LIMITATIONS OF MULTIPLE CROPPING

ALLELOPATHY
- the detrimental effects of higher plants of one species on the germination, growth or development of plants of other species.

MORPHOLOGICAL DIFFERENCES
- the differences in form or structure of the component crops. The morphological difference is primarily related to "mutual shading", which in turn is directly related to photosynthesis.

SALT CROPPING SYSTEM – prevents soil erosion, improves soil fertility and provides a continuous income from diverse crops planted on a hilly land.

AGROFORESTRY – a land-use system where agricultural crops and/or livestock and forest trees are raised one the same land either sequentially through rotational use or simultaneous.

CROP ROTATION – the growing of different crops in a definite order of succession on the same land. The crops in rotation form a mutual and beneficial allelopathic relationship.

LOW EXTERNAL INPUT AGRICULTURE (LEISA) – a low resource, resource-poor, undervalued resource agriculture wherein properties of the physical environment and/or commercial infrastructure do not allow widespread purchase of inputs.

INTEGRATED FARMING SYSTEMS AND INTEGRATED FOOD AND FARMING SYSTEMS – included are the goals of finding and adopting integrated and resource-efficient crop and livestock systems that maintain productivity that are profitable and protect the environment

21 SOIL FERTILITY MANAGEMENT

CROP NUTRITION – very important aspect of crop production; nutrient should be present in proportionately balanced condition, and if any one element is lacking, it should be made available in the soil.

FERTILIZER APPLICATION METHODS

- **BROADCAST** – application is at final harrowing, done either by hand or with the use of a "cyclone spreader"
- **BAND APPLICATION** – fertilizer is applied in a strip 2-3 cm beneath and to the side of the location of the seed during seeding.
- **SIDEDRESSING AND TOPDRESSING**
  - **SIDEDRESSING** – placement of fertilizer along the rows near the base of the plant
  - **TOPDRESSING –** N fertilizers are applied to juvenile crops and are broadcast over the growing plants
- **LOCALIZED PLACEMENT** – placement of fertilizer-centered mudballs in flooded soils; one mudball (urea) is plunged 10-12 cm deep for every four rice seedlings placed spaced at 20 x 30cm which are applied immediately after transplanting
- **FOLIAR APPLICATION** – dissolving the fertilizer material in water and applying it as a spray to plants; is effective in correcting trace element deficiency at critical stages of the crop.

OTHER SOURCES OF NUTRIENT

- **ORGANIC FERTILIZERS** (compost) 1-7%N, 2-13%P_2O_5 and 1-10% K_2O from plant and animal sources
- ***TRICHODEREMAHARZIANUM*** – speeds up decomposition of compost materials (1 ton of compost material needs 10 kg of Trichoderma inoculum)
- **GREEN MANURE** – biomass produced by an N-fixing legume crop plowed under at ear flowering time to serve as source of nutrient to the succeeding crop
- ***AZOLLA*** (*Anabaena azolla*) – water fern that grows symbiotically with blue-green algae; can produce 30T/ha in one growing season equivalent to 150kg of N/ha

LIMING – application of lime to correct soil acidity; ideal pH range is from **6.0-6.5**

DECLINE IN SOIL FERTILITY

- **SOIL EROSION** – physical loss and displacement of the fertile topsoil; categorized into four types:
  - **Geological erosion** – a natural erosion process that leads to soil formation and processes that maintain the soil into a favorable balance suitable for crop growth
  - **Wind erosion** – caused by extreme wind speeds
  - **Water-borne erosion** – caused by rainfall and runoff (emitted interflow and overflow)

- **CROP REMOVAL**
- **CONVERSION OF NUTRIENTS TO UNAVAILABLE FORMS**
  - Combination with other elements forming insoluble forms
  - Microbial mediated transformations
  - Volatilization
  - Leaching

NUTRIENT UPTAKE MECHANISM

- **PASSIVE**
  - ions move with water without metabolic involvement
  - the characteristics of the apoplast (non-living) path determines the rate of passive uptake of nutrients
  - transpiration creates the force necessary for the ascent of sap
- **ACTIVE**
  - ions cross the plasmalemma with the involvement of metabolic energy from ATP and ions move from one cell to another through the plasmodesmata
  - moves ions from a region of lower concentration to a region of higher concentration

FACTORS AFFECTING NUTRIENT UPTAKE

- **Availability of nutrients**
  - partly determined by the pH of the solution
  - some nutrients are chemically bound at low or high pH forming insoluble compounds
- **Stage of growth and development**
  - uptake varies depending on the demand by growth rate
  - at late stage of development, the uptake of nutrients declines due to the declining demand and also due to remobilization of certain elements.

Symptoms of Nutrient Deficiency

Deficiency symptoms for any element depend largely on:

- Function of the element
- Whether or not the element is readily translocated from old to younger leaves

- **Nitrogen** – plant is light green, lower leaves are yellow, drying to light brown color; stalks are short and slender (if deficiency occurs at late stage of growth)
- **Phosphorus** – plant is dark green with red and purple colors; stalks are short and slender (later stage of growth)

- **Potassium** – mottled or chlorotic leaves with large or small spots of dead tissue usually at tips and between veins, more marked at leaf margin; slender stalk
- **Magnesium** – localized mottling or chlorosis with or without spots of dead tissues on lower leaves; chlorotic leaves may redden as in cotton; tips and margins of leaves cup upward; stalks are slender
- **Zinc** – generalized spots, enlarging between veins and eventually involving secondary and primary veins; leaves are thick; stalks have short internodes
- **Calcium** – tips of young leaves typically hook, then the tip and margins die; finally, terminal bud dies
- **Boron** – base of young leaves of terminal bud is light green; the leaves become twisted at later growth, then stem at terminal bud dies
- **Copper** – permanent wilting of young leaves without spots or chlorosis; if deficiency is severe, twigs could not stand erect
- **Manganese** – spots of dead tissues are scattered over the leaf; smallest veins tend to remain green and produce checkered effect
- **Sulfur** – tissues between veins of young leaves are light green; dead spots are not common
- **Iron** – young leaves are chlorotic but the primary veins are typically green; stalks are short and slender

22 WATER MANAGEMENT

WATER – essential and critical input in crops in all stages; the medium with which nutrients are absorbed by plants

METHODS OF IRRIGATION

- **SURFACE IRRIGATION** – water is allowed to pass through the soil surface towards the root zone of the plant
- **FURROW METHOD** – done through the furrows; applicable in gentle slope and soils with high water-holding capacity
- **BASIN METHOD** – water is directly applied on soil surface over the root zone, forming some sort of a basin; can be done on hilly lands with 60-70% efficiency

  - **SPRINKLER SYSTEM** – uses water more efficiently since water is applied in small droplets, requires smaller volume of water and adopted in various slopes and soils; 70-80% efficiency
  - **DRIP SYSTEM OR TRICKLE METHOD** – delivers water through a network of pipes attached to the drippers or nozzles which efficiently regulate the flow of water directly into the root zone; can be combined with fertilization (fertigation) and pesticide application; requires water filtration system to avoid clogging of nozzles and high capital investment; most efficient (80-90%)

MANAGING SOIL MOISTURE

- If water supply is limited, select crops that will grow well under drier conditions (mungbean, cassava, eggplant).
- Select short-term vegetable crops that can be grown near a source of water such as a water well, the drain from washing areas or a water tank.
- Where feasible and affordable, use drip irrigation systems (such as the bucket system) to maximize water usage efficiency.

MANAGING SOIL MOISTURE IN THE DRY SEASON

- Above the soil surface: cover the soil around the plants with a mulch of leaves, cut grass or rice straw.
- If plastic mulch is used, only silver-coated ones should be used since black mulches heat up too much and can cause burning of stems and other plant parts.
- Provide young plants with shade to keep them cool.
- Remove weeds because they compete with the plant's moisture intake.
- Below the surface: incorporate compost or inorganic material in the soil. One large sack of composted organic material should be sufficient for an area of about $10m^2$. Use one sack at the start of the wet season and one sack at the start of the dry season.

MANAGING SOIL MOISTURE IN THE WET SEASON

Above the soil surface:

- Plant crops in high beds to improve aeration and to avoid water logging.
- Plant crops that grow in wet areas such as taro and kangkong.
- Use coconut fronds or other materials to protect young plants and those with tender leaves from heavy rain.

- Grow vine plants up on to a trellis.

23 FARM ENTREPRENEURSHIP

BREAKEVEN YIELD (BEY)

$$\text{BEY} = \frac{\text{Total cost}}{\text{Unit price}}$$

- Farmer needs to produce BEY to cover production costs.
- Yield below BEY implies loss while yield above BEY implies profit.

COST TO PRODUCE A KILOGRAM

$$\text{Cost/kg} = \frac{\text{Total cost/ha}}{\text{Yield in kg/ha}}$$

- With the same total cost and if yield is higher, unit cost proportionally decreases.

RETURN ON INVESTMENT (ROI) = (Total income or gross return)/(Total cost excluding interest expense) where

$$\text{ROI} = \frac{\text{Total income or gross return}}{\text{Total cost excluding interest expense}}$$

wherein **Total cost or gross return = Yield x Unit Price**

- ratio that indicates how much the return per unit cost is.
- An ROI of P2.25 means that P1.25 was earned for every P1.00.

24 TROPICAL LANDSCAPING

LANDSCAPING

Selecting, arranging, and growing plants together with the landscapes for aesthetics, privacy, and pleasure.

MAJOR PHASES

a. Landscape design
b. Landscape implementation
c. Landscape maintenance

BASIC ELEMENTS OF LANDSCAPE DESIGN

a. **LINE** – extending many points on a plane
b. **FORM** – outline that an object creates; 3D effects
c. **TEXTURE** – visual roughness or smoothness
d. **COLOR** – visible pattern of the design
e. **LIGHT** – allows us to see a variety of intensity in colors, textures, lines and shapes
f. **VOLUME OR SPACE** – defines the boundary of a landscape

BASIC PRINCIPLES OF LANDSCAPE DESIGN

a. **BALANCE** – illusion of equilibrium around a real or imaginary central axis
b. **UNITY** – arrangement of planes that produce a single, harmonious design
c. **REPETITION** – using the same size, color, texture or form of material
d. **SEQUENCE** – transition from one area to another
e. **CONTRAST/VARIETY** – break monotony because of too much repetition
f. **EMPHASIS** – focus on dominant or accent features
g. **SCALE AND proportion** – relative size of plants and objects with a particular reference
h. **HARMONY** – pleasing relationship of objects within a landscape
i. **SCALE AND PROPORTION** – relative size of plants and objects with a particular reference
j. **HARMONY** – pleasing relationship of objects within a landscape

PLANTS USED IN LANDSCAPING

- **Ground covers** – plants used to cover the ground to minimize erosion
- **Edging plants** – low growing plants used to define pathways and shapes of planting areas
- **Specimen plants** – plants of special beauty or unusual quality grown to be exhibited alone
- **Accents/Focal point** – one or more plants used as prominent features in the garden
- **Barriers/Screens/Hedges** – plants that provide security and privacy
- **Foundation plants** – dense shrub grown near or along a building

25 RECOMMENDED CROP VARIETIES

There are public institutions and private seed companies that undertake research and development on varietal improvement of major crops. To rationalize the release of varieties emanating from different sources, a system of coordinated ecological trials is in operation since 1955 under the aegis of Philippine Seed Bank (PSB) now renamed National Seed Industry Council (NSIC).

The recommended varieties of crop are only those that have been grown widely in the country which include the following:

A. CEREALS

1. **RICE**: The breeding institutions are IRRI, UPLB, DA-BPI and DA-PhilRice.
   LOWLAND VARIETIES: C4-63 (G), BPI-76 (NS)
   IR 36, IR 42, IR 64, IR 66 (with salinity tolerance) PSB RC-2, PSB RC-4, PSB RC-6, PSB RC-8, PSB RC-10, PSB RC-12,
   PSB RC-14
   LOWLAND F1 HYBRIDS: PSB RC-26H, PSB RC-72H released by PhilRice
   LOWLAND GLUTINOUS VARIETIES: IR 29, IR 65, UPL Ri-1, UPL Ri-3
   RAINFED LOWLAND: IR 46, IR 52, UPL Ri-2
   UPLAND VARIETIES: C-22, IR 45, UPL Ri-5 (with acid sulfate tolerance), UPL Ri-7, PSB RC-1, PSB RC-16 (Ennano)

2. **MAIZE:** The institutions involved in varietal improvement are IPB-UPLB, DAQ and USM.
   The major private companies are Pioneer Overseas Corp-Phil, Cargill Phil, Inc., Ayala Agricultural Development Corporation, BM Domingo and Co., Inc. or Corn World Breeding System Corp and Asian Hybrid Corporation.

   OPEN-POLLINATED VARIETIES: yield 5-6 tons per hectare
   - **YELLOW FLINT CORN**: IPB Var 1 (Ginintuan), IPB Var 5, IPB Var 7, BPI LG Comp 1, USM Var 3, USM Var 5, USM Var 7 IES Cn 3
   - **WHITE FLINT TYPES**: IPB Var 2 (Tanco White), IPB Var 4, USM Var 10, USM Var 12, IES Cn 6, CMU Var 2

   F1 HYBRIDS: Pioneer 3228, SMC 305, SMC 301, IPB 911 (single cross), IPB 947 (3-way cross, IPB 9204 (3-way cross), IPB 921 (PSB 93-37), IPB 919 (PSB Cn 93-36), IPB 913 (PSB Cn 92-24), IPB 929 (PSB Cn 39-38), PSB Cn 93-42, PSB Cn 93-43, PSB CN 93-44, PSB Cn 93-45, PSB Cn 93-46, PSB Cn 94-54, PSB Cn 94-55, PSB Cn 94-56, PSB Cn 94-57, PSB Cn 94-58, PSB Cn 94-59, PSB Cn 94-60, FE 817, FE 820, FE 326, FE 325, BS 9754, BS 9881, BS 9889, TCT 961, TCT 311, TCT 393, TCT 377, TCT 1133, C-838, C-909, C-4043, AG 5355, AG 8351, AG 8353, AG 8360, AG 8362, P-30J32, P-3013, P-3B29, P-30A10, P-3013, P-3023, P-3014, C2 59, CW 208

   SWEET CORN: PSB Cn 93048 (3-way hybrid), PSB Cn 93-49 (sweet and waxy), or DLU Pearl Sweet, PSB Cn 94-52, PSB Cn 94-53

3. **TROPICAL WHEAT:** yields 1.6-1.8 tons/ha as grown in Northern Luzon: Trigo 1, Trigo 2, Trigo 3

4. **SORGHUM**: UPL S-5 (Cosor 5), PSB Sg 93-01 (USMARC 104), PSB Sg-92 (IES Sor 1), PSB Sg 94-02 (IES Sg 2)

B. SUGARCANE: The agencies involved in the breeding work are Sugarcane Regulatory Administration (SRA) and Victorias Milling Corporation (VMC).

Phil 66-14, Phil 56-226, Phil 72-70, Phil 78-1440, Phil 8361, Phil 8477, SRA 77-79, SRA 80-13, SRA 85-83, VMC 71-39, VMC 71-238, VMC 73-229

C. ROOT AND TUBER CROPS: with VisCA, IPB-UPLB

1. **CASSAVA:** UPL Cv 3 (Sultan 1), UPL Cv 4 (Vaqssourinha), UPL Cv 5 (Sultan 2), UPL Cv 1 (Datu), UPL Cv 2 (Lakan 1), Lakan 2, Lakan 3, Lakan 4, PSB Cv 8, PSB Cv 9, PSB Cv 10

2. **SWEET POTATO:** UPL Sp 1 (Kinabakab), UPL Sp 3 (Tinapay), UPL Sp 5 (G 113-2b), UPL Sp 2 (G50-1a), UPL Sp 4 (Cambel), UPL Sp 6, PSB Sp 16 (VisCA), PSB Sp 17 (VisCA)

3. **TARO (GABI):** PSB Vg 2, PSB Vg 3

4. **YAM (UBI)**: PSB Vt 2, PSB Vt 3

D. GRAIN LEGUMES

1. **MUNGBEAN**: mg 50-10A, UPL Mg 1 (Pag-asa), UPL Mg 3 (Pag-asa 3), UPL Mg 5 or Pag-asa 5 (for dry, wet and post rice planting), UPL Mg 7 (Pag-asa 7), UPL Mg 9 (Pag-asa 9), UPL Mg 11 (Pag-asa 11), BPI Mg 9 ((Taiwan Green)

2. **PEANUT:** UPL Pn 2 (Mekong), UPL Pn 4 (Biyaya 4), UPL Pn 8 (Biyaya 8), UPL Pn 10 (Biyaya 10), UPL Pn 12 (Biyaya 12), UPL Pn 14 (Biyaya 14), BPI Pn 9

3. **SOYBEANS:** UPL Sy 4 (Tiwala 4), UPL Sy 6 or PSB Sy 2 (Tiwala 6), UPL Sy 8 (Tiwala 8), UPL Sy 10 (Tiwala 10), BPI Sy 4, PSB Sy 3 (La Granja)

E. FIBER CROPS

1. **COTTON:** UPL Ct 1 (Batac 1), UPL Ct 2 (Batac 2), UPL Ct 3 (Batac 3), UPL Ct 4 (PSB Ct 6), CRDI-1
2. **KENAF:** UPL K-1

F. VEGETABLES: The breeding institutions are IPB-UPLB, DA, East-West Phil, Kaneko Seeds Phil.

1. **POLE SITAO:** UPL PS 1 (Sandigan), UPL PS-2 (Ana), CSL 15 (PSB PS-3), BPI PS 3
2. **BUSH SITAO:** UPL BS 3 (Sumilang), PSB B2-2, CBL 3 (PSB BS-1)
3. **BITTER GOURD:** Makiling, Sta. Rita, Jade Star, F1 Mayon
4. **BOTTLE GOURD:** Tambuli

5. **Cowpea:** UPL Cp 1 (Sagana), UPL Cp 5 (Magbunyi), UPL Cp 7, UPL Cp 9 (Juliet), BPI Cp 4, BPI Cp 3
6. **White Potato:** T-204 (Banahaw), Arka, Siro, Kennebec, Up-to-date, Conchita, Cosima
7. **Cabbage:** F-1 KK Cross and F-1 KY Cross (heat tolerant), Marion market, F-1 Princess #39, F1 Stone Head, YR Summer 50
8. **Tomato:** UPL Tm 1 (Marikit), UPL Tm 2 (Marilag), UPL Tm 6 (Maligaya), Improved Pope
9. **Eggplant:** UPL E.g. 11, Dumaguete Long Purple, Dingras Multiple Purple # 1, E.G. Long Purple
10. **Onion:** Red Globe, Excel, Yellow Granex
11. **Cauliflower:** Early Patna
12. **Chinese Cabbage:** Esperanza, Corazon, Reyna Elena
13. **Cucumber:** UPL Cu-1 (Pilipina), UPL Cu 6 (Pinagpala), Explorer, Panorama
14. **Garlic:** Ilocos Purple Shank, Ilocos White Shank, Batangas Strain
15. **Lima Bean:** Kentucky Wonder, Habas, Sugar Mammoth
16. **Honey Dew Melon:** Tan Dew, Honey Dew
17. **Pechay:** Black Behi
18. **Watermelon:** Sugar Baby
19. **Lettuce:** Dennis Red, Presidente, Bravo, Vanguard, Simpson

G. FRUIT CROPS

1. **Avocado:** Cardinal, De Leon 1, Lopena
2. **Banana:** Lakatan, Bungulan, Latundan, Saba, Cavendish
3. **Cashew:** Magbayto (Acc. No. 1851), Makiling (UPL Cs-1), Guevarra (Acc. No. 1849)
4. **Chico:** Lamao (UPL Ch 1), Gonzales, Pineras, (UPL Ch 2), Ponderosa (UPL Ch 4), Sao Manila (UPL Ch 3)
5. **Citrus**
   - Mandarin: Ladu, Batangas, Calamandarin, King
   - Orange: Hamlin, Valencia
   - Pumelo: Amoy Mantan, Fortich, Siamese, SinuwiLuk
6. **Guyabano:** Dulce (UPL Gn 1), Katasim (UPL Gn 2)ah
7. **Mango:** Carabao (UPL Mg 1), Pico (UPL Mg 2), Nam Doc Mal (UPL Mg 3), Ah Ping (UPL Mg 4), Pope (UPL Mg 5), Otts (UPL Mg 6), Fairchild (UPL Mg 7), Kachamita
8. **Papaya:** Cavite, Solo, Sinta
9. **Pili:** Katutubo (Acc No. 024), Oas (Acc. No. 45), Mabunga (Acc. No. 46), Ibalon (Acc. No. 36), Mayon (Acc. No. 25), Isarog (Acc. No. 27)
10. **Pineapple:** Cayenne, Queen
11. **Rambutan:** Maharlika (UPL Rm 1), Seematjan (UPL Rm 2), AtjehRaplah (UPL Rm 3), Llanez, Seenjonja

H. Plantation Crops

1. **Coconut:** Typica, Javanica, Nana
2. **Coffee:** *Coffea arabica* L., *C. robusta* Linden, *C. excelsa* A. Chev, *C. liberica* Bull ex Hlem
3. **Cacao:** Criollo, Forastero, Trinitario

26 TOP PRODUCING PROVINCES

Source: Bureau of Agricultural Statistics Website (Latest Data as of Feb. 27, 2015)
(2019 PSA Report will be provided separately)

BENGUET: Chrysanthemum, Gladiola, Roses, Orange, Broccoli, Cabbage, Carrots, Cauliflower, Habitchuelas, Chinese Pechay, White Potato
ILOCOS NORTE: Tamarind, Garlic
ILOCOS SUR: Tobacco, Virginia Tobacco
PANGASINAN: Mango, Carabao Mango,Eggplant, Peanut
ISABELA: Tobacco Native, Mongo
NUEVA VISCAYA: Mandarin
BULACAN: String Beans
NUEVA ECIJA: Okra, Onion
BATANGAS: Gourd
LAGUNA: Rambutan, Radish
QUEZON: Coconut (with husk), Ampalaya
ORIENTAL MINDORO: Calamansi
PALAWAN: Cashew
ALBAY: Orchids, Pechay Native, Squash
CATANDUANES: Abaca
SORSOGON: Pili Nut
ILOILO: Watermelon
NE.G.ROS OCCIDENTAL: Sugarcane
BOHOL: Ube
LEYTE: Camote
NORTHERN SAMAR: Gabi
BUKIDNON: Pineapple, Lettuce, Tomato
LANAO DEL NORTE: Ginger
DAVAO DEL NORTE: Banana, Banana Cavendish, Durian
DAVAO DEL SUR: Cacao
NORTH COTABATO: Rubber, Banana Lacatan, Banana Saba
SULTAN KUDARAT: Coffee (dried beans), Coffee Arabica, Coffee Robusta
AGUSAN DEL SUR: Oil Palm (fresh fruit)
LANAO DEL SUR: Cassava
MAGUINDANAO: Kangkong
SULU: Coffee Excelsa, Coffee Liberica, Lanzones, Mangosteen

27 SCIENTIFIC NAMES OF COMMON CROPS

AGRONOMIC CROPS

COMMON NAME	SCIENTIFIC NAME
Cereals/Grain Crops	
Rice	*Oryza sativa*
Corn	*Zea mays*
Sorghum	*Sorghum vulgare*
Millet	*Pennisetum typhoides/ Eleusine coracana*
Wheat	*Triticum aestivum*
Grass Forages	
Elephant grass	*Pennisetum purpureum*
Guinea grass	*Panicum maximum*
Paragrass	*Brachiaria mutica*
Pangola grass	*Digitaria decumbens*
Alabang X	*Dicanthium aristatum*
Forage Legumes	
Centro	*Centrocema pubescens*
Ipil-ipil	*Leucaena leucocephala*
Townsville stylo	*Stylosanthes humilis*
Siratro *atropurpureum*	*Macroptilium*
Crops for Industrial Processing	
Sugarcane	*Saccharum officianrum*
Tobacco	*Nicotiana tobacum*
Castor bean	*Ricinus communis*
Grain Legumes/Pulses	
Mungbean	*Vigna radiata*
Peanut	*Arachis hypogaea*
Soybean *Glycine ax*	
Root Crops	
Cassava	*Manihot esculenta*
Sweet potato	*Ipomoea batatas*
Fiber Crops	
Kenaf	*Hibiscus sabdariffa*
Jute	*Corchorus olitorius*
Ramie	*Boehmeria nivea*
Cotton	*Gossypium hirsutum*

HORTICULTURAL CROPS

COMMON NAME SCIENTIFIC NAME

Pomological or Fruit Crops

Abiu ***Pouteria caimito*** (Sapotaceae) Atemoya ***Annona cherimola x squamosa*** (Annonaceae)
Avocado ***Persea Americana*** (Lauraceae) Banana edible ***Musa*** (Musaceae) Breadfruit (Rimas)***Artocarpus altilis*** (Moraceae)
Bignay ***Antidesma bunius*** (Euphorbiaceae) Bilimbi (kamias) ***Averrhoa bilimbi*** (Oxalidaceae)
Binjai (bauno) ***Mangifera caesia*** (Anacardiaceae) Canistel (tiesa) ***Pouteria campechiana*** (Sapotaceae) Caimito ***Chrysophyllum caimito*** (Sapotaceae) Calamondin ***Citrofortunella microcarpa*** (calamansi) (Rutacea) ***Averrhoa carambola*** (balimbing (Oxalidaceae)
Cashew ***Anacardium occidentale*** (Anacardiaceae) Citron ***Citrus medica*** (Rotaceae)
Custard apple ***Annona reticulata (Annonaceae)*** (anonas)
Durian ***Durio zibethinus*** (Bombacaceae) Galo ***Anacolosa luzoniensis*** (Olaceceae) Governor's plum ***Flacoutia indica*** (Flacourtiaceae) (bitungol)
Granadilla ***Passiiflora quadrangularis*** (Passifloraceae)
Grape ***Vitis vinifera*** (Vitaceae)
Guava ***Psidium guajava*** (Myrtaceae) Indian jujube ***Ziziphus mauritiana*** (rhamnaceae)
Jackfruit ***Artocarpus heterophyllus*** (Moraceae) Jambolan (duhat) ***Syzygium cumini*** (Myrtaceae)
Java apple ***Syzygium samarangense*** makopa) (Myrtaceae)
Kalumpit Terminalia microcarpa (Combretaceae) Kamansi ***Artocarpus camansi*** (Moraceae)
Kuwini (Huani) ***Mangifera odorata*** (Anacardiaceae) Kubili ***Cubilia cubili*** (Sapindaceae)
Langsat ***Lansium domesticum*** (Lanzones) (Meliaceae)
Lemon ***Citrus limon*** Rutaceae)
Lime ***Citrus aurantifolia*** (Rutaceae)
Lychee ***Litchi chinensis*** (Sapindaceae)
Mabolo ***Diospyros blancoi*** (Ebenaceae)
Macadamia ***Macadamia integrifolia*** (Proteaceae)
Malay apple ***Syzygium malaccense*** (yambu) (Myrtaceae)
Malay gooseberry ***Phyllantus acidus***

(iba) (Euphorbiaceae)
Mamey sapote Pouteria sapota (Sapotaceae)
Manila tamarind ***Pithecellobium dulce***
(Leguminosae) Melinjo (bago) ***Gnetum gnemon***
(Gnetaceae) Mandarin orange ***Citrus reticulata***
(Rutaceae)
Mango ***Mangifera indica*** (Anacardiaceae)
Mangosteen ***Garcinia mangostana***
(Guttiferae) Marang Artocarpus odoratissimus
(Moraceae) Mulberry Morus ***alba*** (Moraceae)
Paho ***Mangifera altissima*** (Anacardiaceae)
Panama berry ***Muntigia calabura***
(datiles) (Elaeocarpaceae)
Papaya ***Carica papaya*** (Caricaceae)
Passion fruit ***Passiflora edulis***
(Passifloraceae) Polynesian ***Inocarpus fagiferus***
Chestnut (Leguminosae)
Pomegranate ***Punica granatum***
(Punicaceae) (Granada)
Pulasan ***Nephelium ramboutan-ake***
(Sapindaceae)

Pili ***Canarium ovatum***
(Burseraceae) Pineapple ***Ananas comosus***
(Bromeliaceae) Pummelo ***Citrus maxima***
(Rutaceae)
Rambutan ***Nephelium lappaceum*** (Sapindaceae)
Red mombin ***Spondias purpurea***
(siniguelas) (Anacardiaceae)
Santol ***Sandoricum koetjape***
(Meliaceae) Sapodilla (chico) ***Manilkara zapota*** (Sapotaceae) Soursop ***Annona muricata*** (Annonaceae) (guyabano)
Strawberry ***Frageria ananassa***
(Rosaceae) Sweet orange ***Citrus sinensis*** (Rutaceae) Sugar palm ***Arenga pinnata*** (Palmae)

(kaong)
Sugarapple (atis) ***Annona squamosa***
(Annonaceae) Tamarind ***Tamarindus indica***
(Leguminosae)

Olericultural or Vegetable Crops

Asparagus ***Asparagus officinalis***
(Asparagaceae) Bottle gourd (upo) ***Lagenaria siceraria*** (Cucurbitaceae)

Bittergourd ***Momordica charantia***
(ampalaya) (Cucurbitaceae)
Cabbage ***Brassica oleracea*** var. ***capitate***
(Cruciferae) Carrot ***Daucus carota*** var. sativus
(Umbelliferae)
Cauliflower ***Brassica oleracea*** var. ***botrytis***
(Cruciferae)
Celery ***Apium graveolens*** var. ***dulce***(umbelliferae)
Ceylon spinach
(alugbati) ***Baella alba*** (Basellaceae)
Chayote ***Sechium edule***
(Cucurbitaceae)
Chickpea
(garbanzos) ***Cicer arietinum*** (Fabaceae)
Cowpea (paayap) ***Vigna unguiculate*** subsp. ***Unguiculata***
(Fabaceae)
Cucumber ***Cucumis sativus***
(Cucurbitaceae) Eggplant ***Solanum melongena*** (Solanaceae) Garlic ***Allium sativum*** (Alliaceae)
Green amaranth
(kulitis) ***Amaranthus viridis***
(Amaranthaceae)
Horseradish tree
(malunggay) ***Moringa oleifera***
(Moringaceae) Katuray ***Sesbania grandiflora*** (Fabaceae) Lettuce ***Lactuca sativa*** (Compositae)