Plant Growth & Development

• Growth Processes
• Growth Requirements
• Types of Growth & Development
  – Factors

Growth Processes

• Photosynthesis
  – Creating carbohydrates (stored energy) from CO₂ + water + sunlight in the presence of chlorophyll

• Respiration
  – An energy releasing reaction; chemical energy originating through photosynthesis is used for growth and development

• Net Photosynthesis
  – Total Photosynthesis – Total Respiration
  – Net Photosynthesis = Biological Yield
  • Increasing Total Photosynthesis or Decreasing Respiration will Increase Biological Yield

Plant Growth & Development

• Economic Yield
  – Weigh per unit area of the edible portion of the crop

• Biological Yield
  – Economic yield plus all remaining supporting structures not used for consumption

• Harvest Index
  – Ratio of Economic yield to Biological yield
Growth Requirements

- Nutrients
- Water
- Temperature (Heat)
- Light
- Growth Substances (Hormones)

Nutrients

- 19 Essential elements
  - Carbon, Hydrogen, Oxygen
    - CO₂ & H₂O
  - Major Nutrients
    - Nitrogen
    - Phosphorus
    - Potassium
  - Minor Nutrients:
    - Calcium, Iron, Copper, Sulfur, Magnesium, Manganese, Zinc, Boron, Chlorine, Cobalt, Sodium, Silicon and Molybdenum
  - Carbon, Hydrogen, Oxygen & Nitrogen = 95% of plant solids

Nutrient & Water Absorption

- Most absorption occurs near the apexes of young roots
- Older roots tend to get "corky" (layers impervious to water/nutrient absorption)
- Young plants have a relatively small root area:
  - Have a relatively high water and nutrient requirement
**Water**

- Most vegetables have a high water content (lettuce = 95%)
- Most vegetables require much more water than most agronomic crops
  - Water is often the limiting factor in vegetable production
- Water Quality and Quantity are equally important
  - Salinity is often the major quality problem
  - (More later)

**Water Loss**

- Most water is lost from plants through the stomates on leaves
- Environmental factors that affect water loss
  - Humidity & Wind
    - ↑ Humidity, ↓ Low Wind = ?
    - ↓ Humidity, ↑ High Wind = ?
- Plants may become deficient in water even when soil supplies are adequate
  - Stomates will close, reducing moisture loss and also CO₂ uptake, which will affect ?

**Temperature**

- Optimum Temperature Range
  - Maximum photosynthesis and normal respiration
- Diurnal Temperature
  - Fluctuation between day and night temperatures
  - For all crops: Optimum day temperature is higher than optimum night temperature
  - Optimum temp for photosynthesis is higher than optimum temp for respiration
Diurnal Temperatures

- Optimum yields usually occur when night temperatures are in the upper half of the range during the vegetative phase, and in the lower half during the reproductive phase.
- Cooler night temperatures (within range) tend to improve quality.

Heat Units

- Quantity of Heat determines crop maturity.
  - Base temperature established for each crop.
  - Mean daily temperature calculated.
  - Subtract base from mean to get daily heat units.
  - *e.g.*: Tomato base temp = 50°F
  - High temp = 80°F, low temp = 60°F
  - Heat units = (80+60)/2 = 70 – 50 = 20 heat units.
- Other factors also influence heat units, such as soil temperature.

Temperature Effects on Crops

- Warm season crops produce maximum yields under relatively high temperatures.
- Cool season crops produce maximum yields under relatively low temperatures.
- Excessive temperatures will adversely affect crop yields.
Light

- Intensity and Quality affect crop growth
- Quality difficult to manipulate, especially in the field
- Intensity can be manipulated by plant density and planting date
- Warm season crops tend to require higher light intensity compared to cool season crops

Growth Substances

- Hormones: Auxins, Gibberellins, Cytokinins & Inhibitors
- Auxins:
  - Cell elongation, proliferation & differentiation
  - Apical dominance, phototropism, geotropism, root initiation
- Gibberellins
  - Stem elongation, dormancy, flowering, light & temperature responses
- Cytokinins
  - Cell growth & differentiation; keep detached leaves green
- Inhibitors
  - Restricted growth, dormancy, abscission and senescence
  - When would you want to restrict or prevent growth?

Types of Growth & Development

- Vegetative Phase
  - Carbohydrate Utilization
- Reproductive Phase
  - Accumulation or storage of carbohydrates
Vegetative Phase

- From seed germination through growth of the primary supportive structure
- Three important processes:
  - Cell division
  - Cell enlargement
  - Cell differentiation (initial stages)
- Requires large quantities of carbohydrates
- Growth rates determined by growth potential and availability of carbohydrates
- Quality influenced by growth rates

Vegetative Growth Factors

- Genetic Factors
  - Cultivar
    - Does it have the yield potential
    - Is it adapted to your growing area
- Environmental Factors
  - Planting date, Plant density
  - Proper soils and preparation, with sufficient nutrients and water (but not excessive)
  - Presence of pests (insects, weeds & diseases)

Reproductive Growth Phase

- Maturation of tissues manufactured during vegetative phase
- Production of growth regulators
- Development of flower buds, flowers, fruit and seed, or the development of storage organs
- Relatively little cell division occurs
- Most of the carbohydrates are accumulated in the fruit, seed or storage organs
Types of Reproductive Growth

- Dominance of vegetative growth during first phase, and dominance of reproductive growth during second phase
  - Sweet corn, beans, determinate crops
- Dominance of vegetative growth during first phase, and a relatively equal balance of vegetative/reproductive growth during second phase
  - Cucurbit crops, eggplant, indeterminate crops

Reproductive Triggers

- Vernalization
  - Temperature treatment below a minimum for a minimum length of time (established for each crop)
  - May be Obligate or Quantitative
- Photoperiod
  - Length of day/night (long-day vs. short-day)
  - May be Obligate or Quantitative
  - The majority of vegetable crops are day-neutral

Reproductive Triggers

Vernalization:
- Temperature treatment below a minimum for a minimum length of time (established for each crop)

- Quantitative
  - Lettuce, radish, spinach, Chinese cabbage, kohlrabi, turnips, endive, chicory
- Obligate
  - Beets, cabbage, carrots, celery, Swiss chard, collards, kale, leeks, onion, parsley, parsnips, rutabaga, brussels sprouts, cauliflower, broccoli
Reproductive Triggers

Photoperiod:
Length of day/night (long-day vs. short-day)

- **Quantitative Long-day**
  - Beets, radish, parsnip, carrot, celery, lettuce, Swiss chard, Chinese cabbage, turnips
- **Quantitative Short-day**
  - Sweet corn
- **Obligate Long-day**
  - Spinach, endive, chicory
  - Onion (bulbing)
- **Obligate Short-day**
  - Sweet potato

---

• Why are reproductive triggers important?
  - For reproductive crop plants:
    • Must have enough supportive structures to support reproductive growth
  - For vegetative crop plants
    • Must reach marketable size and harvest before reproductive growth begins