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)

Concept of Limiting Factor

- Almost always, one of the growth requirements is limiting production
- The limiting factor could be any of the growth requirements
- Once you correct the limiting factor, another growth factor will likely limit production
- If all the growth requirements are optimized, genetics will limit production

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