CROP MANAGEMENT

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2016 Authors/Instructors for Crop Management

- Jerry Cherney, E.V. Baker Professor, School of Integrative Plant Sciences, Section Soil and Crop Sciences, Cornell University.
- Sid Bosworth, Extension Associate Professor, University of Vermont
- Margaret Smith, Professor, School of Integrative Plant Sciences, Section Plant Breeding and Genetics, Cornell University.
- Heather Darby, Extension Associate Professor, University of Vermont

With thanks to our past contributors:

- Bill Cox, Professor, School of Integrative Plant Sciences, Section Soil and Crop Sciences, Cornell University.

Lead Editors: Nicole Smaranda, NRCCA Intern, and Quirine Ketterings, NRCCA Co-Chair.

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Competency Area 1: Crop Adaptation

Soil Adaptation of Crops

1. Know the response of corn, alfalfa, perennial grasses, wheat, oats, and soybeans to:

a. Soil pH range

a) General responses to pH:

Acid tolerant	Rye, oats	> 5.0 to 5.2
Acid sensitive	Barley, alfalfa, soybeans	> 6.2
Alkali tolerant	Alfalfa, barley	< 7.8
Alkali sensitive	Soybean, rye	< 7.0

b) Acidic soils with low soil pH inhibit nodulation in crops which affects nitrogen fixation. Low pH also causes Al and Mn toxicity and deficiency of Ca, Mg and Mo.

c) Most crops grow best between 6.0 and 7.0 pH because of maximum nutrient availability. Refer to table in soil fertility section.

d) Some soils in NY have a pH of close to 8.0 but corn, soybeans, and wheat are adapted to these alkali soils because of low sodium content in Northeast soils. Select crop species based on specific pH needs.

b. Soil drainage classification range

a) Agronomic crops can respond differently to soil moisture. Proper drainage impacts crop plants by:

- Improving nutrient uptake and efficiency
- Reducing disease potential
- Allowing root growth
- Allowing more timely planting and harvest
- Improving performance of crop protection chemicals
- Ensuring adequate microorganism activity
- Increasing early season soil temperature
- Decreasing opportunities for compaction

b) Response to poor drainage varies by:

- Species.
  - Tolerance to poor drainage by species:

Decreases	Forage crops	Grain Crops
↓	Reed canarygrass	Rye
↓	Tall fescue	Oats
↓	Smooth bromegrass	Soybean
↓	Orchardgrass	Wheat
↓	Timothy	Barley = Corn
	Alfalfa	Sorghum

  - Alfalfa and most cool season grasses cannot survive poor drainage conditions.

- Time of season and crop growth stage.
  - Early establishment phase: seedlings are generally sensitive to poor drainage conditions
  - Early season corn: sensitive to poor drainage until the growing point is above ground and may drown out when subjected to an extended period of ponded water until mid-June when the stalk elongates and the growing point extends above ground.
  - Early season wheat: also sensitive to poor drainage while growing point is below ground. May drown out or heave out of the ground in poorly drained soils after a freeze and thaw cycle.
  - Early season soybean: may be susceptible to drowning out although less sensitive than corn.
  - Mid-season corn and wheat: continued sensitivity to poor drainage; symptoms include yellowing, reduced growth, delayed development through vegetative growth.
  - Reproductive period: corn and wheat become more tolerant of standing water in fields while soybean continues to be sensitive to poorly drained fields during flowering because nitrogen fixation is affected.

c) Soil drainage classification range of particular fields affects species selection decisions.
- Site-specific species selection in NY: www.forages.org
- Site-specific species selection in PA: http://www.forages.psu.edu/selection_tool/index.html

2. Know the recommended soil pH ranges for major Northeast crops.

Crop Species	Optimum Soil pH range
Alfalfa	6.2 - 7.8
Barley	6.5 - 7.8
Birdsfoot trefoil	6.0 - 6.7
Clovers	6.0 - 6.8
Corn	5.8 - 7.5
Grasses	5.6 - 6.8
Oats	5.2 - 7.5
Soybeans	6.0 - 7.0
Wheat	5.8 - 7.5

Climatic Adaptation of Crops

3. Understand the adaptation of major Northeast crops to extremes in precipitation on well-drained, moderately well drained, and poorly drained soils.

a. Extremes in precipitation include higher likelihoods of both increasing heavy rain and snow events and more intense droughts.
   - Crops in well drained soil will tolerate heavy rain and snow better because drainage will prevent puddling and flood damage. Crops in well drained soil would be sensitive to drought because of lower water holding capacity.
   - Crops in moderately well drained soils will have average tolerance of extremes in precipitation. This soil drainage classification will still drain during heavy rain or snow but will hold water better during drought as well.

  - Crops in poorly drained soils will tolerate drought best but will suffer from flood damage during heavy rain and snow.

b. Crop responses and adaptations to extremes in precipitation:
  - Corn
    - In well drained soils corn requires about 15-18 inches of precipitation from May–September for maximum yields. In poor to moderate drained soils, corn can produce maximum yields on 12-15 inches of precipitation from May–September.
    - Corn is most sensitive to drought from 2 weeks before silking to 3 weeks after silking (July and early August). Drought at this time can reduce corn grain yields by 50% and silage yields by 35-50%. Wet conditions during this time usually result in very high corn yields.
  - Wheat
    - Wheat is a very drought tolerant crop and almost never suffers from drought stress in the Northeast. Maximum yields can be attained with only 5-6 inches or precipitation from April through June on silt loam and clay loam soils and with 7-8 inches on well drained soils. Yields are lower when spring conditions are wet because of increased disease pressure and less N-use efficiency of fertilizer N.
  - Soybeans
    - Soybeans also require about 15-18 inches of precipitation from May through September on most soils.
    - Soybeans are most sensitive to drought during the pod and seed-filling periods in August. Soybean yields can be reduced by 50% if August is dry and plants are in well drained soils. Yields are reduced by about 25% on deep soils with high water holding capacity with dry August conditions.
  - Forage crops
    - Some forage legumes such as alfalfa have a deep tap root which is able to access water during drought, even in well drained soils. A poor drained soil may impede the growth of the taproot and inhibit plant growth.
    - Grasses with a shallow root system have the ability to go dormant in the summer when conditions are hot and dry.
    - Clovers and trefoils have a physiological adaptation to low O_2 availability which allows them to be successful in poorly drained soils during extremes in heavy precipitation.
    - Some forage crops are very well adapted and can tolerate both drought in well-drained soil and heavy rain in poorly-rained soil, i.e. reed canarygrass.

4. Understand the adaptation of major Northeast crops to extremes in temperature.

Adaptation of forage crops to temperature extremes.

- High temperature:
  - Hastens reproductive development.
  - Increase the water requirement.
  - Hastens forage quality decline.
  - Can result in “blasting” of floral buds.

- Low temperature:
  - Delays reproductive development.
  - Decreases the water requirement.
  - Delays forage quality decline.
  - Very low temperatures (e.g. frost) will reduce forage quality.

Fall harvest management of alfalfa. Historically, alfalfa harvest was discouraged between Sept. 1 and Oct. 15, to allow alfalfa to build up root reserves prior to overwintering. With advances in alfalfa breeding, however, this recommendation has been updated, with less emphasis on calendar date. As long as there is a 6-7 week rest interval between the second-to-last and last harvests of the season, the date of the final harvest has less significance. There may be some advantage to having alfalfa regrow at least 6-8 inches before a killing frost, to allow this regrowth to catch and hold a snow cover.

Overwintering of alfalfa. Most often it is combination of events that determines whether an alfalfa stand will survive. A full stand of alfalfa can be considered to have 4 live plants per square foot, or about 40+ shoots per square foot.

Length of growing season

- Corn and soybeans short-season hybrids and varieties have expanded the adaptation north and it is now possible to grow corn for grain and soybeans in Northern NY and Northern New England where the growing season is only 120 days long.

Cardinal Temperatures (Optimum-Maximum-Minimum):

- Corn and soybeans- 80-85, 95-100°, 40-45°. Corn and soybeans yield best when average high temperatures are 80 degrees in July and August with average low temperatures of about 60. Higher temperatures, especially under dry conditions, can reduce the yield of both crops.
- Wheat-70-75°, 85-90, 30-35°. Winter wheat is a very drought tolerant crop but high temperatures (>85 degrees) during the grain-filling period under dry conditions reduce yields somewhat because of the shorter grain-filling period.

Winter survival-sensitivity of crowns to extreme winter temperatures decreases from wheat>barley>oats.

- Winter wheat and in most years winter barley are well-adapted to central and western NY and New England because snow cover protects the crown from damage. Also, winter wheat has inherently high tolerance to cold winter temperatures, whereas winter barley has less tolerance. Thus, winter wheat is better adapted to the Northeast than winter barley.
- Winter wheat and barley are not adapted to Northern NY or Northern New England. Oats will winter kill throughout the entire Northeast region (except maybe the Long Island area).

Growth and development at extreme temperatures:

- High temperatures accelerate growth and development. Growth ceases at high temperature extreme. High temperatures during grain-filling promote senescence and premature cessation of grain-growth. Corn, wheat, and soybeans will attain physiological maturity 1-2 weeks earlier than normal under high temperatures and dry conditions during grain-filling.
- Cool temperatures retard growth and development. Cool nights, especially, slow the growth of summer crops and result in a late harvest. Grain yields, however, can be higher under these conditions because of the extended grain-filling period.

- Corn can tolerate temperatures from 29-32 degrees before the 5th leaf-stage (May to mid-June) because the growing point is below the ground (i.e. corn can tolerate early season frost).
- Soybeans can also tolerate a light frost-30 degrees- at the cotyledon or unifoliate stage (May and early June) because side growth terminals will take the place of the lead terminal. Soybeans will not tolerate frost after this period.
- Corn and soybeans, however, will die with an extended period (>4 hours) of temperatures less than 28 degrees at all stages of growth.
- Wheat will tolerate frost at all stages.

Competency Area 2: Tillage Systems

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5. Know the Northeast soil types best adapted to fall tillage. Know the advantages and disadvantages of fall tillage.

Fall tillage is best adapted to the heavy clay loam soils with minimum slope that are typically too wet to work in the spring. These soils work up reasonably well in the fall and are less susceptible to winter erosion because of their limited slope. In the spring they are usually quite friable and a one-pass secondary tillage operation usually results in a good seedbed.

The advantage to fall tillage is that the soil profile is usually drier in the fall, especially at the deeper depths, so any type of deep tillage can do a good job of shattering and not smearing the soil. Another advantage to working the soil in the fall is that it usually occurs when there is time before fall harvest (grain corn) or after fall harvest (corn silage) instead of during the spring when time is limited for primary tillage operations.

The disadvantage to fall tillage is that the soil is exposed from fall through winter so it is more susceptible to erosion, especially if heavy rains and flooded conditions occur. Only soils that are too wet to work in the spring and that have a minimum slope should be moldboard plowed in the fall, Deep tillage to break up pans and to loosen the soil at deeper depths can be performed on soils with moderate erosion potential because deep tillage usually results in a rough seedbed that is less prone to erosion.

6. Know advantages and limitations of spring tillage.

The major problem with spring tillage is that soils can typically be too wet for optimum tillage conditions and time is a major constraint in the spring for planting the crop in a timely manner. Also, secondary spring tillage operations leave the soil surface more susceptible to crusting formation. The advantage of spring tillage is that it loosens the soil and leaves the seedbed in excellent physical condition for a 1-2 month period. Also, compared to fall tillage, the soil is only exposed for about a 6-week period before the crop fills in so the erosion potential is less with spring tillage. See also #5.

7. Describe the advantages and limitations of plow, chisel, strip tillage, zone tillage and no-tillage systems for corn and alfalfa production in the Northeast.

Advantages of a plow tillage system:

(a) Can improve soil physical conditions (aeration, tilth, less soil resistance, lowers soil bulk density, etc.) for a 1-2 month period of time,
(b) Weed control method that may also reduce insect and pathogen problems,
(c) Incorporates fertilizers and chemicals,
(d) May result in a better seedbed for stand establishment of corn,
(e) Incorporates residue so the soil warms up faster.

Disadvantages of a plow tillage system:
(a) Costly tillage expenses for labor, fuel, and machinery,
(b) Can delay planting of corn and soybeans,
(c) Can result in soil compaction or plowpans,
(d) Can result in more soil erosion,
(e) Soil organic matter does not build up in the soil.

Advantages of chisel or reduced tillage systems:
(a) May reduce soil erosion,
(b) Can conserve soil moisture on droughty soils,
(c) Saves time,
(d) Saves labor, fuel, and machinery costs,
(e) Usually more than 30% residue on the soil surface so in conservation compliance.

Disadvantages of chisel or reduced tillage systems
(a) Can reduce soil temperatures so corn and soybeans get off to a slower start,
(b) Can reduce crop stand because seedbed may be rougher,
(c) Can increase pest problems, especially weeds.

Advantages of No-Till
(a) Reduces soil erosion,
(b) Reduces fuel, machine, and labor costs,
(c) Improves soil moisture conditions on droughty soils or in dry years,
(d) Saves time,
(e) Reduces soil crusting so can be advantage for stand establishment of soybeans,
(f) Traps snow in winter wheat fields so better protection of the crown and better overwintering

Disadvantages of No-Till
(a) Cooler spring soil temperatures so corn and soybeans get off to a slower start,
(b) Wetter soils in spring on soil with drainage problems,
(c) Can increase pest problems,
(d) Increased soil strength can inhibit early-season root growth on poorly structured soils in a dry spring,
(e) Delays crop development so corn may be wetter at harvest so higher grain-drying costs.

8. Know how to make economically and environmentally sound tillage recommendations in a given situation.

The best tillage system depends on the soil (slope and texture), stand establishment of the crop (large seeded corn and soybeans vs. small seeded perennial forages), the fuel and labor costs of the tillage system, and other factors such as long-term sustainability (buildup of organic matter, sequestering of CO_2, etc.). Soils that are highly erodible are best adapted to no-till or a reduced tillage system that leaves more than 50% residue on the surface.

Generally, soils that have drainage or cool temperature constraints are better adapted to moldboard plow or chisel tillage systems whereas droughty soils or soils that warm up rapidly are better adapted to a reduced or no-till system. Also, large seeded crops such as corn, soybeans, and wheat are better adapted to a no-till or reduced tillage system than small-seeded crops, such as perennial forages.

9. Describe the ideal seedbed conditions for corn, alfalfa, perennial grasses, small grains, and soybeans.

Alfalfa and perennial grasses. Seed size of most perennial forage species is small, making seedbed preparation critical for successful forage plantings. An ideal seedbed should be smooth, firm and free of clods. This requires a moldboard or chisel plow, followed by secondary tillage with a disc or field cultivator. Overworking heavy soils is undesirable and will result in breakdown of soil structure and crusting. Small amounts of crop residue on the surface can help prevent crusting and reduce soil erosion, but large amounts of crop residue will leave the soil too loose. A rough rule-of-thumb is that a footprint in the seedbed should not be more than an inch deep.

Corn, soybeans, and wheat. Seed size is large and most modern corn planters and grain drills can handle a considerable amount of surface residue. Consequently, seedbed conditions are less important and all three crops can be successfully planted into almost any type of field condition. Soil crusting and soil moisture availability are critical factors in the success of soybean establishment so no-till conditions generally reduce soil crusting problems and improve soil moisture conditions. Soil temperature is of major importance to early-planted corn so high residue conditions can reduce stand establishment in early-planted corn and delay early-season development. Wheat stand establishment is almost always successful so field conditions are not a major factor.

Competency Area 3: Seeding Factors

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10. Understand the importance of certified seed in small grain production.

What is Certified Seed?

Certification is an independent, third party means of quality control for seed
- Ensures varietal identity
- Evaluates seed purity and germination

Generations of Certified Seed:

Breeder Seed – developed by the plant breeder
Foundation Seed – grown from Breeder Seed
Registered Seed – grown from Foundation Seed
Certified Seed – grown from Foundation or Registered Seed, sold to farmers

<u>Certified Seed Assures Varietal Identity</u>
Seed fields are inspected
Seed lots are inspected
High quality standards are applied

<u>Seed Purity and Germination are Assessed and Reported on the Certification Tag</u>
Germination percentage:
- A laboratory test that classifies seeds as normal or dead
- Abnormal seeds are classified based on technician's experience
- Does <u>not</u> tell:
  - How many plants will establish in the field
  - How many plants will produce harvestable product
- Weed seed content:
  - Objectionable weeds
  - Noxious weeds as # seeds per pound
- Other crop seed content
- Inert material content (chaff, dirt, broken seed, etc.)

<u>U.S. Federal Seed Act</u>
Establishes minimum quality standards for Certified Seed
- State standards may be the same or more stringent than these
- Standards vary with crop kind

Delegates Certification responsibility to State Departments of Agriculture
- NYS Department of Agriculture and Markets for New York
- Similar agencies for other northeastern states

<u>Certified Seed Tag</u>
Lists the following information:
- Kind (crop)
- Variety or hybrid name
- Seed test results and date (both germination and purity results)
- State or country of origin
- Seed producer or seed company
- Any restrictions on use of seed or crop

This information allows calculation of the amount of "pure live seed" in a bag:
- Pure live seed is seed of the advertised crop kind and variety that should germinate. It does not include: weed seed, other crop seed, inert material.
- Calculation:
  - % pure seed = 100% - (% weed seed + % other crop seed + % inert material)
  - % pure live seed = % pure seed * % germination
- Allows accurate calculation of seeding rates
  - A 50 lb bag of seed that has 90% pure seed and 90% germination will contain:
  - 50 lb * 0.90 * 0.90 = 40.5 lb pure live seed

Crops Certified in New York

Alfalfa	Grasses (some)
Barley	Oat
Buckwheat	Potato
Corn (some)	Soybean
Dry Bean	Wheat

Crops Certified in Maine

Alfalfa	Grasses (some)

These appear to be the only northeastern states with crop certification programs in place at this time.

Importance of Certified Seed

For small grains, soybean, buckwheat, etc.:
- You get the variety advertised – no varietal mixtures or drift
- You get high seed quality (for good stands)
- You don't plant weeds (i.e. no noxious weeds and few, if any, objectionable weeds
- Seed contains few, if any, off types or other crops
- Good germination and germination rate listed on label
- Inspected and certified by an official seed certification agency
  - An unbiased third party (NYSIP in New York State)
  - Set up to assure all of the above

Some seed companies have strong internal quality control programs
- They may not certify seed
- Buyers should make sure their quality control is high

Good seed pays!! Poor seed costs!!

Seed testing in New York

Official laboratory (only accepts samples from New York):
- New York State Seed Testing Laboratory (http://www.nysaes.cornell.edu/hort/seedlab/)
- New York State Agricultural Experiment Station
- Geneva, New York

Costs for farm seeds vary depending on crop kind:
- Germination test: $10.00 per sample on average
- Purity test: cost is highly variable depending on crop kind
- Combined germination and purity test is usually a bit less than the sum of both costs

Other seed testing laboratories:

There are a number of private seed testing laboratories that can also be used but they may be more costly. Examples include the following:

- Midwest Seed Services, Brookings, SD
- Ransom Seed Lab, Carpintera, CA
- Nelson Seed Testing, Prior Lake, MN

- MD Seed Analysis, Santa Barbara, CA
- Sterling Seed Testing, Dover, OK
- Biodiagnostics, Inc., River Falls, WI
- 20/20 Seed Labs, Nisku, AB & Winnipeg, MB
- STA Laboratories, Longmont, CO & Gilroy, CA
- Ag-Biotech, Inc., San Juan Bautista, CA
- California Seed & Plant Lab Inc., Elverta, CA
- Professional Seed Research, Inc., Sugar Grove, IL
- The Tryon Group, Madison WI
- HyPure, Norton, OH
- Agri Seed Testing, Salem, OR

11. Know the factors that influence corn hybrid selection in the Northeast.

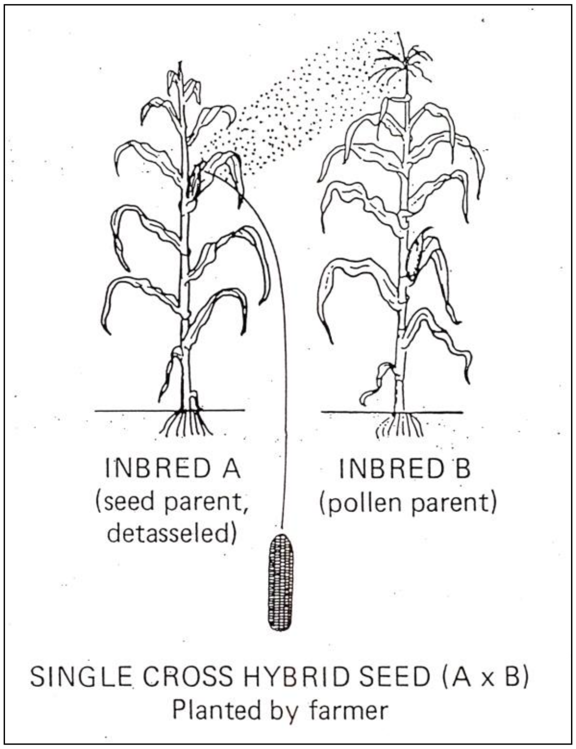
What is a Hybrid?

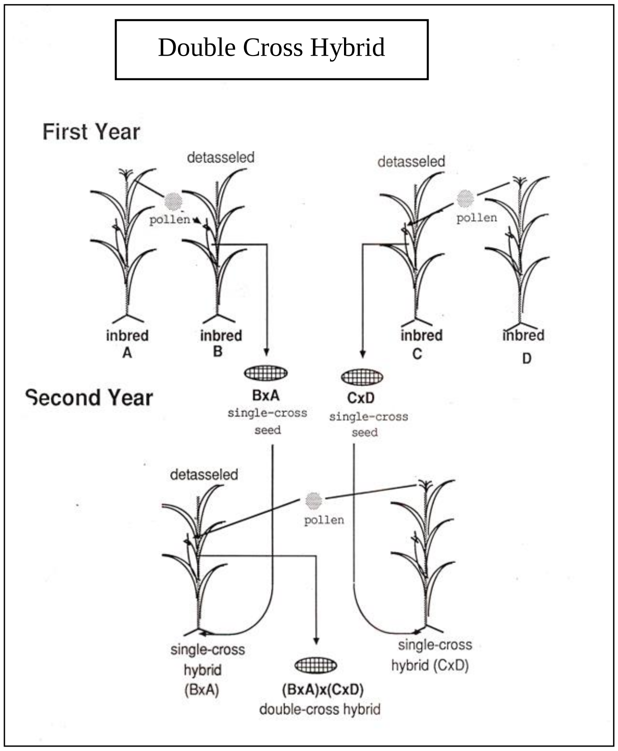
The first generation offspring of a cross between individuals differing in one or more genes.

Types of hybrids:

- Single cross hybrid – progeny of a cross between 2 parents
- Double cross hybrid – progeny of a cross between two single crosses (has 4 parents).
- Three way cross hybrid – progeny of a cross between a single cross and another parent (has 3 parents).
- Varietal hybrid – progeny of a cross between two varieties.

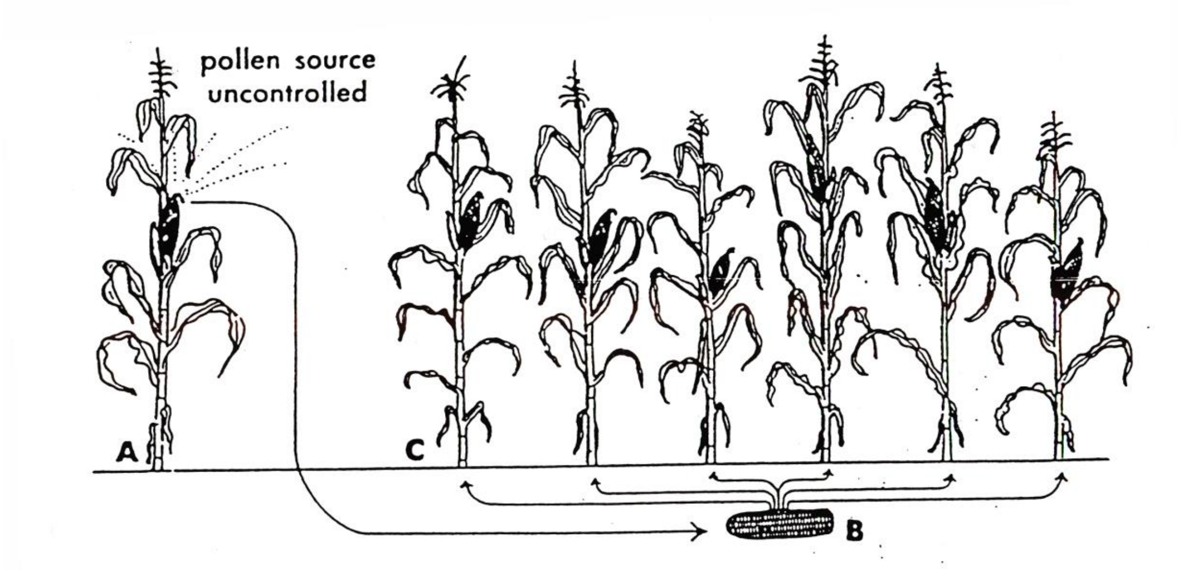
Hybrids often have better vigor (yield, size, maturity) than their parents.





Hybrids vs. Open-pollinated Varieties

Corn open-pollinated varieties (OPVs) are genetically variable because they are a mix of many different hybrids.



A = parent plant selected by seed saver, B = seed to be planted, C = resulting OPV plants (each genetically distinct)

Farmers can save seed of an OPV because the same mix of genes generally will be there from year to year.

The same OPV can change gradually from selection.

- Natural selection occurs due to the environment where the OPV is grown.
- Farmer selection can be done to pick the best ears from the best plants.

Thus, seed of a named OPV from different seed producers may be slightly different.

Corn hybrids are usually seed produced by crossing inbred parents.

- Inbreds are a result of continued pollination of a plant by itself.
- Inbreds are genetically uniform or true breeding.
- A field of an inbred that receives only its own pollen will produce seed that is genetically the same as what was planted. Inbreds are generally short with small ears and seeds (lots of rounds).

Most corn hybrids today are single crosses of two inbred parents.

- Farmers should not save seed from a hybrid planting because the resulting plants will be extremely variable and will not perform as well as the original hybrid seed.

<u>For Grain Production</u>

- Right maturity (most important!)
- High grain yield
- Strong stalk and good roots
- High test weight

<u>For Silage Production</u>

- Right maturity (mid milk line for silage)
- High tonnage (grain+stalk+leaves)
- High digestibility-(highly affected by management factors, including hybrid selection, plant densities, and harvest timing as well as silo management

Other characteristics depend on grower's interest and needs!

12. Know the factors that influence forage species and cultivar selection in the Northeast.

- Winter hardiness. Select varieties with appropriate winter hardiness to minimize winter injury and winter kill.
- Diseases. Select varieties with maximum resistance to diseases common in the Northeast (see pest management section of this manual).
- Yield. Select high yielding cultivars based on the closest alfalfa variety trial sites.

Alfalfa is a multi-year crop, so survival through winter and over time is important. When selecting a variety, first for disease resistance to verticillium wilt, phytophthora root rot, anthracnose (Hudson Valley only in NY), bacterial wilt (all modern varieties are resistant), maybe also fusarium wilt (not typically an economic problem in NY).

Also look for:

- Fast recovery
- Winter hardiness (fall dormancy ratings of 2 to 4)
- High yield
- High quality

Alfalfa Ratings for Disease Resistance
Alfalfa varieties are genetically variable, so you almost never find all plants uniformly resistant
Diseases are rated by this scale:
HR = highly resistant, 50% or more of plants are resistant
R = resistant, 31-50% of the plants are resistant
MR = moderately resistant, 15-30% of the plants are resistant
LR = low resistance, 5-15% of the plants are resistant
S = susceptible, 0-5% of the plants are resistant
Individual plants may show disease symptoms even in R or HR varieties, but enough plants will be resistant to keep disease damage to a minimum. In choosing varieties, aim for R or HR ratings on all important diseases

Variety choice – the bottom line
Requires appropriate testing data and a knowledge of producer's particular needs
What's important to the grower is performance (yield, quality, etc.) in her/his environment!
Use the best data available for the grower's location or similar areas
Cornell Guide series has variety evaluation data
Seed companies also evaluate varieties, but mostly only their own brand

13. Know the factors used to determine optimum planting date of major Northeast crops.

Factors used to determine optimum planting date of forage crops in the Northeast.

- Spring seeding. This is typically late April to early May for perennial grasses and can be as late as June 1 in southern NY and June 7 in northern NY for alfalfa. Soil moisture is generally adequate in the spring.
- Late summer. This is typically late August in southern NY and mid-August in northern NY for perennial grasses. For alfalfa, seeding should be completed by mid-August in southern NY and early August in northern NY. White mold is much more likely on summer seeded alfalfa.

- Frost seeding. Broadcast seeding prior to the spring soil freeze-thaw cycles can be successful with some species, such as red clover, but are likely to fail with other species, such as reed canarygrass and birdsfoot trefoil.

Planting date factors for corn, soybeans, and wheat

- Temperature
  - Hastens reproductive development.
  - Summer crops – can begin planting at minimum temperatures for germination (after mid-April or early May, depending upon location).
  - Corn: 45-50°F
  - Soybean: 50-55°F
  - Small grains - begin germination at 32°F so temperature is never a constraint for spring grains and almost never a constraint for winter grains.

- Moisture
  - Corn - is very hygroscopic so dry soil conditions usually do not deter corn emergence in the Northeast (but lack of moisture in the seed zone can reduce emergence in the western Corn Belt). If soil conditions are very dry, corn can be planted up to 3 inches deep because the coleoptile (seed leaf) can puncture through tough soil conditions to help emergence from deep soil depths.
  - Soybean - high imbibition requirement (more than 50% by weight) so soybeans are very sensitive to dry soil conditions. Soybeans also have a hypocotyl that can be broken during the emergence process under tough soil conditions (crusted soil) so soybeans can not be successfully planted more than 2 inches deep. Adequate moisture of the seedbed can be a constraint to stand establishment in soybean, especially under an intensive tillage system.
  - Small grains - moisture is almost never a factor in successful establishment in the Northeast because it is usually moist when planting small grains. Small grains also have a coleoptile so under dryland conditions (Pacific Northwest, High Plains, etc.) wheat can be successfully planted up to 3 inches deep.

- Soil Conditions
  - Under wet soil conditions, wait until the soil dries before planting (all crops) or else you run the risk of soil compaction during planting. So if it is early May and temperatures are ideal but soil conditions are wet, do not plant corn or soybeans.

- Pest-free date
  - Winter wheat - delay planting until after Hessian-fly-free date (Sept. 15th in most of the Northeast).

- Other Factors
  - Late-spring frosts – growers in regions with late spring killing frosts may hold off on planting corn and soybeans in late April even with favorable soil conditions and temperatures.
  - Tillage system - ridge tillers can plant corn earlier as tilled soil dries and warms up quicker.

14. Recognize the consequences of seeding major Northeast crops too early or too late.

Consequences of seeding forage crops in the Northeast too early or too late.

- Spring seeding. Seeding too early in cold, wet soils can reduce germination. Seeding too late in the spring will risk the multiple stresses of high temperature, lack of moisture and weed competition.
- Late summer. Advantages of late summer seedings include 1) less competition from weeds, 2) seedings can be made after early-harvested crops, 3) avoids the spring workload, 4) liming, fertilization and tillage are done during drier weather, reducing soil compaction risk, and 5) damping-off diseases of seedlings are usually not a problem. The primary disadvantage is available moisture. Also, if seedings are too late in the season to allow for 6 weeks of growth before a killing frost, there is a risk of winterkill, particularly with species such as reed canarygrass, with slow growing, weak seedlings.
- Frost seeding. The primary advantage is low cost, the primary disadvantage is high risk of seeding failure.

Consequences of seeding corn, soybeans, and wheat too early:

- Reduced plant stands of corn and soybeans
  - Chilling stress during imbibition may reduce germination.
  - Extended emergence time because of cool temperatures make both corn and soybeans more susceptible to seed corn maggot/wireworm damage and plant pathogen damage, reducing corn and soybean emergence and final stands.
  - Early-season pests such as cutworm and slugs, can further reduce stands after emergence because corn growth is slow during early vegetative growth under cool conditions and corn cannot outgrow these pests.
  - Chilling stress of emerged crop may further reduce stands.
- Increased potential for pest problems in winter wheat.
  - Aphids can transmit BYDV in early-seeded winter wheat, which can lead to 30% yield reductions.
  - Hessian fly can infect early-planted wheat and can take plants out in the spring.
  - Higher potential for powdery mildew.
  - Too much fall growth could result in smothering of the crop in the winter and early spring.
- Increased potential for early-season frost problems.
  - Corn and soybeans - Higher probability of encountering late spring killing frost.
  - Winter wheat - Frost does not affect the plant until the growing point is above the ground so early-season frost is not a factor.

Consequences of seeding too late:

- High probability the crop will not mature (corn and soybeans).
  - Yield reduction.
  - Crop quality reduction (low test weight in corn and reduced oil/protein content of soybeans)
  - Higher drying costs for corn and perhaps soybeans will have to be dried (usually no need to dry soybeans).
- Delayed harvest.
  - Premature frost requires the crop to lose more moisture so longer dry down period. Corn and soybean harvest can be delayed until December or even January or February.

  - Spring grains -high probability spring grains encounter more heat/moisture stress during flowering and grain-filling period.
- Yield reduction (winter wheat).
  - Higher probability for overwintering problems because of limited growth in the fall.
  - Yield reduction due to lower stand.
  - Pest problems may be reduced so could compensate a bit for lower yields.
  - 1-week delay in maturity that may or may not mean more heat/water stress during flowering and grain-filling.

Competency Area 4: Seeding Rates and Row Spacing

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15. Know factors that influence the seeding rate of major Northeast crops.

- Optimum seeding rate depends on the interaction of the crop's characteristics and the environment that it is growing in.
  - General rule is to plant at higher populations under favorable environmental conditions (moisture and N) and to reduce seeding rates as environment becomes less favorable.
  - Corn-higher populations for grain (30000 plants/acre final stands) on soils that have good water holding capacity. Reduce populations (26,000 plants/acre final stands) on droughty soils.
- <u>Crop characteristics</u> - compensation ability
  - Soybeans and wheat - both crops compensate or fill in where there is a gap. Consequently, both crops have a broader optimum population than corn. Corn does not compensate as well so seeding rate needs to be more precise.
- <u>Tillage system/planting date</u> -can result in less favorable conditions for emergence
  - Corn and soybean - increase seeding rate for early planting dates or as tillage is reduced.
  - Winter wheat and spring grains - delayed planting results in less tillering so increase the seeding rate.
- <u>Crop utilization</u> - dry matter yields respond to higher seeding rate.
  - Corn silage vs. grain – use a higher seeding rate for corn silage.
  - Small gains - forage vs. grain – use a higher seeding rate for forage.
  - Small grain companion crops – use a lower seeding rate for companion crops.
- <u>Row spacing</u> - narrow rows create more favorable environment for light utilization so beans and corn respond to higher seeding rates.
  - Soybeans 7" row-spacing requires 180,000 plants/acre compared to 150,000 plants/acre for 30" rows.
  - Corn - responds to higher populations in narrow rows (15-inch vs. 30-inch).
- <u>Planter</u>
  - Small grains -increase seeding rate when broadcasting vs. drilling seed because of better emergence under drilled vs. broadcast conditions.
- <u>Growth habit of crop.</u>
  - Corn - fixed vs. flex ear. Many believe flex ear types can yield well at lower populations.
  - Soybean - bush vs. narrow growth habit. Bush type varieties are supposed to do better at wider rows and lower seeding rates.

    - Corn bred for a vertical leaf type, especially above the ear, responds to higher populations.
    - Soybeans - same.
- Variety seed size - soybean and wheat varieties can have very different seed size. Plant small seeded varieties (many seeds/lb) at lower lbs/acre or bu/acre than large seeded varieties.

Factors influencing seeding rate of forage crops in the Northeast.

- Seed size. Seeds per pound can vary in forage crops from 2 thousand to over 2 million. Seed size, or any seed coating, may influence the rate of seed delivery through the seeding implement.
- Pure live seed (PLS). This is a function of seed germination and seed purity. E.g. 95% germination and 97% purity = 0.95 x 0.97 = 92% PLS. Planting rate equals the recommended seeding rate divided by the PLS value. e.g. a desired seeding rate of 12 lb/acre in the above example is 12/0.92 = 13 lb/acre.
- Soil type. Lower seeding rates can be used on light, sandy soils because of more complete emergence.
- Seedbed condition and seeding method. Lower rates can be used on well-prepared seedbeds. Higher rates provide some insurance on less than optimum seedbeds, however high seeding rates will probably not succeed on a poor seedbed.

16. Know the factors that influence the planting pattern of major Northeast crops. Know the advantages of broadcast versus drilled small grains.

Equi-distant spacing between and within rows is the ideal pattern for most crops.

- Small grains – There is a yield response to narrow-row drills (i.e. 4-inch drills) so European wheat planted is in narrow rows. In the Northeast, wheat is planted in 7-inch rows because no 4-inch drills are available.
- Soybeans - plant at 30-, 15-, and 7-inch rows. Soybeans yield best in New York and New England at 7-inch row spacing because of the more equi-distant spacing (7 by 3 inch pattern compared with a 30 by 1.5 inch pattern). But a corn planter has better depth control than a drill so soybean stands emerge more rapidly and more uniform in 30-inch row spacing than 7-inch row spacing.
- Corn silage yields better in narrow rows because of a more equidistant spacing (15 inch by 12 inch vs. a 30 by 6 inch pattern).

Available equipment-planting pattern must match your other equipment, especially the harvester.

- Corn – Kemper or bi-directional chopper heads make narrow row (15-inch) corn silage possible. Equipment is currently not available to harvest narrow corn for grain so all corn grain has 30-inch row spacing. Also, it is more difficult to sidedress 15-inch spaced rows than 30-inch rows.

Pest control

- Soybeans - drilling in 7-inch rows precludes cultivation and can result in increased occurrence of white mold.
- Narrow-row corn makes post-emergence herbicide application (i.e. Roundup) more difficult and some of the rows get run over by the spray rig.

Broadcast vs. drilled small grains

- An advantage of broadcasting small grains with a fertilizer spreader is that the small grain can be planted much more rapidly than what would be possible with a grain drill. However, there is an additional cost for harrowing in the seed after broadcasting. Furthermore, the final stand is usually lower with broadcast than with drilled small grains because of poor seed depth placement with the broadcast/harrowing operation (some seed still remains on the surface). The latter trip on the field can also result in higher total costs in seeding a small grain. When small grains (rye) are used as a cover crop, broadcasting might be the most suitable method because the cover crop can be rapidly planted. When small grains are to be harvested as a crop, using a grain drill would be recommended because of more uniform final stand establishment.

17. Know recommended seeding rates for major Northeast crops.

Soybeans:

The recommended seeding rate depends on planting pattern. The general recommendation is to seed at 180,000 seeds/acre for drilled soybeans and about 160,000 seeds/acre for soybeans in 30-inch row spacing. Soil type is not a major factor in soybean seeding rate recommendations because soybeans fill in so well that they use about the same amount of water, regardless of final stands.

Corn for grain:

The recommended seeding rate depends on soil type. Soils that have high water holding capacity should have final stands of about 30,000 plants per acre. Assuming a 90% emergence rate for corn, the actual seeding rate should be about 32,500 seeds/acre (somewhat higher if seeded early under no-till conditions because emergence may be less than 90% but only 31,000 seeds/acre if planted in late May under plowed conditions because emergence will be 95% or higher). Droughty soils with low water holding capacity should have final stands of only 26,000 plants/acre because droughty conditions set in more easily on these soils. Consequently, seeding rates should be about 30,000 plants/acre on these soils with adjustments made for planting date and soil conditions.

Corn grain vs. corn silage seeding rates:

Silage corn can be seeded at higher rates because dry matter or biomass production responds more favorably to high seeding rates than grain production does. Generally, corn silage should be seeded at about 4,000 more kernels/acre with final stands 3500 plants/acre higher than corn for grain. Maximum yield for corn silage occurs at final stands of close to 40,000 plants/acre but quality decreases. Consequently, final stands of corn silage should be at 33,000-34,000 plants/acre on soils with high water holding capacity (36,000-37,000 kernel/acre seeding rate with 90% emergence rate) and 26,000-28,000 plants/acre on droughty soils.

Wheat:

The recommended seeding rate depends on planting date. Wheat is planted anytime from mid-September to early November. Also, wheat tillers profusely if the seeding rate is low and can “fill in” and compensate for low final stands. Seeding rates should be about 2 bu/acre for wheat planted before mid-October and 2 ½ bu/acre when planted after mid-October. Growers can fine-tune their seeding rates because seed size varies with many wheat varieties and go with 1.6 million seeds/acre until mid-October and then increase the seeding rate to 2.0 million seeds/acre after that.

Perennial forages

Pure species:
- Alfalfa – 12-15 lb/a
- Red clover – 4-8 lb/a
- Birdsfoot trefoil – 4-6 lb/a
- Timothy – 4-6 lb/a
- Orchardgrass – 4-8 lb/a
- Smooth bromegrass – 5-8 lb/a
- Reed canarygrass – 8-10 lb/a

Alfalfa-grass mixtures:
- Alfalfa (10-12 lb/a) and
- Tall fescue (3-4 lb/a) or
- Meadow fescue (3-4 lb/a) or
- Reed canarygrass (6-8 lb/a) or
- Orchardgrass (2-4 lb/a) or
- Timothy (4-6 lb/a)

See also response to 15 and 18.

18. Know the advantages and disadvantages of seeding pure grass or legume stands versus mixed stands.

- Pure alfalfa. If the soil is well drained and optimum for alfalfa growth, pure alfalfa is an option. The primary advantage of pure alfalfa seeding is the ability to use weed control, either herbicides or a combination of glyphosate and Roundup Ready alfalfa varieties. Some commercial hay markets may pay a premium for pure alfalfa forage. A pure grass stand can be harvested at the optimum quality for alfalfa. It is possible but problematic to apply manure to pure alfalfa stands. Pure alfalfa will maximize yield and quality on good alfalfa land.
- Pure grass. If the soil type is not optimum for legumes, then pure grass can be sown. A perennial grass stand has more options for manure application. A pure grass stand can be harvested at the optimum quality for the grass species, and will increase the spring harvest window.
- Mixed alfalfa-grass stands. If conditions are not optimal for alfalfa, a mixture may be planted. Mixed stands eliminate the need to fertilize pure grass with expensive commercial N fertilizer. As alfalfa declines in a mixed stand, grass can fill in the void. Grass will reduce the potential for alfalfa heaving in the spring on fragipan soils prone to heaving. Mixed alfalfa grass can be harvested at an intermediate time (early for pure alfalfa and late for pure grass) to provide optimum quality for the mixture. Over 80% of all alfalfa acreage in NY is seeded to alfalfa-grass.
- Mixed grass stands. In some cases where soil types and drainage are highly variable in a given field, it can be advantageous to plant a mixture of perennial grasses. Different locations in the field may end up dominated by different grass species. This can maximize yield but does not optimize quality as grasses of differing quality must be harvested at the same time.

19. Know the recommended seeding depths for major Northeast crops.

Seeding depth for forage crops.

- Optimum seeding depth varies with species, soil type, soil moisture, time of seeding, and firmness of the seedbed. Seed without good seed-soil contact is likely to dry out during the germination process. Seed planted too deep will not have the seed reserves to survive emergence. In humid areas best results are to seed at a depth of 0.2 to 0.5 inches. Late spring and summer seedings should be sown somewhat deeper due to increased moisture stress.

Established plants from 100 seeds, based on soil type and seeding depth

	Sand			Clay			Loam		
Depth	0.5	1.0	2.0	0.5	1.0	2.0	0.5	1.0	2.0
Species	Established plants, %								
Alfalfa	71	73	40	52	48	13	59	55	16
Red clover	67	66	27	40	35	7	47	45	13
Bromegrass	71	64	29	56	37	6	68	50	19
Orchardgrass	61	56	13	60	26	1	56	39	16
Sund, J.M. et al., 1966. pp.319-323. Proc. 10th Int. Grassl. Congr., Helsinki, Finland.									

Seeding depth considerations:

- Crop response to planting depth
  - Deep planting.
    - Emergence time delayed.
    - May result in crusting damage to emerging seedlings - soybeans in particular.
    - May enhance emergence because of better moisture-corn in particular.
- Crop characteristics.
  - Monocots such as corn and small grains have a coleoptile which emerges first. They are less vulnerable to mechanical damage from crusted soils so generally they can be plant deep without problems. The ideal depth for corn is about 1.5-2.0 inches but they can be planted up to 3-inches if it is dry and warm. Planting should be in the 1.5 inch range if done in cool moist conditions.
  - Dicots such as soybeans have the hypocotyl emerge first. The hypocotyl is susceptible to mechanical damage so problems can occur with deep planting. The planting depth for soybean should be from about 1.25 to 2.0 inches. Drilled soybeans are usually planted at the 1.25-inch depth because of depth control issues with the drill whereas soybeans can be planted at the 2-inch depth with a corn planter if is dry and warm. Planting depth is more crucial with soybeans than corn or wheat because planting at a shallow depth (<1.25 inches) can result in emergence problems if it turns dry, especially under intensive tillage, and planting too deep (>2.0 inches) can result in emergence problems, especially if the soil crusts before emergence.
  - Seed size - smaller seeds (alfalfa) are planted shallower than bigger seed (corn or soybean)
- Planting equipment.
  - Row crop planter - excellent control of planting depth so you can plant within the recommended depth.
  - Drill-may have depth control problems at times so may plant too shallow for conditions.
  - Broadcast small grains-surface applied and must harrow in.
- Herbicide placement.
  - Plant corn or wheat below herbicide treated zone.

Competency Area 5: Considerations in Replanting Decisions

20. Know the minimum stand for major Northeast crops before considering replanting. Recognize factors that result in thin stands of Northeast crops.

Determining stand density:

1) Measure out 1/1000 of an "acre in several representative areas of the field.
   - 30-inch row -17 feet and 5 inches
   - Number of plants X 1000 = plants/acre
2) Measure out plants in areas of the field.
   - Determine square feet in measuring area.
   - 43560 square feet/square feet in area = correction factor.
   - Plants counted x correction factor = plants/acre.

Minimum stands and replanting in the Northeast:

Forage Crops:

Poor seedbed preparation, incorrect seeding rate of PLS, improper seeding depth, and incorrect seeding date can all result in thin stands, and can all be controlled. Excess moisture or drought conditions cannot be controlled and may also result in poor stands. It is impossible to assess the success of a perennial grass seeding by counting plants per unit area. Grasses have the ability to eventually spread out over the open spaces and fill in a stand. If essentially no plants are visible after all should have emerged, replanting is a consideration. A spring seeding may not be replanted till late summer, and a late summer seeding requiring replanting may not be accomplished till the following spring. Alfalfa seedings should have at least 10-12 plants per square foot (20-30 is optimum), or they will not have a good chance of coming through the first winter with an adequate full stand.

Corn:

Usually don't replant grain corn if final stand densities are ≥16,000 plants/acre and plants are evenly distributed throughout the field. For silage, final stands should be less than 18,000 plants acre before considering replanting. If there are major skips in the field, it may pay to go in and replant portions of the field where final stands are extremely low.

Effects of skips in 20 feet of row:

Grain:	2 foot skip = no effect
	3 foot skip = 5-10% yield loss
Silage:	2 foot skip = 5% yield loss

Questions to consider in making a replanting decision:

Do first planted seedlings have:

- Well developed roots?
- A good start?
- Good weed control?
- Two-thirds of a stand?

REMEMBER: Later planting costs one bushel per day in grain yield, so yield is hurt no matter what!

Alfalfa:

Desired alfalfa stands:

Year	Desired Plants per Square Foot
Fall 1st (seeding) year	15-20
Spring 2nd year	10-12
Spring 3rd year	3-5
Spring 4th year	3-4

Dig up roots, look for rot, insect damage
Consider replanting if:
Fewer plants than noted above or uneven stands (lots of skips)
Grass can help – may tilt towards keeping the stand
Weeds will NOT help – may tilt towards replacing the stand

Seed appearance	Likely problem
1. No seed, no sign of seed	Planter problems
2. Seeds soft, rotten	Seed dead when planted
3. Seeds hard, not germinated	Dry soil or dry pockets in trash
4. Seeds gone, seedlings lying on soil surface	Birds (pulling up plants to get seeds)
5. Seeds gone, signs of scratching or digging	Squirrels or (less likely) birds
6. Seeds dug up, germs gnawed out, leaving half-moon shaped endosperm	Mice or rats
7. Seeds have holes in them (worms may be present)	Seed corn maggot or wireworm
8. Seeds present, root system okay, plants cut off near or at the base	Cutworm
9. Seeds okay, plants small, roots stunted and/or "burned" at tips	Fertilizer burn/injury

21. Describe the type of damage that hail, frost, drought and wind can cause corn, small grains, soybeans and forage crops.

Hail and wind damage are not significant issues with perennial forage crops. Frost may damage new seedlings, but generally not if they are sown at the proper time. Some frost damage of leaves is not significant, only if plants are frozen to the ground should replanting be considered. Flooding and drought are the major environment stresses for forage crops. Alfalfa is very susceptible to poor soil drainage conditions, whereas many grasses are somewhat resistant or very resistant, such as reed canarygrass. Perennial grasses are frequently subject to drought damage, which appears as a drying and dying back of leaf blades from the tip and leaf margins, accompanied by minimal plant growth. Alfalfa winter kill or winter damage is typically a cumulative effect of a series of stresses, as noted in the worksheet below.

22. Recognize when major Northeast crops are most susceptible to specific environmental stresses such as frost, defoliation, drought, etc.

Calculate Risk of Alfalfa Winter Injury worksheet (courtesy of Dan Undersander, Univ. of Wis.):

	Point Value	Your Score
1. What is your stand age?		
• > 3 yrs	• 4	
• 2-3 yrs	• 2	________
• < 1	• 1	
2. Describe your alfalfa variety:		
A. *What is the Winterhardiness?*		
• Adequate winter survival (score 4)	• 3	
• Good winter survival (score 3)	• 2	________
• Very good winter survival (score 2)	• 1	
B. *What is it disease resistance?*		
• Moderate resistance to only bacterial wilt	• 4	
• Moderate or higher resistance to bacterial wilt plus either Phytophthora Root Rot, Fusarium wilt or Verticillium wilt	• 3	________
• Moderate or higher resistance to all above mentioned diseases	• 1	
Alfalfa variety total score (multiply a. x b.)		________
3. What is your soil pH?		
• <6.0	• 4	
• 6.1-6.5	• 2	________
• 6.6 or greater	• 0	
4. What is your soil exchangeable K level?		
• Low (<80)	• 4	
• Medium (80-120 ppm)	• 3	
• Optimum (120-160 ppm)	• 1	________
• High (>160ppm)	• 0	
5. What is your soil drainage?		
• Poor (somewhat poorly drained)	• 3	
• Medium (well to moderately well drained)	• 2	________
• Excellent (sandy soils)	• 1	
6. What is your soil moisture during fall/winter?		
• Medium to dry	• 0	
• Wet	• 5	________
7. Describe harvest frequency (*Cut Interval + Last Cutting Date*):		
<30 days	**<30**	
Sept 1 to Oct 15	• 5	
After Oct 15	• 4	
Before Sept	• 3	
30 to 35 days	**30-35**	
Sept 1 to Oct 15	• 4	
After Oct 15	• 2	________
Before Sept	• 0	
>35 days	**>35**	
Sept 1 to Oct 15	• 2	
After Oct 15	• 0	
Before Sept	• 0	
8. For a mid-Sept. or Oct. cut, do you leave> 6-inch stubble?		
1. No	• 1	
2. Yes	• 0	________
Determine your total score (Sum points from questions 1-8)		________

Winter injury risk	
If you score:	Your risk is:
3-7	low/below average
8-12	moderate/average
13-17	high/above average
>17	very high to dangerous

Competency Area 6: Crop Staging, Growth and Development

Crop Staging - Grain Crops and Soybeans

23. Know the different systems used to stage corn, small grains and soybean.

Small Grain-Feekes scale is most commonly used scale in the USA (Zadoks scale in Europe):

- Stage 1-one shoot or seedling stage
- Stage 2-tillering begins
- Stage 3-tillers formed
- Stage 4-leaf sheath lengthens
- Stage 5-leaf sheath strongly erected
- Stage 6 –first node of stem visible or jointing stage (growing point is now above ground)
- Stage 7-second node visible
- Stage 8-last leaf just visible
- Stage 9-ligule of last leaf just visible
- Stage 10-“boot” stage
- Stage 10.1-early heading (head of the wheat plant is now visible)
- Stage 10.5-flowering or anthesis stage
- Stage 11-ripening or grain-filling

Corn-Iowa or leaf ligule staging method:

- VE-emergence
- V1-1st leaf
- V2-ligule of 2nd leaf is visible
- V3-ligule of 3rd leaf is visible
- Vn-ligule of nth leaf is visible
- VT-tasseling
- R1-silking
- R2-blister of kernel
- R3-milk stage of kernel
- R4-dough stage of kernel
- R5-dent stage of kernel
- R6-physiological maturity

Soybean-Iowa method:

- VE-emergence
- VC-cotyledons are visible
- V1-1st leaf node is fully developed
- V2-2nd leaf node if fully developed
- Vn-nth leaf node if fully developed
- R1-beginning flowering
- R2-full bloom or flowering
- R3-beginning pod development
- R4-full pod development
- R5-beginning seed development
- R6-full seed development
- R7-beginning maturity
- R8-full maturity

24. Know how to identify growth stages between emergence and physiological maturity of corn, small grain, and soybean.

See item 23.

Crop Staging - Forage Legumes and Grasses

25. Describe the systems used to stage forage legumes and grasses.

Alfalfa staging system (http://alfalfa.ucdavis.edu/IrrigatedAlfalfa/pdfs/UCAlfalfa8289GrowthDev_free.pdf).

Stage 0: Early vegetative. Stem length ≤ 6 inches.
Stage 1: Mid-vegetative. Stem length 6-12 inches.
Stage 2: late vegetative. Stem length > 12 inches (no visible buds).
Stage 3: Early bud. 1-2 nodes with visible buds.
Stage 4: Late bud. ≥ 3 nodes with visible buds.
Stage 5: Early flower. One node with one open flower.
Stage 6: Late flower. ≥ 2 nodes with open flowers.
Stage 7: Early seed pod. 1-3 nodes with green seed pods.
Stage 8: Late seed pod. ≥ 4 nodes with green seed pods.
Stage 9: Ripe seed pod. Nodes with brown mature seed pods.

Perennial grass staging system:

- Perennial grass proceeds through a sequence of developmental stages: 1) germination, 2) vegetative; 3) elongation; 4) reproductive, and 5) seed ripening. The vegetative growth period is characterized by the development of leaves. Elongation is the period during which stem internodes elongate and is also referred to as jointing. During elongation the developing inflorescence pushes through the uppermost leaf sheath commonly referred to as boot stage. The reproductive stage is the period during which the developing inflorescence emerges and pollination occurs.
- Quantifying growth stages (Moore et al., Agron. J. 83:1073. 1991). The five growth stages above have been related to a continuous numerical index. Germination stages are numbered from 0 to 0.9 and seed production stages are numbered from 4.0 to 4.9 on the numerical scale. Vegetative stages 1.0 to 1.9 start with emergence of first leaf and the index increases with each additional collared leaf. Elongation stages range from 2.0 to 2.9 starting with onset of elongation and the index increases with each additional palpable/visible node. The Reproductive stages range from 3.0 to 3.9 and start with boot stage. The emergence of the inflorescence through post-anthesis is included. Each stage of the system also has a mnemonic code (e.g. R1 = inflorescence emergence).

Primary and secondary growth stages and their numerical indices and descriptions for staging growth and development of perennial grasses.

Stage	Index	Description
Germination		
G0	0.0	Dry seed
G1	0.1	Imbibition
G2	0.3	Radicle emergence
G3	0.5	Coleoptile emergence
G4	0.7	Mesocotyl and/or coleoptile elongation
G5	0.9	Coleoptile emergence from soil

Stage	Index	Description
Vegetative-Leaf development		
VE or V0	1.0	Emergence of first leaf
V1	(1/N)+0.9	First leaf collared
V2	(2/N)+0.9	Second leaf collared
Vn	(n/N)+0.9	N^{th} leaf collared
Elongation-Stem elongation		
E0	2.0	Onset of stem elongation
E1	(1/N)+1.9	First node palpable/visible
E2	(2/N)+1.9	Second node palpable/visible
En	(n/N)+1.9	N^{th} node palpable/visible
Reproductive-Floral development		
R0	3.0	Boot stage
R1	3.1	Inflorescense emergence/1^{st} spikelet visible
R2	3.3	Spikelets fully emerged/peduncle not emerged
R3	3.5	Inflorescense emerged/peduncle fully elongated
R4	3.7	Anther emergence/anthesis
R5	3.9	Post-anthesis/fertilization
Seed development and ripening		
S0	4.0	Caryopsis visible
S1	4.1	Milk
S2	4.3	Soft dough
S3	4.5	Hard dough
S4	4.7	Endosperm hard/physiological maturity
S5	4.9	Endosperm dry/seed ripe

26. Know how to determine mean stage of development for alfalfa.

To determine mean stage of development, a representative sample of at least 40 stems is cut leaving a 1 ¼" stubble. There are two methods of calculating mean stage of development.

a. Mean Stage by Count (MSC):
   Calculated as the average of the individual stage categories in the sample, weighted for the number of stems at each stage.

   MSC = ∑ (stage number x number of stems) / total number of stems

   [(stage number x number of stems) / total number of stems] is added up for all the stages present in the sample, and this sum is the MSC.

   For example, if a sample has 10 stems (stage 3); 25 stems (stage 4); and 6 stems (stage 5):

   $$MSC = \frac{(10 \times 3)+(25 \times 4)+(6 \times 5)}{(10 + 25 + 6)} = 160/41 = \mathbf{3.90}$$

b. Mean Stage by Weight (MSW):
Calculated like MSC, except weighted for dry weight of stems at each stage.

MSW = ∑ (stage number x dry wt. of stems in stage) / total dry weight of stems Simply replace the "number of stems" in MSC with weight (in grams) of the stems.

MSW is more closely related to forage quality compared to MSC, but more time consuming to determine.

Growth and Development

27. Know how to calculate Growing Degree Days (GDD) using the 86 - 50 system for corn, or the Base 41 system for forages. Know how environmental effects such as water stress or photoperiod affect the accuracy of GDD in predicting growth and development of corn.

Crops that respond to day length (actually responding to night length) are photoperiodic-sensitive.

- Short-day crops–corn. Begins the reproductive phase when day length is shorter than critical threshold--i.e. <15 hours. Hybrids with different maturities (i.e. 90 vs.100 day corn hybrid) respond to different photoperiodic lengths (i.e., 90-day hybrid may begin the reproductive process when day length is less than 15 hours, whereas the 100-day hybrid may begin the reproductive process when day length is less than 14 hours and 45 minutes).
- Day-neutral crops –day length does not affect their flowering –soybean varieties grown in the Northeast are day-neutral and respond to temperature (soybeans that are grown in southern regions are photoperiodic and considered a short-day crop and will begin the reproductive process when day length is less than a critical threshold).
- Long-day crops-begin flowering when day length exceeds critical threshold level-wheat and rye are long-day crops and begin the reproductive process once day length exceeds a critical threshold.

Vernalization — an extended period of cold temperatures required to induce reproductive development in crops. Winter annuals such as winter wheat, winter canola, and rye require vernalization for reproductive development. If you plant winter wheat in the spring, it may grow like a bunch grass and may not elongate or head out.

Growing degree day or heat unit

- Summary of daily average temperature that assumes that the rate of growth or development of the crop increases linearly with an increase in temperature above a base temperature to a maximum temperature.
- Most GDD or heat unit systems have a base temperature that assumes minimum or no growth below the base.
- Most systems have cut-off values that limit maximum and minimum temperatures.
- Most GDD systems used to classify corn hybrid maturity ratings.

Basis for and calculation of GDD
Now used in Cornell Guide for Integrated Field Crop Management

Based on the observation that corn does not grow much below 50˚F or above 86˚F

Calculation:
GDD is a calculation of the number of degrees by which the average daily temperature exceeds a base of 50˚F. The formula is: GDD = [(high temp. for day + low temp. for day) / 2] – 50˚F, but:
- If high temperature for the day is >86˚F, use 86˚F for the high in the formula
- If low temperature for the day is <50˚F, use 50˚F for the low in the formula

The GDD can be summed over days to indicate the amount of heat for growth that the crop has received over any period of the growing season.

60 + 50 = 55 average temperature; 55 – 50 = 5 GDD
60 + 40 substitute 50 for low; 60 + 50 = 55 average temperature; 55–50=5 GDD
80 + 60 = 70 average temperature; 70 - 50 = 20 GDD
90 + 60 substitute 86 for high; 86 + 60 = 73 average temperature; 73–50=23 GGD

Minnesota Relative Maturity – an alternative system of defining maturity for corn
Called the “day” system or “days to relative maturity” or “days RM”
- Based on days needed for corn to mature in specified east-west belts in Minnesota
- Each new hybrid is tested and compared with standard checks
- Based on this comparison the hybrid is assigned a “day” rating

Required by Minnesota law!
- Works as a benchmark for maturity ratings in Minnesota

Does it fit the Northeast?
- Not very well, but farmers are used to it!
- Actual days are not accurate but relative numbers are helpful – a “95-day” hybrid will be earlier maturing than a “100-day” hybrid

Environmental Effects on GDD Accuracy
GDD is a valuable but rough guide to maturity time for corn hybrids.
GDD measures can be affected by:
- Sunny weather (speeds maturity)
- Cloudy weather (slows maturity)
- Dry weather (speeds maturity) unless it occurs before silking and then silking is delayed until more favorable moisture conditions occur
- Wet weather (slows maturity)

A hot, dry, sunny summer (like 2005) can bring early maturity (e.g., crop ready before the GDD numbers would suggest)
A cool, wet, cloudy summer (like 2004) can bring late maturity (e.g., crop ready later than the GDD numbers would suggest)

GDD, Milk Line, and Dry Matter Percentage in Corn Silage
These are all rough guides to corn maturity

Kernel Milk Line:
- Break an ear, look at the non-embryo side of the kernels (the broken surface of the tip half of the ear), and find the line between milky and dry endosperm

Visual average around the ear is considered kernel milk line
Half milk line occurs at about 35% dry matter

If August-September are hot and dry, plants hold less water:
Moisture is 2-5% less at half milk line
Hot, dry weather
- early half milk line and less water at half milk line
- plants take twice as long to reach 35% dry matter

If August-September are cool and wet, plants hold more water:
Moisture is 2-5% more at half milk line
Cool, wet weather
- Late half milk line and more water at half milk line
- Plants take twice as long to reach 35% dry matter

Silage makers must watch crop progression closely to produce high quality silage and keep track of both milk line and moisture.

Soybean Maturity Groups-soybean varieties are classified according to which maturity group that they are in (Maturity Groups 000 through Group IX. Maturity Group 000 are the shortest season varieties and Group 0, I, and II varieties are longer-season varieties).

- Ottawa Region in Canada-grow Group 000 to Group 0 varieties.
- Northern NY and New England –Group 0 and Group I varieties are best adapted to temperatures and length of growing season.
- Central NY and New England-Group I, II, and III (if planted early) are best adapted to these regions.

28. Recognize the relationship between the growth and development of major Northeast crops and management factors.

Growing Degree Days for forages:

- GDD, base 41F: Unlike grain crops, forage crops do not use the 86-50 system, and most frequently use a base temperature of 41F for calculating GDD. A mean daily temperature is calculated and the number of degrees above the base temperature equals the GDD accumulated for that day. For example: if the max. temperature is 74F and min. is 40F then ((74 + 40)/2)–41=16 GDD today.

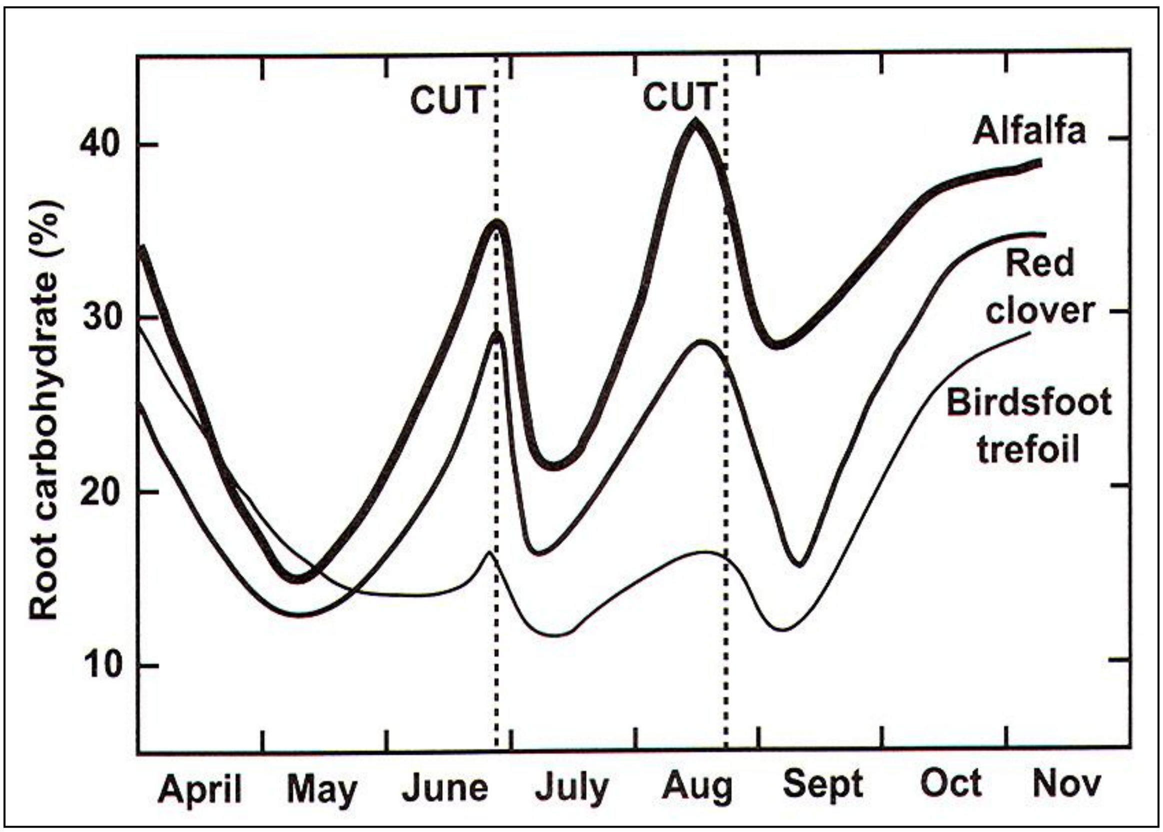
- Accumulation of GDD: The date to start accumulation of GDD for perennial forages should be when the crop breaks dormancy. Often this is estimated by starting GDD accumulation after 5 consecutive days where the mean daily temperature exceeds the base temperature (above 41 F).

Relationship between Growth and Development and Management – Forages:

- Alfalfa; Initial growth in the spring relies on nonstructural carbohydrates in the alfalfa taproot, until the plant is 6-8 inches tall. Then carbohydrates are accumulated in the roots until either full bloom or harvest. Root carbohydrates are then used again to initiate regrowth from crown buds. Cyclic accumulation and depletion of root reserves occurs throughout the harvest season, with a similar pattern in most clovers.

- Birdsfoot Trefoil (BFT): Carbohydrate reserves in BFT follow a cyclic pattern of utilization and storage similar to alfalfa, but less pronounced. Carbohydrate reserves are at a relatively low level during most of the growing season for BFT. The low accumulation of carbohydrate reserves maintained by BFT explains why it is best to leave some photosynthetic area on the plants when grazed. BFT can persist under frequent, but not close, grazing better than alfalfa or red clover, even though it has a low level of carbohydrate reserves. BFT does not perform well under high temperature conditions.

- Red Clover: Red clover is a relatively short-lived perennial which usually behaves as a biennial in the northern USA. Red clover is one of the most rapid growing and competitive perennial forage crops, which can succeed with frost seeding. Seasonal fluctuations of available carbohydrate reserves are similar to that of alfalfa. Flowering is influenced by the length of the light period, it is possible to re-seed red clover in a stand by allowing the crop to go to seed. Red clover does perform well under high temperatures or low soil moisture, and has a number of diseases that cause economic damage.



Changes in root storage carbohydrates of legumes through the season, as influenced by harvest (D. Smith. 1962. Crop Sci. 2:75-78).

Competency Area 7: Forage Harvesting Factors

Perennial Crops

29. Know the critical factors influencing first cutting of alfalfa or perennial grasses.

a. Know the basic procedures for evaluating forage quality of grasses and legumes.

A number of quality indicators, such as total fiber (NDF), digestibility, fiber digestibility, protein, and Relative Forage Quality (RFQ), are useful for evaluating the quality of a harvested forage. Animal rations can be relatively easily balanced to make up for a shortage of energy or protein, but not fiber. Therefore, forages should be harvested at the optimum fiber content (NDF) for the class of livestock being fed. Morphological stage in alfalfa is a not a good indicator of forage quality. Morphological stage in grass is a good indicator of forage quality at later maturity stages, but once the inflorescence emerges from the boot in grasses, optimum forage quality is lost. Spring alfalfa quality is best predicted using the PEAQ equations (Predictive Equations for Alfalfa Quality) developed in Wisconsin, that are based on the maximum height of alfalfa and the maximum growth stage.

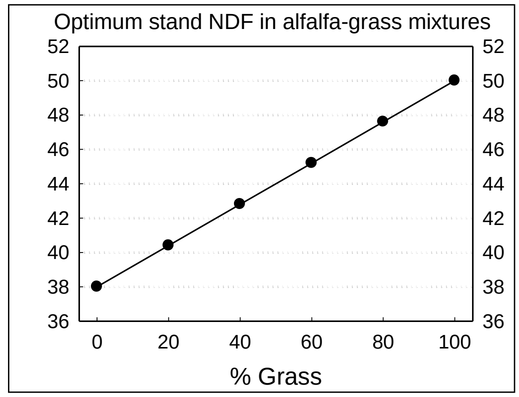
Max. alfalfa	%Grass in the stand (dry matter basis)								
height, in.	10	20	30	40	50	60	70	80	90
14	23.5	26.7	29.9	33.1	36.3	39.5	42.7	45.9	49.1
15	24.3	27.5	30.7	33.9	37.1	40.3	43.5	46.7	49.9
16	25.1	28.3	31.5	34.7	37.9	41.1	44.3	47.5	50.7
17	25.9	29.1	32.3	35.5	38.7	41.9	45.1	48.3	51.5
18	26.8	30.0	33.2	36.4	39.6	42.8	46.0	49.2	52.4
19	27.6	30.8	34.0	37.2	40.4	43.6	46.8	50.0	53.2
20	28.4	31.6	34.8	38.0	41.2	44.4	47.6	50.8	54.0
21	29.2	32.4	35.6	38.8	42.0	45.2	48.4	51.6	54.8
22	30.1	33.3	36.5	39.7	42.9	46.1	49.3	52.5	55.7
23	30.9	34.1	37.3	40.5	43.7	46.9	50.1	53.3	56.5
24	31.7	34.9	38.1	41.3	44.5	47.7	50.9	54.1	57.3
25	32.5	35.7	38.9	42.1	45.3	48.5	51.7	54.9	58.1
26	33.4	36.6	39.8	43.0	46.2	49.4	52.6	55.8	59.0
27	34.2	37.4	40.6	43.8	47.0	50.2	53.4	56.6	59.8
28	35.0	38.2	41.4	44.6	47.8	51.0	54.2	57.4	60.6
29	35.8	39.0	42.2	45.4	48.6	51.8	55.0	58.2	61.4
30	36.7	39.9	43.1	46.3	49.5	52.7	55.9	59.1	62.3
31	37.5	40.7	43.9	47.1	50.3	53.5	56.7	59.9	63.1
32	38.3	41.5	44.7	47.9	51.1	54.3	57.5	60.7	63.9
33	39.1	42.3	45.5	48.7	51.9	55.1	58.3	61.5	64.7
34	40.0	43.2	46.4	49.6	52.8	56.0	59.2	62.4	65.6
35	40.8	44.0	47.2	50.4	53.6	56.8	60.0	63.2	66.4

Estimated stand NDF of a mixed alfalfa-grass stand based on alfalfa height and the percent grass in the stand.

The best estimate of harvest time for pure grass is less precise and is often based on calendar date (e.g. the last week of May in central NY). This will be between early and very late boot stage. Spring harvest of alfalfa-grass mixtures is based on alfalfa maximum height and the proportion of grass in the stand.

b. Know the optimum forage quality (NDF, ADF, CP, etc.) for alfalfa and perennial grasses.

Ideal forage quality is a function of the class of animal being fed the forage. For lactating dairy cattle, standing alfalfa in the field prior to harvest should be 38% NDF. At this stage CP (crude protein) will be approximately 19-20%. For pure grass stands, ideal NDF is approximately 50%. A lower NDF value would be associated with insufficient forage yield for a grass harvest. Grass should have sufficient N fertilization to result in CP of 17-18% at harvest. Optimum NDF in alfalfa-grass mixtures is a function of the proportion of grass in the stand.



Spring harvest of alfalfa-grass mixtures are based on the proportion of grass in the mixture.
Management to produce dry cow forage.

1. Regular soil testing.
2. Set aside fields lowest in K.
3. Avoid all forms of K fertilizer, including manure.
4. If production declines, include some K fertilizer.
5. Harvest spring grass after flowering.
6. Use grass re-growth (lowest in K) for cows just prior to calving.

30. Understand how frequency of harvest is related to forage yield, quality, food reserves, and stand longevity.

Food Reserves. Alfalfa and red clover build up reserves each regrowth period and then deplete reserves after harvest for regrowth (discussed under Area 10). Birdsfoot trefoil root reserves remain low throughout much of the growing season. Food reserves in perennial grasses follow a similar pattern to alfalfa. Storage may be in rhizomes (bluegrass, bromegrass, reed canarygrass), stem bases (timothy), or lower internodes ("corms" – orchardgrass). In general, frequent harvest (4-5 cuts/growing season): lowers food reserves, shortens stand life, increases forage quality, and may decrease total seasonal yield. Some species (such as timothy and bromegrass) are more sensitive than others to frequent harvest. See also Section 22, alfalfa winter injury assessment.

Grazing Management Summary. Graze early in the spring, harvest and store forage from fields not grazed early. Rotationally graze with a high enough animal density to prevent selective grazing. The length of the rest period will depend on height of the forage after the last grazing and the growth rate of the forage. Forage growth rate will depend on the species, the season of the year, the amount of rainfall received, and the fertility program.

Rotational Stocking. Planning procedures.

1. Estimate the total forage requirement.
2. Estimate the forage supply.
3. Determine the paddock residency period.
4. Calculate the paddock size.
5. Determine the number of paddocks required.
6. Estimate the number of acres required.

Annual Crops

31. Describe the stage of development when corn is ready to harvest as silage.

a. Know the basic procedures for evaluating forage quality, including fiber digestibility.

Corn silage harvest should commence when whole plant moisture is at about 68% for bunker silos and 65% for tower silos. Corn silage yields increase and quality decreases as moisture decreases from 70 to 60%. A good compromise for yield and quality of corn silage is in the 63-68% moisture range (32-37% dry matter). Harvesting above 70% moisture will result in effluent losses from a bunker silo and above 65% will result in effluent losses form a tower silo. Harvesting at less than 58% moisture will result in fermentation problems because of lack of moisture; water may have to be added to the silo.

Corn silage moisture can range from 58-65% (35-42% dry matter) at the half-milk line stage of the grain so the milk line should only be used as a guide on when to begin corn silage harvest. In years with dry and warm conditions in August and early September, corn silage moisture can be at the 65-68% moisture range (32-35% dry matter) at the dent stage of corn development (R5).

Corn silage moisture is in the 68% range from 35-40 days after silking if corn silage harvest typically occurs in early September harvest, the 40-45 day range if it typically occurs in mid-September, and the 45-50 day range if it typically occurs in late September. Hybrid selection should be based on these harvest goals.

Another guide to use: corn silage moisture is usually in the 68% range at about 800 GDD after silking.

b. Know the ideal forage quality at harvest (NDFD, ADF, NDF, NEL, TDN, etc.).

Unlike perennial forages, there is no real set of guidelines for the ideal corn silage quality at harvest. Generally, NDF should be in the low 40% range, CP should be at about 8%, NDFD (30 hour) should be in the 55% range, and starch should be in the low 30% range. Climatic conditions during the growing season, however, can greatly influence these values (wet year typically results in higher NDF and lower NDFD values, dry year can reduce starch values, high-yielding year can dilute or lower CP values, low-yielding year can concentrate or increase CP values, etc.).

In addition, management practices such as hybrid selection, planting density, and harvest management further influence these values. Some hybrids will produce very high yields with high NDF values; other hybrids will have low yields with very high NDFD values (i.e. brown midrib hybrids); some hybrids will have high starch values; whereas other hybrids will have lower starch values.

Higher planting density typically results in lower CP values (dilution effect because of higher yields) and lower starch and higher NDF values, especially in dry years.

Timing of harvest also greatly influences forage quality. NDFD digestibility decreases as whole plant moisture decreases but starch values increase because of more grain development. Likewise, NDF values decrease between 70 and 60% moisture because of the increase in the grain portion in the silage. Also, CP values also decrease because of the dilution effect (yields are increasing).

32. Describe the stage of development when small grains are ready to harvest as silage.

Small grain crops can provide good quality forage for silage, if harvested in a timely manner. Optimum harvest from a quality standpoint is the mid-boot stage. Yield will be approximately 40% lower than if harvested at a dough grain stage, but protein and fiber digestibility will be acceptable for lactating dairy cow forage. Small grains are more appropriate as a supplemental or emergency forage crop when forage supplies are low, since the relatively low yields with relatively high input costs make them economically marginal if adequate forage supplies are available from perennial forage crops.

Competency Area 8: Cropping Systems

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33. Know advantages and limitations of growing cover crops and companion crops in a cropping system.

Cover crops:

- Advantages
  - Can protect from soil erosion - winter rye after corn silage
  - Add nutrients to the soil - legumes such as red clover frost-seeder into winter wheat
  - Improve soil structure – incorporates organic matter into the soil which may improve soil aggregation.
  - Improves environmental quality - can reduce NO_3-leaching after harvest and soil P losses associated with runoff.
- Disadvantages
  - Establishment costs including fuel, labor, machinery, and seed costs and machinery and/or herbicide costs (tillage or chemical) to kill or remove the cover crop.
  - May deplete soil moisture for next year's crop under dry spring conditions.
  - Allelopathic effects-rye cover crop may reduce corn stands, especially in reduced tillage systems.

Companion crops:

- Advantages
  - Can reduce soil erosion losses because companion crops (i.e. small grains with alfalfa) grow more rapidly than forages.
  - Allows for yield of companion crop during the establishment year of the forage.
- Limitations
  - Limits herbicide selection.
  - Added seed costs for companion crop.
  - Can compete for moisture in dry conditions
  - Harvesting the companion crop, such as barley, can be a challenge if the companion crop is short (barley in a dry year) and the perennial forage gets above it.
- Companion crops were universally used for perennial forage establishment in the past, they are rarely used now. They produce a forage crop for the establishment year, may help to control soil erosion, and may help control weeds. Potential disadvantages include lodging/smothering of the perennial seeding, delaying the establishment of the perennial crop or completely killing it out. If

small grain or small grain/field pea mixtures are used, plant before May 1 in southern NY and before May 15 in northern NY. A minimum yield of 1.5 to 2 dry tons/acre is needed to recover establishment costs.

34. Compare and contrast single crop systems and crop rotations such as corn-alfalfa, corn-soybean, wheat/clover, etc. for:

A. Yield
B. Soil structure
C. Soil nutrient status
D. Insect pests
E. Pathogens
F. Weeds
G. Economics

Crop rotation:

- Increase in crop yields
  - Corn-soybean rotation – 10% yield increase for corn and a 5% yield increase for soybeans.
  - Corn-alfalfa rotation – corn yields increase 10% independent of soil fertility contribution.
- Breaks pest cycle, especially pathogens and insects
  - Wheat must rotate because of soil-borne disease problems.
  - Soybeans must rotate if nematodes, fusarium (sudden-death syndrome), or white mold are a problem.
  - Corn-soybean rotation. Corn rootworm control in corn in the Northeast
- Can increase soil N status for the corn crop
  - Corn – alfalfa-no need to sidedress N.
  - Corn – soybeans-can reduce sidedress N rate on corn
- Can improve soil physical conditions
  - Corn – alfalfa. Deep-rooted alfalfa improves soil structure for the corn crop
- Disrupts weed cycles
  - Corn - wheat (summer-winter crop).
- Diversification of economic risk
  - Corn - soybean-wheat. Excellent year in Midwest so corn and soybean prices down. But wheat price may be up.
- Better utilization of labor and equipment.
  - Wheat - plant in September, topdress in April, and harvest in July. Doesn't interfere with management practices on corn and soybeans.
- Requires more equipment
  - Row crop planter and grain drill.
  - Corn and small grain head.

Single or monocrop system

- Reverse of above

Double-cropping systems

- Two or more crops are harvested from the same field in a single season.
  - Wheat - soybean in Southeast
  - Barley - corn in California
  - Northeast-difficult to do because of the shorter growing season

- Harvest first crop as soon as possible. Usually the second crop is no-tilled or planted into reduced tillage system to save time.
    - May go with earliest maturing small grain (which usually has no effect on yield).
    - Plant early maturing second crop which has lower yield potential.
- Problems-dry conditions can result in crop failure or very low yields of the second crop.

35. Compare and contrast different residue management systems for corn on:

A. Yield
B. Soil Structure
C. Soil water and nutrient status
D. Insect pests
E. Pathogens
F. Weeds
G. Economics

A. Yield

Corn generally yields better under high-tillage systems on droughty soils that have low water holding capacity. Conversely, corn usually yields lower on poorly drained soils that are cool in the spring under high residue systems because high residue keep soil cool and wet longer.

B. Structure

High residue management systems on corn generally improve soil structure because increased residue increases aeration, infiltration, and water-holding capacity of these soils. But under very dry spring conditions, silt and clay loam soils can have higher bulk densities under high residue systems (i.e. no-till) and make it difficult for root penetration. Timely rains in June or July alleviate this problem.

C. Soil water and nutrient status

High corn residue soils can initially result in less N availability because of immobilization of N under these high C:N ratio conditions. High residue conditions with alfalfa or soybean does not cause this problem. High residue conditions can also result in stratification of P and K in the upper soil zones because of the lack of incorporation. High residue conditions, however, reduce runoff of P during high rainfall events resulting in greater P in the soil over time. Finally, high residue conditions can result in macropores in the soil profile so during high rainfall events some N or P can be leached.

D. Insect pests

Generally, high residue conditions increase the incidence of insect pests, especially soil insect pests. High residue conditions, especially from green manure crops or sod, encourage greater wireworm, cutworm, and white grub problems.

E. Pathogens

High residue systems, especially in a continuous corn or second-year corn crop, can increase occurrence of the leaf blights, eye spot, gray leaf spot, and anthracnose.

F. Weeds

High residue systems typically encourage more perennial weeds such as dandelions or quackgrass but over time less annual weeds, such as pigweed or lambsquarter.

G. Economics

There are not clear-cut economic outcomes on residue management systems of corn. High residue systems greatly reduce fuel, labor, and machinery costs but can increase seed costs and drying costs of the grain. Sometimes high-residue management systems may increase pest control costs but not always. Yields can be higher or lower under different management systems and that also tends to greatly influence the economics of corn residue management systems.

36. Understand the aspects of crop management that can affect long-term sustainability of different cropping systems.

Cropping systems are a community of plants managed by farmers to achieve a set of goals. Long-term sustainability can be defined as the management and conservation of natural resources in a manner to ensure continued satisfaction of human needs for future generations. Soil is the basic resource for sustainable cropping. Measureable indicators of soil productivity and soil quality can be a major component for evaluating long term sustainability.

Basic aspects of crop management that impact long-term sustainability include crop rotation, companion and cover crops, fallow, fertilization, and residue management systems. We can measure and attempt to understand these crop management practices relative to long-term sustainability using the following indicators:

Soil productivity. Measures of soil productivity need to be meaningful to local farmers. Interpretation of soil productivity indicators requires an understanding of the biological mechanisms that impact soil and crop behavior.

Soil quality. Soil biological activity and community structure, along with soil physical structure, are good indicators of healthy soils. Over time such indicators should be stable or improving, to allow for cropping system sustainability.

Crop yield. Crop yields can be extremely variable, due to uncontrolled environmental conditions. Long-term yields for a given cropping system must be relatively stable to achieve long-term sustainability.

Pest management. Insect, pathogen, and weed populations need to remain relatively stable or need to decline with acceptable crop management practices. If pesticide application rates or frequency of application are increasing over time, system sustainability is impacted.

Net greenhouse gas emissions. Sustainable cropping systems of the future will need to rank relatively high for minimizing net greenhouse gas emissions.

Economic inputs. Crop value is often beyond the control of producers, but the stability of input costs will greatly impact economic sustainability. Heavy reliance on inputs with very unstable pricing (e.g. fuel, N fertilizer) will threaten economic sustainability.

37. Know the basic criteria for organically grown crops, and the primary advantages and disadvantages of organic farming.

Organically grown crops must be grown from seed that:

- has been organically produced (unless documentation is provided indicating that attempts to procure organic seed of appropriate varieties were unsuccessful)
- has no genetically engineered traits (e.g., is “non-GMO”)

Basic criteria for organically grown crops (these will vary with the specific organization)

- Protect. Protect the environment, minimize soil degradation and erosion, and decrease pollution.
- Replenish. Replenish and maintain long-term soil health by optimizing conditions for biological activity within the soil.
- Maintain. Maintain diversity within the farming enterprise, and protect and enhance biological diversity of native plants and wildlife. Maintain integrity of organic food and products (genetic engineering or food irradiation prohibited).
- Recycle. Recycle materials and resources to the greatest extent possible.
- Provide. Provide attentive care that promotes the health and behavioral needs of livestock.
- Advantages. Long-term sustainability. Products often sell at a premium price.
- Disadvantages. It can be very difficult to control weeds, insects and diseases. Yields may not be maximized or may not be economically competitive.