Chapter 2
Weed Biology and Ecology

1. Introduction/definitions

   - weed biology - the study of the establishment, growth, reproduction, and life cycles of weeds

   - weed ecology - the study of the interaction or relationship between a weed and its environment (other living organisms as well as abiotic factors)

   - weed seed production - numbers and implications

     a single weed potentially produces many seeds; annual plants must set seed for the species to survive

     a pigweed plant produces >117,000 seeds/plant; common ragweed 3,380 seeds/plant

     Implication: one weed plant causes potential problems in next year's crop; weed control breaks the cycle of replenishing the seed reservoir

     Not all seeds germinate the next season. Why? Weed seeds have a dormancy mechanism where seed produced each year will not all germinate the following year (will be discussed later)

     Result: large reservoir of seeds. Complete removal of seedbank expensive and nearly impossible

2. Weed seed dissemination - natural or artificial movement and dispersal of seeds. In general seeds can not move on their own and depend on other factors for dissemination

   - natural

     wind - some weeds have special adaptations that aid in spread by wind

     a. small, light seeds: witchweed (*Striga* sp.)

     b. feathery pappus: dandelion (*Taraxacum officinale*), annual Sowthistle (*Sonchus aoleraceous*)

     c. tufts of hair (cottonlike covering): aster (*Aster* sp.), milkweed (*Aesclepias* sp.)

     d. winged appendages - woody plants: maple (*Acer* sp.), pines (*Pinus* sp.)
     e. winged appendages - herbaceous plants: wild carrot (*Daucus* sp.), dock (*Rumex* sp.)

f. tumbling of dead parent plant: tumbling pigweed (*Amaranthus albus*), Russian thistle (*Salsola iberica*)

g. gluey seedcoats - adhere to leaves which are moved by the wind: Plaintain (*Plantago* sp.), small mistletoe (*Arceuthobuim* sp.)

water - movement in surface water, streams, irrigation/drainage canals

a. light, corky structures: cucumbers (Cucurbitaceae), jimsonweed (*Datura stramonuim*)

b. air-filled bladders or pods: curly dock (*Rumex crispus*), groundcherry (*Physalis* sp.)

c. irrigation water - source of weed seed.

animals - carry seed clinging to fur or clothes, ingested and spread

a. hooks, bristles, barbs catch in animal's fur: cocklebur, beggarticks, sandbur

b. sticky or mucilaginous seed coats adhere to passing animals: Florida beggarweed

c. resistant to digestion and excreted in the animal's feces: huisache, mesquite, mistletoe, and itchgrass by birds

forceful dehiscence - seed pods eject or propel the seed a short distance from the plant. mexicanweed, wild poinsettia, and impatiens

- see Figures 1.1 and 1.3 - (Various seeds and fruits showing devices for dissemination and forceful dehiscence; page **15**)

- artificial

  movement by machinery, harvesting equipment, disks and tillage equipment, trucks and other vehicles, highway equipment, oil drilling equipment, contaminated crop seed

  Dissemination of perennial weeds by vegetative propagules – one tuber of yellow nutsedge can produce 146 tubers in 14 weeks, johnsongrass can produce 200 to 300 ft. of rhizome in one season.

  Propagules are often moved by tillage equipment. Common occurrence in sugarcane fields where perennial weeds are spread form the headland (turn row) into the field

3. Weed seed germination

   - definition / process - the process of initiating growth in seeds

   - factors affecting:

moisture - seeds imbibe water, enzyme systems are activated, stored food used for energy

temperature -

a. cool season weeds germinate at lower temperature than warm season weeds. Russian pigweed can germinate in frozen soil.

b. high temperatures often cause secondary dormancy

c. alternating temperatures are best for optimum germination

oxygen -

a. low levels often required for aquatic plants such as cattails

b. cultivation often increases germination due to increased oxygen levels in the soil

light - not required by all seeds

a. quantity: Virginia pepperweed requires light for germination. Henbit will only germinate in the dark. Other light sensitive species include morningglory, velvetleaf, wild mustard, and curly dock.

b. quality: lettuce - 50% germination when exposed to infrared light (greater than 7000 angstroms), 100% when exposed to red light (6470-7000 angstroms), and no light only 8%.

c. duration: photoperiod - related to length of dark vs. light period

chemical inhibitors in soil - quackgrass, johnsongrass, bermudagrass, wild oat, and walnut release allelopathic substances that inhibit the germination of other seeds

4. Weed seed dormancy

- definition - a resting stage; a state of inhibited germination when all conditions required for germination are met; a survival mechanism for plants

  prevents seeds from all germinating at the same time possibly under adverse conditions; it would be easy to control weeds if it were not for dormancy
- causes of:

  seed coat impermeable to water or oxygen: impermeable to water - annual morningglory, burcucumber. Impermeable to oxygen - ragweed, crabgrass, quackgrass.

  Cocklebur - 2 seeds/bur and one germinates the first year; the other germinates later due to impermeability to oxygen

seed coat impermeable to both water and oxygen - hard seed coat: Forcibly encloses the embryo and prevents germination.

Pigweed, mustard, pepperweed, shepherd's purse. May be overcome by mechanical or chemical scarification.

immature embryo - embryo must be fully developed before germination will occur e.g. smartweed.

after ripening - embryo appears to be mature morphologically, but must undergo certain physiological changes before germination can occur; similar to immature embryo but in this case cool temperatures may be required for several months

endogenous chemical inhibitors - may be turned on and off in this process, not completely understood

5. Other factors affecting germination

   - depth of burial - most seeds germinate when positioned in the upper 1 inch of the soil; some germinate as deep as 4-6 inches.

   - tillage - exposes seeds to light; oxygen concentration more favorable; repositions seed in an environment more favorable to germination.

   - fire - high temperature could help to scarify seed coat; black soil would warm faster as well; allows more light to reach soil surface; removal of litter reduces competition and eliminates plants producing allelopathic substances

6. Weed seed longevity - longevity is synonymous with viability over time; dependent on depth of burial (the deeper the longer the seed will remain viable) and length of time the seed remains buried

   - Beal's experiments - conducted in Michigan from 1884-1970; placed seeds of 20 weeds in pint bottles and buried 18 inches deep in the field: every 5 years (1884-1920) and every 10 years thereafter seeds were removed and tested for germination - Results: most seeds germinated after 10 years and several species germinated after 80 years
   - In other research weed seed longevity varies by species as follows:

common cocklebur	16 years
foxtail	20 years
johnsongrass	20 years
redroot pigweed	40 years
velvetleaf	40 years
itchgrass	2-3 years

Weed seed production even for one year can assure that weeds will be a problem for many years to come; this should be considered when planning weed control programs

7. Weed - crop competition

- competition - Implies that two or more plants are vying for space and resources such that gaining access to a resource by one plant will limit access by another plant.

  Interference: synonymous with competition, but also brings in the possibility that allelopathic compounds may be involved as well as competition for space and resources

- competitiveness determined by:

  time of emergence of weed in relation to crop

  a. the first plant to effectively obtain water, nutrients, and light has a competitive advantage over plants that emerge later (analogy of running a race)

  b. weeds emerging prior to or with the crop have the greatest effect on crop yield

     white mustard emerging 3 days prior to field peas: 54% reduction in yield; if emerging 4 days after the peas: 17% reduction in yield.

     giant foxtail emerging with soybeans or corn resulted in a 27% and 13% reduction in yield, respectively

  c. weed competition during the first 4 to 6 weeks tends to have the greatest effect on crop yields e.g.

     soybeans 4-5 weeks weed free; cotton 6-8 weeks, peanuts 6 weeks, onions 12 weeks; sunflower 4-6 weeks

     Consequently, if weeds are removed during the first 2 to 4 weeks after emergence with the crop (dependent on the specific crop), yield may not be affected

     discuss preemergence/postemergence weed control programs

  d. late emerging weeds (some weeds are shade tolerant and are capable of emerging from under the crop canopy)

     often late emerging weeds do not affect crop yield, but rather crop quality and interfere with harvest operations e.g.

     wild garlic decreases wheat quality.

     black nightshade berries and balloonvine are same size as soybeans and difficult to separate

wild poinsettia remains green at the time of harvest – gums up combine and increases moisture; also can increase foreign matter (trash) in the sample delivered to elevator.

morningglory entangles combine header

weed density - interspecific and intraspecific competition

a. interspecific competition between different species (itchgrass and soybeans); intraspecific between same species (itchgrass and itchgrass)

b. within a species, as the density of the weed increases, crop yields decrease

biomass, shape, and height of the weed have a strong impact on the effect of density on crop yield (e.g., it takes more foxtail to compete with soybeans comparable to cocklebur)

c. high densities of weeds result in intraspecific competition, often decreasing the net effect of each individual weed on the crop field

d. density is not a good means to predict yield losses

growth form - height and canopy cover

a. tall or climbing: cocklebur, sicklepod, morningglory, smellmellon

b. dense canopy:
grasses
jimsonweed and cocklebur

c. extensive root system:
broadleaf plants vs. grasses

growth rate

rapid development of a foliar canopy
rapid growth and establishment of roots

adaptation to stress

the greater the ability of the weed to adapt to stress the greater the competitive ability

stresses include: shade tolerance, drought tolerance, tolerance to wet soil conditions and low soil fertility, disease/insect tolerance

allelopathy

some plants produce toxins that enter the soil and prevent normal development of other plants; usually results in inhibition of germination, formation of abnormal seedlings, prevention of root elongation, and cellular disorganization

Examples of plants with allelopathic properties:

black walnut produces juglone – excreted from the roots.
quackgrass, bermudagrass, johnsongrass, giant foxtail, jimsonweed, others

This is an expanding research area (comment on no till, reduced till implications, and use of cover crops)

8. Weed thresholds

- utility of economic thresholds and criticism of weed science; used extensively in insect management but a new area of weed control research emphasis

  economic thresholds is the level of pest pressure at which if a control measure is not used then an economic loss will occur

  Therefore, decisions should be based on economics

- limitations of weed thresholds

  a. difficult to set thresholds because weed densities within a field vary and weed size is affected by density i.e. smaller weed size in high densities and larger in low densities

  b. time of emergence very important - weeds emerging with the crop have a greater impact on yield than those emerging 2-4 weeks later; higher densities are required to decrease yields when the weeds emerge later than the crop
  c. should be based on economics which can change depending on the cost of the herbicide and value of the crop

  d. other factors making the development of thresholds difficult include:

     crop vigor and crop competitiveness would be important (this can vary among cultivars of a crop)

     <u>environmental stress</u> - temperature extremes, soil moisture conditions

     <u>cultural practices</u> - row spacing, fertilization, tillage system, etc.

  e. multiple weeds - interaction among weeds and limited data in this area

  f. effect of weed control on crop quality and harvest and seed production effects on subsequent years may or may not be considered

g. effect of preemergence herbicide on weed competition - does this change the threshold level? are weeds treated but not killed by the herbicide as competitive as those not exposed to herbicide?

- computer based decision aid programs

  HERB - North Carolina State University and University of Arkansas (first attempt at using thresholds in weed management)

  HADSS computer software program (current research area)

  a. Herbicide Application Decision Support System - second generation of HERB

  b. weed counts are made in field (no./100 ft^2) and entered; weed sizes and moisture status information added

     crop yield expected and price entered; herbicide recommendations are provided ranked on the net return; user is able to change prices of herbicides if needed

     recommendations are made based on an extensive database which includes competitive indices for each weed and crop based on research along with the yield limiting effect of weeds at various densities within individual crops, also included is weed control recommendations for all herbicides labeled in the crops

     HADSS software is being validated in Louisiana corn, soybean, and cotton and should be in the hands of County Agents and consultants for 2003 season

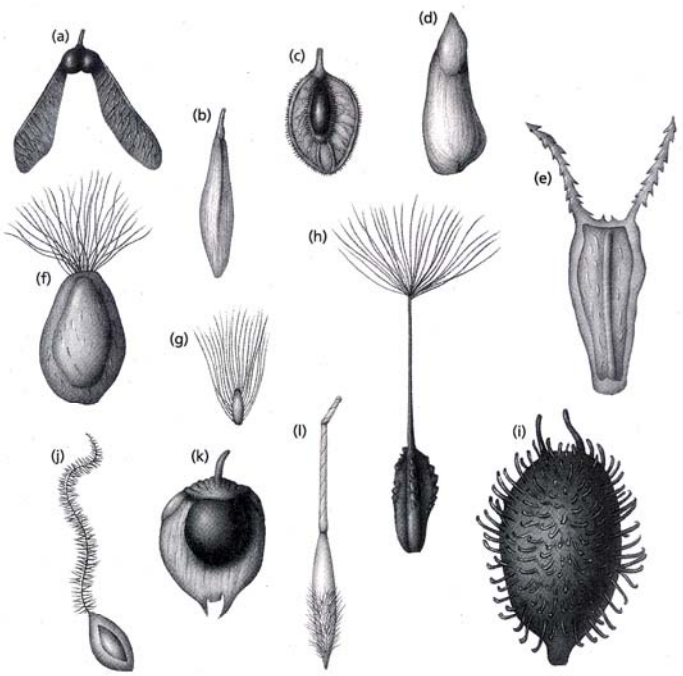

FIGURE 1.1 ■ Various seeds and fruits showing devices for dissemination. (a) Winged fruit of maple (*Acer*). (b) Winged fruit of ash (*Fraxinus*). (c) Winged fruit of elm (*Ulmus*). (d) Winged seed of pine (*Pinus*). (e) Barbed fruit of spanish-needles (*Bidens*). (f) Milkweed (*Asclepias*) seed with tuft of hair. (g) Hairy seed of cottonwood (*Populus*). (h) Fruit of dandelion (*Taraxacum*) with parachutelike tuft of hairs. (i) Hooked fruit of cocklebur (*Xanthium*). (j) Fruit of *Clematis* with long plumelike style. (k) Fruit of groundcherry (*Physalis*), with membranous envelope. (l) Bearded fruit of porcupinegrass (*Stipa*).

SOURCE: R. M. Holman and W. W. Robbins. 1939. *General botany,* p. 294. New York: John Wiley & Sons, Inc.

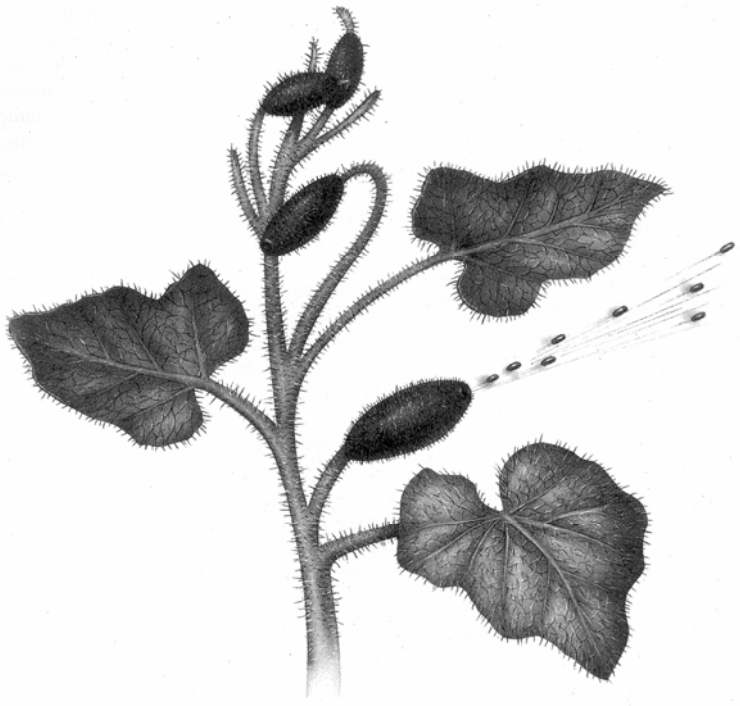

FIGURE 1.3 ■ Forceful dehiscence of the seedpod of the squirting cucumber.

SOURCE: R. M. Holman and W. W. Robbins. 1939. *General botany,* p. 295. New York: John Wiley & Sons, Inc.