2. HISTORY OF ORGANIC GARDENING

Farming in the olden times

- **Agricultural practices** (from Roman books)
  - crop rotation
  - manure application
  - green manure
  - tillage
  - use of lime
  - growth of legumes for soil improvement
- **traditional(natural) farming**- no synthetic chemicals, practiced for thousands of years
- **industrial revolution**
  - introduced inorganic methods
  - conventional farming—> used synthetic chemical fertilisers and pesticides
    - ++productivity, profitability

Pre-World War II

- first 40 years of 20th century—rapidly changed farming
  - **gasoline-powered engines**
  - **reduced need for farm labor**
    - improved plant varieties
    - labor-saving machinery
    - chemical fertilisers and pesticides
- farmer population —decreasing
  - bigger fields, more specialised cropping
- **Justus von Liebig**:
  - German chemist
  - "father of the chemical fertilizer" — promoted importance of adding inorganic minerals as plant nutrition
  - **Law of the Minimum**-growth controlled not by total amount of resources available but by the scarcest resource(limiting factor)
- **Sir John Lawes**:
  - produced superphosphate
  - &**Sir Joseph Gilbert** *Rothamsted Research Station*
    - investigates impact of inorganic and organic fertilizers in crop yields
- **Haber and Bosch**
  - developed process that converts nitrogen gas into ammonia → NH_4NO_3 — nitrate fertilizer
  - organophosphate nerve gas — insecticides
  - DDT — pesticide
    - ↳launching the era of pesticide use

After World War II

- widespread use as DDT
  - insects became resistant
  - chemicals did not decomposed rapidly, persisted in environment
  - banned in many countries
  - *"Silent Spring"*- Rachel Carson
- **biomagnification**- when chemicals become concentrated in tissues as they move up the food chain
  - fat soluble chemicals
  - long life span
  - biologically active (reactive to organic matter)
- pesticide overuse

The Green Revolution 1960's

- increase in crop production through
  - new high-yielding varieties
  - controlled irrigation
  - chemical fertiliser
  - chemical pesticides
  - machinery
- consequences of orienting toward economic profit:
  - increased yield
  - negative impact on farmers and environment
  - lead to **monoculture cropping system**
    - leads to **loss of genetic diversity**

Problems with Chemical Farming

- decrease in soil fertility
- need to use more chemical fertilisers every year (pesticide resistance)
- increase in disease and pest problems
- contaminated water
- contaminate produce

Modern Organic Farming

- **Sir Albert Howard**: "father of modern organic agriculture"
  - *An Agricultural Testament*: problems of plant diseases, soil erosion under chemical agriculture
- **Natural farming:**
  - no-till system for small-scale grain production
  - Principles:
    - no plowing
    - no chemical fertilisers
    - no pesticides
    - ducks, carps helps eat pests and slugs
    - ground covered using straw from previous crop as mulch
- **Kyusei(saving) Nature Farming**

Mokichi Okada

- effective microorganisms (EM) to improve soil's production power
  - lower cost to farmer
  - inputs made from natural materials
  - higher yield
  - high quality food
  - sustainable, easily practiced

Organic agriculture

- **crop rotation**
  - avoid buildup of pathogens and pests when continuously cropped
  - balance fertility demands
  - improve soil structure and fertility—alternate deep-rooted & shallow-rooted plants
  - replenish nitrogen—grow legumes or use green manure

Organic gardening principles

- no chemicals
- use biological pest control
- weeds controlled mechanically and through cover crops and mulch
- rely on crop rotation, crop residues, mulch, cover crops, manures, compost to maintain soil productivity
- grow variety of crops rather than 1

5

3.ROLE OF ORGANIC MATTER

- decay detrivores - soil - plants - herbivores - primary predators - secondary predators
- **earthworms**- provide porosity to aerate soil, allow water to infiltrate soil
  - high porosity = air and water goes deeper = plant growth
  - produce humus

Sources of organic matter

- crop residue
- green manure
- livestock manure
- organic wastes

Categories of OM

1. living soil organisms
2. fresh organic residue
3. active fraction
4. stabilized OM (humus)

Decomposition

- breaking down of carbon and nutrients in dead organic matter
- complex organic molecules -> simple organic and inorganic molecules
- releases nutrients available to microbes and plants

- carbon, oxygen, hydrogen, nitrogen, etc.
- release by-products, wastes
  - food for other soil organisms
  - **complex polysaccharides**- hold soil together
- **Humus**- chemically-stabilised products of decomposition
  - lignin —>DECOMPOSITION —>humus
  - C:N ratio=10:1

Factors of decomposition:

1) living organisms
2) environmental conditions
   1) moisture
   2) temperature: low=good
   3) oxygen: more= good
3) quality of decomposing materials (C:N ratio)

Results of decomposition:

- breakdown of organic residues
- nutrient mineralization-produce available nutrients
  - water-soluble compounds
  - inorganic and organic nutrients
- transfer of organic carbon, nutrients and energy into soil organisms, humus, CO_2

6

4. SOIL ORGANIC MATTER MANAGEMENT

- soil organic matter level declines if rate of addition < rate of decomposition

How to build up organic matter:

1. **Add more organic material**
   - grow healthy, productive crops
     - medium harvest index
   - grow cover crops
   - apply compost/manure
2. **Reduce losses**
   - reduce tillage—less oxygen for microbes
   - control erosion
   - avoid buying crop residue

Things that reduce soil organic matter

1. **monoculture crops**
   - continuous cultivation = soil compaction
   - soil aeration decreases
   - poor root growth
2. **grow plants with high harvest index**
   - reduce crop residues
3. **bare fallow practice**
   - give land some "rest"

- organic material degraded further
5. **burn crop residues**
   - destroys little layer and diminishes amount of OM in soil
5. **remove crop residues**
   - crop residues should be returned to soil as manure/composts
6. **tillage/plowing**
   - increases aeration
     - speeds up decomposition
- **mulch**- organic/inorganic
- C:N ratio
  - carbon- structural frameworks and energy
  - nitrogen- protein and enzyme productions
  - high N = high decomposition rate
  - C:N low = too hot = kills microorganism
  - C:N high = not enough N

3 5. PLANT GROWTH AND FACTORS AFFECTING IT

- **binomial nomenclature**: Genus, species

Plant groups

1. **Bryophytes**
   - phylum Bryophyta
   - non-vascular plants (don't conduct tissue)
     - limited size
   - damp places
   - ex: moss
2. **Ferns**
   - vascular
   - reproduces by spores
   - no true leaves; only fronds
3. **Gymnosperms**
   - reproduce with seeds found in cones
   - conifer
   - evergreen
4. **Angiosperms**
   - reproduce by flowers
   - **monocot**: flower parts in multiples of 3
   - **dicot**: flower parts in multiples of 4 or 5

Agronomic crops: grown for grain, feed, for processing into oil, starch, protein, flour
- rice, sugarcane, spices&herbs, cotton, tobacco

Horticultural crops: garden plants
- fruits, vegetables, ornamentals

Plant growth

- plant increase by cell division and enlargement

Measuring growth
- increase in fresh weight,dry weight
- volume
- length
- surface area

Shoot growth
- determinate
- indeterminate

Plant growth patterns
- **Annuals**
  - herbaceous plants
  - life cycle=1 growing season
  - germination—growth—flowering—death
- **Biennuals**
  - herbaceous plants
  - life cycle = 2 growing seasons
  - germination→growth→flowering→dormancy (repeat)
- **Perennials**
  - herbaceous or woody
  - life cycle= more than 2

Basic requirements for plant growth

- oxygen, co2
- light
  - photosynthesis, photomorphogenesis
- water
- minerals
- appropriate temperatures
- hormones

Tropisms —growth responses to a stimuli
- **phototropism**: light
- **gravitropism**: gravity
- **thigmotropism**: touch

Root system
- primary root system
  - tap root, lateral root
- fibrous root system
  - adventitious root
- **root functions:**
  - absorb water, nutrients
  - provide stability
  - synthesise plant hormones
  - store energy produced by plants

Hormones
- Auxins
  - cell elongation
- Cytokinins
  - apical (ยอด) dominance
  - delay leaf senescence(process leading to death)
- Gibberellins
  - seed germination
  - stem elongation
- Abscisic acid
  - seed dormancy
  - stress hormone
- Ethylene
  - fruit ripening

not sure but not in syllabus

6. PLANT NUTRITION

Nutrients Reservoirs

- soil: water and minerals
- air: carbon dioxide
- branching root system and shoot system of vascular plant ensure networking with both reservoirs

Macronutrients and Micronutrients

- most organic mass comes from CO_2 in the air, but also depends on soil nutrients
- chemical elements essential for plant to complete life cycle
- **macronutrients** (9 essential elements)
  - plants require them in large amounts
  - C O H N K Ca Mg P S
- **micronutrients** 7
  - need in small amounts
  - Cl Fe Zn Mn B Cu Ni Mo

Fertiliser

- commercially produced— mined/prepared by industrial processes
- **organic fertilisers**- manure, fishmeal, compost

Nitrogen

- greatest effect on plant growth

→ macronutrient

- provides proteins, nucleic acids, chlorophyll, host of other important organic molecules

→ dead organic material DECOMPOSITION.

- bacteria and fungi break down organic N into nitrate ions so plants can use

Nutrients mobility

- mobile while in a solution of water .
- move from roots to shoots

Mineral deficiency

- symptoms depend on nutrient's function and mobility of nutrient
- deficiency of mobile nutrient
  - affects older organs (young tissues can more efficiently draw minerals)
- deficiency of less mobile nutrient
  - affects young organs (old tissue has store of minerals to fall back on)
- most common deficiencies:
  - nitrogen, potassium, phosphorus

Requirement for optimum growth

- growth media
- light
- water
- temperature
- fertiliser

GROWTH MEDIA

soilless mix- ~~organic+inorganic~~ substances that provide sufficient support for plant growth

- no topsoil
- common components:
  - **peat moss**: nutrient&moisture holding capacity
  - **perlite**: aerate soil
  - **vermiculite**: moisture holding capacity
  - **coir**: hold water and air
  - **sand**: reduce overall water holding cap
  - **rice husk**: drainage of growth media
- advantages:
  - uniform :doesn't vary in components,texture,nutrients
  - sterile
  - can be manipulated
  - personalised
  - lightweight—easy to ship/move
- disadvantages:
  - added more frequently
    - lack minor plant food elements that soil usually has
  - lightweight—wind can blow dry pots over
  - difficult to transplant plant from soil to soilless
  - high cost

Field Grown Vs. Container

- container disadvantages
  - need more water
    - above ground, dry quicker
  - become pot-bound
  - higher start-up cost

Watering

- need more water in active growth and flowering stage
- hydrogen in water key nutrient for photosynthesis
- water is carrier of dissolved nutrients from soil into roots
- water sustains plant cells
- no water= dead plants
- factors affecting watering:
  - weather, soil type, plant type
  - media- more porous mix=more water
  - size of container- small ones dry out faster
  - type of container
  - surface mulch- mulch reduce needs of water
- when to water:
  - observation: wilt/ loss of color/dullness

Lighting

- light intensity requirements vary from plants
  - direct sun

- partial sun/weak sun
- indirect/filtered light

Temperature
- daytime temp 20-30C
- night temp drop 5-10C below daytime temp

Air Conditioning
- can trouble plants
- should be located away from direct air flows

Humidity
- need additional moisture if atmosphere dry

Pruning
- shapes the plant
- more compact
- train growth/form of plant
- remove dead/diseased parts

7. PLANT-MICROBE INTERACTION

- **microbe**- microscopic organisms
  - virus
  - bacterium
  - fungus
  - nematode—roundworms

positive interactions

- **symbiosis**- long-term interactions b/w diff biological species (benefits both)
  - **rhizobium**
    - nitrogen fixing bacteria associating with roots of legumes
    - green manure
  - **mycorrhiza**
    - assoc of fungus and roots of plants
    - fungus transfers nutrients to plants
    - **ectomycorrhiza**
      - surrounds root
    - **endomycorrhiza**
      - penetrates intracellular cells of roots
      - produces vesicular-arbuscular mycorrhiza VAM: collect food, nutrients exchange
  - **rhizosphere microorganism**
    - high microbial density
    - induce plant growth, releases
      - auxin, gibberellin
    - keeps moisture
    - inhibit growth of soil pathogen
    - decrease soil toxicity
    - nutrient recycling
    - ex. *trichoderma*
  - **lichen**
    - association of fungus + plant, algae
    - metabolites leaked from both
    - fungus surrounds algal cells to provide moisture,co2
    - air pollution indicator
    - **Crustose:** cover substrate like crust
    - **Foliose:** leafy form
    - **Fruticose:** shrubby form

negative interactions

- **parasitism/pathogen**: parasite benefits from host
  - causes **plant disease**
  - **how:**
    - nutrient competition
    - inhibition of plant metabolism
    - inhibition of vascular system
    - destroy plant cells for nutrients
  - **causes**:
    - fungal diseases—leaf spots, powdery mildew
    - bacterial diseases—soft rot, leaf blight, wilt
    - viral diseases—ringspot, mosaic
    - nematode diseases
      - cyst
      - foliar
    - higher parasitic plant disease
  - **3 Factors that cause disease:**
    - virulent pathogen
    - susceptible plant
    - suitable environment for a disease
  - **how pathogens damage plants?**
    - wounds
    - natural openings: stomata, hydathodes, lenticels
    - direct penetration: cuticle, epidermal cells
  - **symptoms**:
    - leaf spot
    - leaf blight
    - mosaic
    - stem rot
    - wilt

8. PEST CONTROL

- **pest**- organisms that cause damage to agriculture by feeding on it
  - pathogens
  - insects
  - rats

Control Methods

- **Resistant varieties**: pest cannot eat it
- **Mechanical control:** destroy diseased plant by burning
- **crop rotation**: plant non-host plant of pathogen
- **trap crops**: attractive host plant to lure insects away from main crops
- **natural chemicals**: soap water

- **biological control**: control pathogens by natural enemies
  - antibiosis
    - nematode trapping fungi
  - competition
    - biocontrol agents out-compete pathogenic microbes
  - parasite
    - control by trichoderma
- Bacterial antagonists
  - bacillus, pseudomonas, streptomyces
- fungal antagonists
  - gliocladium, trichoderma

- insect control

- Repel plants for pest insects:
  - Anise Hyssop—cabbage moths
  - Borage—Aphids, Colorado Potato Beetles, Squash Bugs
  - Pot Marigolds—Asparagus beetles
- Bacterial pathogens of insects:
  - Bacillus popilliae (milky disease)
  - bacillus thuringiensis- kills caterpillar
- Fungal pathogens of insects
  - zygomycota
  - ascomycotina
  - cordyceps sinensis
  - metarhizium anisopliae (green fungus)
  - beauveria bassiana (white fungus

8

9. ORGANIC FERTILISER

- **fertiliser**- materials occurring naturally or commercially produced for application to soil
  - add deficient nutrients
  - costs 20% of all crop productions
  - increases yield by 50%
- **profitable** when:
  - based on soil test
  - added in efficient manner
  - soil is managed
- **unprofitable** when:
  - soil moisture limited
  - pest and adverse temps are problem
  - increased yield has less market value than cost of fertiliser

Principles of Organic Gardening

- soil food web- microorganisms provide nutrients to plants and soil

Soil Organisms

- **photosynthesizer**- plants, algae&bacteria
  - capture energy, fix CO_2
- **decomposers**- bacteria & fungi
  - break down residue
  - retain nutrients in biomass
- **mutualist**- bacteria & funcgi
  - enhance plant growth
  - fix nitrogen
  - deliver nutrients
- **earthworms**- break down residue, enhance soil structure

Requirements of living system:

- food
- air
- water
- shelter
- living organism

Feeding soil a balanced diet:

- compost
- cover crops
- organic mulches
- organic residues
- other organic nutrients

Organic VS. Chemical Fertilisers

- organic slower rate of release ~~than synthetic~~
  - in response to environmental factors
    - soil moisture and temperature
- chemical bad for environment
- **Advantages** of organic fertilisers:
  - mild, non-caustic materials
  - slow release=available longer
  - high OM content=improvements in soil
  - sources of many essential elements
  - recycling of materials
- **Disadvantages**:
  - low concentration of nutrients= large application
  - slow release=don't supply plant's immediate needs
  - concentration too low to supply needs
  - expensive
- **Organic amendments**
  - increase OM content in soil
  - increase nutrient storage capabilities
  - supplies plant nutrients
  - stabilizes pH
  - promotes beneficial microbial populations
- **Pre-plant preparations**
  - soil analysis*
  - adjust pH → because diff to change pH after establishment
  - adding soil amendments prior to planting
- **Fertilizers: numbers on the bag** (ratio)
  - total N
  - available P_2O_5
  - Soluble K_2O

  $N : P_2O_5 : K_2O$
- **Law of Minimum**—Justus vol Liebig
- **Role of Mineral Nutrients**
  - affect crop quality and yield
    - direct
    - indirect

the mineral that has greatest effect on plant growth

- N excess= cell บวม

ORGANIC

Manure

- low nutrition per volume
- rapidly decay
- heat generating
- unpleasant odor

Cover Crops

- green manure
- grasses/legumes
- planted after harvest of primary crop
- benefits:
  - reduced soil erosion ✓
  - improve soil structure ✓
  - suppress weeds, insects, diseases ✓
  - enhance soil fertility ✓

Compost

- organic fertiliser produced by composting organic materials
- organic waste -> biological reduction-> compost
- greens + มีหลายอย่าง (Greens → N-rich materials)
- browns (Browns → C-rich material)
- composting methods:
  - without aeration
    - slow, smelly
  - with aeration
    - rapid, not smelly
  - **conventional composting**
    - layer organic materials (30cm)
    - overlay with animal manure (5cm)
    - repeat 4-5 times
    - water
    - cover on top with soil to keep humid
  - to make quicker compost:
    - make good mixture
    - control temperature
    - aerate compost heap
    - optimize humidity—not too wet/dry
    - add effective microorganisms
      - สารเร่ง
  - composting requires:
  - heating
  - covering with white fiber
- done when:
  - temperature—room temp
  - color dark brown
  - fine, aggregate, irregular shape and size texture
  - no bad smell
  - some seedlings/mushrooms can grow on it
- why compost is better than manure?
  - clean (heating kills pathogenic disease)
  - no smell
- why compost:
  - cheap
  - simple
  - no chemicals which kill soil organisms
  - better plant and water quality
- what should not be used as organic fertilisers
  - heavy metal/toxin contaminated materials
  - strong acid/base
  - wood—hard to decompose
  - diseased manure
  - green manure with risk of weed
- use coffee grounds, rain-tree leaves

Crop Residue

- portion of plant remaining in soil after harvest
- maintains OM
- can harbor disease and insect pests
  - avoided by crop rotation
- benefits:
  - increased OM content
  - increased soil aggregation
  - prevents soil crusting, erosion
  - improves water infiltration rates
  - provides nutrients

Mulches

- keep soil cool in summer
- retain soil moisture ✓
- adds organic matter, helps in nutrition
- improves soil structure
- reduce weed pressure
- increase soil water holding capacity

Ground vs. Foliar Application

- **Ground**: most efficient way to apply nitrogen, phosphorus, potassium, magnesium
  - large amounts
- **Foliar**: boron, zinc, copper, manganese
  - small amounts

12

10. POSTHARVEST MANAGEMENT ✓

- 1/3 of fresh produce harvested lost between harvest and consumption
- **post-harvest management**- deals with time period from harvest to ultimate utilization/ death of product
- **post-harvest loss**
  - nutritional value
  - flavor
  - economic value
- **post-harvest problems:**
  - weight loss

- fruit blemish
- fruit softening
- peel wilting
- chilling injury

- **factors affecting post-harvest quality**
  - **internal**
    - transpiration
    - respiration
    - ethylene production
    - changes of chemical compositions
    - development & growth of product
  - **external**
    - temperature
    - humidity
    - gaseous compositions
    - light
    - gravity
    - diseases, insects

Ethylene : Hormone (fruit ripening)

- **effects of ethylene**
  - chlorophyll degradation
  - abscission
  - fruit softening
  - changes of carbohydrate
  - stimulate flower senescence
- stimulated when plant tissues are injured
- fruits
  - climatcteric fruit
    - increased respiration (cellular)
    - increased ethylene production
    - softening
    - chlorophyll degradation
    - aroma,flavor

Harvesting index

- days after planting
- days after anthesis
- days after fruiting
- physical measurements: color, shape, size, firmness
- biochemical measurements
- physiological measurements: ethylene production, respiration

Management techniques for fruits and vegetables

- **harvesting**
  - time, tool
  - man and animal labor
  - machine harvesting
- **cleaning/sorting/grading/sizing**
- **treatment(cold/heat/waxing)**
  - **cooling:** aircooling, hydro-cooling, ice cooling
  - **heating:** hot-water immersion, high temperature forced air, vapour heat
    - insect control
    - prolong shelf life
  - **wax**- from plant,animal, petroleum, synthetic
  - control of ethylene
    - air ventilation, activated charcoal
- **packing—storage**
  - contain, protect produce from compression bruising, vibration rubbing
  - types:
    - sack and net, basket, wooden crates,..
- **transport**
- **retail handling**

Guidelines

- pollution sources should be identified
- product should be protected with non-organic product
- organic and non-organic should be be stored/transported together
- use biodegradable material for packaging

13

11. CERTIFICATION

- 5 consumer questions/issues
  - does the food product affect health of my family?
  - does production of food product treat animals in humane way?
  - are production processes environmentally friendly?
  - are other people affected by production/ processing techniques?
  - does product conform to my religious belief?

Branding Vs. Certification

- **branding**- identifies seller's goods from those of others
- **certification**- guarantee standards
  - purpose: support consumer confidence in meaning of organic label

Defining "Organic"

- foods produced w/o hormones, insecticides, chemical fertilizers, genetic modifications
- **certified organic**—labeled by USDA
- who should be certified?
  - anyone who labels their products as 'organic'
- farmers think that:
  - costly
  - complicated
  - impossible to satisfy
- **Benefits:**
  - higher prices for goods
  - increased market access
  - improved price stabilization

Costs:
- price of attaining certification
- production process changes
- record keeping costs
- brand design&marketing

- **producer payoff from certification**
  - immediate recognition by high-income consumers
  - customers willing to pay for healthy, socially responsible food
- **first-party/self certification**
  - "truth-in-labeling laws"
  - no generally accepted standards
- **third-party certification**
  - established umbrella program
  - certifying party does not benefit from sale of good
  - functions:
    - standard setting: specify criteria, quality levels
    - testing/inspection
    - provide labels to certified producers
    - enforcement: continued testing
  - types of certifying agencies:
    - government agencies
    - NGOs
    - private companies
  - steps to certification
    - select certifier
    - submit application and organic system plan
      - history of substances applied to land for previous 3 years
      - organic products being grown/ processed
      - organic plan—practices/substances used in production
    - documents reviewed by certifier
    - on-site inspection/ re-inspection
    - inspection report review
    - certification
  - **IFOAM accreditation** (international federation of organic agricultural movement)
  - **ACT (alternative agriculture Network)**
    - 85 NGOs working on sustainable agriculture
    - organic agriculture certification thailand
    - farming system in harmony of ecology without using synthetic chemicals and artificial fertilisers
    - in-line with IFOAM norms
    - certification programme covers
      - crop production, processing, wild products, input manufacturing, aquaculture, smallholder groups
  - farm certification~3 year process +/-
    - yearly maintenance of certification
  - organic markets—increasing

4

12. AGRICULTURAL TECHNOLOGY VS. ORGANIC GARDENING

- **biotechnology**- use of biological organisms in agricultural &industrial processes to make products valuable to humans
  - tearless onions

Breeding Technology

- Black Tomatoes

Grafting

- TomTato
  - tomato+potato
- Potato Tom

Hydroponics

- grow plants in solution of nutrients necessary for plant growth rather than in direct soil
- uses some synthetic chemicals

Plant Tissue Culture

- growth and development of plant seeds, organs, explants, tissues, cells on nutrient media under sterile conditions
- generates lots of plants at a time
- reasons to use tissue culture:
  - virus-free reproduction
  - make many identical clones
- **micropropagation**- asexual reproduction
- **tissue culture medium**
  - water, mineral salts, carbon sources, vitamins, plant growth regulators

Transgenic plant

- **Gene technology**
  - foreign genes can be introduced
  - faster than traditional plant breeding
  - specific genes can be transferred
    - more control than traditional plant breeding
- **Transgenic plant technologies**
  - require tissue culture
  - **DNA recombination**- taking DNA of 1 organism and moving it to another
  - result= **genetically modified organisms (GMOs)**

often use sterile young leaf as target

bacterium

- **step1:get your gene** → place into plasmid for amplification in E.coli
- **step2: prepare your receiving tissue** → involve tissue culture
- **step3: get your DNA into target plant**
  - methods:
    - gene gun
      - use naked DNA (linear)
      - coat DNA onto beads (gold or tungsten)
      - use air pressure to fire into tissue
      - DNA coated onto surface of gold particles
      - blasted into sample of plant cells
      - placed on selective media containing herbicide for 3 weeks
      - small plantlets transplanted into soil and acclimated under high humidity conditions
    - Plant transformation method
      - Agrobacterium tumefaciens ← inserting gene via
      - electric pulse (electroporation) ← introducing genes into protoplast via (no cell wall)
  - survival of transformed cells on selection medium
    - **antibiotic**- kanamycin resistant gene
    - **herbicide**- glyphosate resistant gene
      - kills all plants it come in contact with
      - inhibits ESPS synthase in an amino acid pathway
        - no amino acid=plant dies
      - resistant ESPS synthase gene allows crops to survive spraying
        - Roundup Ready
  - selection for transformed plant:
  - display of a reporter gene
    - marker gene- makes plant show color
  - **insect resistant plants**
    - BT toxin gene from bacteria
    - bacillus thuringiensis
    - provides resistance from insects without using insecticides
    - BT-corn, BT-cotton, BT-rice
      - monarch butterfly larvae consume leaves dusted with Bt corn pollen
      - dies
  - MerA gene—plants can grow on mercurium contaminated soils
  - MerB gene—organomercurial lyase
  - **Flavr Savr tomato** anti-softening gene (Flavr Savr Gene)
    - harvest in green
    - chemically ripened by ethylene gas
  - **virus resistance**
    - coat protein
    - transgenic: papaya, tomato,plum
    - transgenes: PRSV coat protein, CymMV coat protein
  - **golden rice**: transgenic rice with genes for production of vitamin A

GM-rice → prevent and treat vitamin A and iron deficiencies.

13. COMPARISON BETWEEN ORGANIC GARDENING AND CHEMICAL GARDENING

9

- ORGANIC

- natural fertilisers: manure, compost
- depends on healthy soil
  - drains well
  - stores moisture
  - resists erosion
  - absorb nutrients

moving plants in the greenhouse → conveyor belt syst.

- natural pest management
  - crop rotation
  - natural pesticides
  - bio-control (ducks eat pests)
  - biodiversity: intercropping
  - increase in soil microorganism activity

- CONVENTIONAL (CHEMICAL)

- synthetic pesticides
  - effective/potent, long-lasting
    - decrease in soil bacteria and fungi
    - pests become resistant to pesticides
- soil fertility
  - inorganic N
- produce
  - economy-oriented
  - emphasis on growth and production
- inorganic fertilizers cause:
  - soil hardening
  - salty soil
  - less soil microbial activities=less nutrients
  - reduced soil water holding capacity
  - increase soil erosion
- Chemical agriculture → the result of the desire to get more food from less farmers at the soonest time
  - plants need atleast 14 nutrients from soil other than C,H,O
    - if lack—add fertiliser
  - not enough rainfall
    - irrigation
  - soil too compacted
    - plow
  - plant disease
    - pesticide
  - too much machinery = compact soil

- monoculture=soil deteriorates
  - lessens productivity of soil
- inseciticides,fungicides
  - expensive, toxic pollutants, diseases resistance
  - carcinogenic
- herbicides: toxic pollutants, more resistant weeds
- less cooperation among neighbours
- lower quality nutrient levels in produce

- inorganic fertilisers

- **problems:**
  - micronutrient depletion
  - high energy consumption

- organic fertilisers

- lower nutrient content, solubility, nutrient release rates than inorganic ffertilisers
- **advantages**
  - improve soil aggregate
    - improve moisture-retaining capability
  - prevent topsoil erosion
  - increase nutrient absorptions in soil
    - use less fertiliser
  - release nutrients at slower, more consistent rate
    - less nutrient waste
  - prevent disease
  - long-lasting
- **disadvantages**
  - dilute source of nutrients compared to inorganic
  - more variable than inorganic
  - may contain pathogens
  - more labor needed to compost organic fertiliser

11

14. BENEFITS OF ORGANIC GARDENING

- **insecticides**
  - carbofuran—highly toxic
  - chlorpyrifos—risk of lung cancer
    - baygon
- Thailand 5th amount of insecticides used
- 4th herbicide use
- **pesticides**
  - hormone disrupters
  - risk of breast cancer
  - non-persistent, moderately persistent, persistent
- **roundup** herbicide (glyphosate)
  - popular chemical weed killer
  - has glyphosate
- **Atrazine**
  - top selling herbicide
  - detected in many rivers, water supplies
  - castrate male frogs into females
- **Borax** (sodium borate)
  - found in detergents, cosmetics
  - risk liver cancer
- **polystyrene foam boxes**
  - leak chemicals into food under heat
  - contains **benzene**
    - cause bone marrow damage, leukemia
    - cancer-causing substance
- **polyvinyl chloride (PVC)**
  - contains **phthalates**
    - makes it soft and flexible (bottles, baby's teething rings, nail polish)
    - subjected to heat—leak into beverage —acidic
- **polycarbonate**
  - drinking bottles, food containers
  - releases **bisphenol A**
    - makes them clear and unbreakable
    - retard brain development
- beer and coke cans
  - **phosphoric acid** (makes it fizzy) interacts with **aluminium** can
    - can make a hole in the can over time
    - aluminium dissolved into liquid
    - **aluminium poisoning**
      - poisonous to nervous system
- cosmetics
  - contain **magnesium aluminium silicate**
    - prevent caking, give smooth application
- conventional farming results in higher crude protein content but poorer quality protein than organic content
  - high N levels = lower content of essential amino acids