EC03-180 Kentucky Bluegrass Seed Production in Western Nebraska and Eastern Wyoming

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Kentucky Bluegrass

SEED

PRODUCTION

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In recent years, Kentucky bluegrass seed has become a viable, high-value, alternative crop in western Nebraska and eastern Wyoming. This perennial crop provides many potential benefits in regional cropping systems, including:

1) reduced soil erosion,
2) increased soil organic matter, tilth, and water holding capacity,
3) increased nutrient availability,
4) disruption of pest cycles,
5) increased productivity for future crops, and
6) enhanced utilization of labor and equipment resources.

Kentucky bluegrass seed production is management intensive and careful consideration must be given to establishment and maintenance decisions in order to optimize seed quality, seed yield, and stand longevity.

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Field Selection

When selecting a field for Kentucky bluegrass seed production, various factors need to be considered, including:

1) soil type,
2) cropping history,
3) availability of year-round irrigation water, and
4) potential weed contamination sources.

Selected fields should be characterized by moderately well-drained soils, such as sandy loam, loam, or silt loam soils, with an adequate soil profile depth (2-4 feet) for water and nutrient storage and a pH of 6.5-7.8. Coarse textured soils can be used for grass seed production, but these soils may require specific management practices, such as no-till planting, to maximize soil water retention and minimize the potential for soil erosion and nutrient leaching.

Cropping history can be invaluable in helping minimize establishment and seed production problems. Particular attention should be given to potential herbicide carryover, residual nutrient levels, and weed infestations associated with previous crops. Although many broadleaf perennial weeds can be selectively controlled during the life of the grass seed crop, it is best if these weeds are effectively controlled prior to planting. Volunteer plants from previous crops, perennial noxious weeds (Canada thistle, field bindweed, quackgrass, leafy spurge, and curly dock) and coarse-textured, undesirable perennial forage grasses (smooth brome, intermediate wheat grass, tall fescue, common Kentucky bluegrass, and rough bluegrass) are best controlled during the production, post-harvest, or fallow period associated with other rotational crops. Some herbicides labeled for this purpose are glyphosate (Roundup), glyphosate + 2,4-D (Landmaster), dicamba (Clarity), clopyralid + 2,4-D (Curtail), and 2,4-D amine. Consult the herbicide label for appropriate rates and timing.

Noxious weeds that escape general weed control procedures must be hand rogued or spot treated in order to meet certification standards.

Kentucky bluegrass seed production on the Central High Plains requires approximately 20-26 inches of water. In most cases, this will require irrigation water to be available early and late during the irrigation season. Pivot systems are most commonly used for irrigation. Furrow irrigation systems can be used, although water efficiency is reduced and additional management and labor are required.

Nebraska and Wyoming Seed Certification standards require that a field be free of bluegrass and other objectionable grasses for eligibility to produce certified or registered classes of seed (see Seed Certification section, page 14). Therefore, it is necessary to eliminate or limit potential contamination sources that may introduce unwanted weed or crop seed. Contamination from bluegrass growing on ditch banks is particularly troublesome and must be handled aggressively. Weed or foreign crop seed can be introduced by animal grazing, irrigation water and equipment, even if control measures appear adequate.
CROPP ESTABLISHMENT

Cultivar Selection
Kentucky bluegrass cultivars are evaluated annually and many improved cultivars are available for seed production. All new releases are proprietary cultivars developed by private seed companies or universities and protected from increase without authorization.

Seed increase contracts are usually issued with specific production limitations, quality conditions, and marketing agreements (see "An Introduction to Agricultural Production and Marketing Contracts," University of Nebraska NebFact NF00-449). In addition to company standards, most contracts require that cultivars be grown, conditioned, and marketed under a seed certification program. An adjustment in seed contract price may be required for cultivars with lower seed yield potential, realizing that seed yield can be influenced by cultivar, management, and area of adaptation.

Please contact the authors for additional information on selecting cultivars for seed production in western Nebraska and eastern Wyoming.

Field Preparation
With the flexibility of spring or summer seeding, various cultural practices can be used to prepare a bluegrass seed field. Spring plantings (April-early June) are most commonly seeded into fields following dry edible beans, but seeding after corn and potatoes also may be an option. Soil erodibility, residue cover, and compaction determine the need for plowing, field cultivating, chiseling, and subsequent packing to obtain a proper seedbed. Spring plantings are nonproductive in the year of establishment, but they have the best chance for maximizing yield potential the following year since they are less time sensitive to preplanting operations.

Field preparations for summer plantings usually are integrated with cropping systems that produce spring cereals such as oats, millet, or barley. Volunteer spring cereals can be a problem during summer establishment, but the problem can be minimized if the cereal is harvested as hay, or haylage, prior to or during the bloom stage. If the spring cereal is harvested as grain, the combine will need to be equipped with a chaff spreader

Guidelines for Establishing Kentucky Bluegrass Seed Crop

Calendar Year 1
1) Select a moderately well-drained field with high nutrient capacity and limited potential for weed pressure. Fields previously planted to dry edible beans work well in this rotation.
2) Use a herbicide in dry edible beans that will not carry over. Do not use pendimethalin (Prowl), ethalfluralin (Sonalan), trifluralin (Treflan), imazethapyr (Pursuit), or imazamox (Raptor).
3) Ensure control of grassy and noxious weeds before, during, and after dry edible bean production.

Calendar Year 2
1) Prepare a firm seedbed in March and plant oats. Incorporate 40-60 lbs P₂O₅ and 60 lbs N per acre at planting time. Control weeds in the oat crop and harvest oats for hay in the boot stage (early June).
2) Prior to no-till planting of grass seed, by August 15, spray the oat stubble with glyphosate (Roundup). If soil conditions are dry at planting time, apply water before planting to fill the top foot of soil.
3) Plant seed in 12-14 inch rows, no deeper than 1/4 inch, at the rate of 2-4 lbs per acre. Treat seed with metalaxyl (Apron) to minimize potential seedling diseases.
4) Apply light irrigations as needed (0.25-0.50 inch) for approximately 30 days to facilitate germination and seedling development. Thereafter, maintain the water content in the top foot of soil at or near field capacity.
5) If necessary, broadleaf weeds can be treated with bromoxynil (Buctril) or MCPA after crop emergence. In mid-September, apply pendimethalin (Pendulum) for the control of broadleaf and winter annual grass weeds.
6) Broadcast apply 80-100 lbs nitrogen per acre in the fall (mid-October) and immediately irrigate to distribute the nitrogen throughout the top foot of soil.
7) Continue to monitor soil moisture and maintain the top two feet of soil near field capacity.
and the straw baled before planting. After harvesting the spring cereal, the grass seed crop can be no-till planted into stubble in late July or early August. Because pivot systems can complete an irrigation cycle approximately every 24 hours, crop establishment can be accomplished during dry, hot summer conditions.

With the use of glyphosate (Roundup) as a preplant, weed control treatment, no-till planting is recommended on soils that are highly susceptible to wind and/or water erosion. Preplant operations need to be well planned, since seeding before August 15 is critical to the establishment of sufficient tiller growth (juvenile period) to develop reproductive capability the next growing season. When crops are lost to hail in early summer, bluegrass can be substituted into the cropping system, provided that potential herbicide carryover and cropping restrictions are accounted for.

**Seeding**

Kentucky bluegrass seed is small (1.5-2 million seeds per pound) and should be planted shallow, no deeper than 1/4 inch, in a firm seedbed similar to that prepared for a new seeding of alfalfa. Seeders equipped with double-disc openers, depth bands, and packer wheels will maintain a consistent planting depth and help establish good seed to soil contact. Seed production fields should be planted at seeding rates of 2-4 pounds per acre. Row spacings of 12-14 inches are commonly used, although wider row spacings may need to be considered for varieties with aggressive growth characteristics. It is advisable to plant seed treated with Apron to prevent potential stand loss from Pythium damping-off.

During the first production season, Kentucky bluegrass is slow to develop adequate size for floral induction or sufficient tillering for a high-yielding crop. Therefore, Kentucky bluegrass is preferably seeded without a companion crop, since these crops are too competitive and impede tiller development. Prior to planting Kentucky bluegrass, a ground cover can be planted and then killed when it is four to six inches tall to buffer wind and water erosion and help maintain soil surface moisture.

**Fertilization**

Establishment of a grass seed crop requires soil testing to determine residual levels of soil nutrients. Taking into account soil residual and irrigation water nitrogen, 120-140 pounds of nitrogen should be available to the first-year crop in the top two feet of soil. Nitrogen should be split applied (one-third preplant, two-thirds in fall) if the total recommended nitrogen exceeds 80 pounds per acre. If soil residual phosphorus (Olsen P soil test) is medium or lower, 40-80 pounds of P₂O₅ is recommended. If the potassium (K) soil test is medium or lower, 60-100 pounds of K₂O should be applied. It is often recommended that elemental sulfur be applied (10-15 pounds per acre) on sandy soils that are low in organic matter. Iron, applied as iron chelate, may be needed to prevent chlorosis, or yellowing of new leaves, on soils with a pH greater than or equal to 7.5.

**Irrigation**

Because grass seed is planted shallow, several light irrigations (0.25-0.50 inch) may be required for stand establishment. If soil water conditions are dry at planting, apply water before planting to fill the top foot of soil. This strategy allows less water to be applied less frequently after planting because soil water is available below the seed. Applying all of the water needed for germination after planting can result in excessive water evaporation and soil aggregate breakdown. These conditions increase the potential for surface crusting and wind erosion. In addition, excessive irrigations can prolong water saturation within the rooting zone and wetness of the soil surface, conditions which promote root rot diseases and seedling blights.

After crop emergence, available water must be maintained in the top foot of soil so that early development of roots and tillers is not impeded by dry soil. From early August to early September (after emergence of summer plantings), monitor soil water content to a depth of two feet to ensure that soil water will be available after the last irrigation, usually to mid to late October.
Weed Management

Weed management in established stands of Kentucky bluegrass presents some unique challenges. Herbicide usage is the preferred method for weed control since mechanical methods such as cultivation and “gapping” are of limited value. Postemergence herbicides can be used effectively to control broadleaf weeds during the growing season and unwanted, winter annual grasses. Broadleaf perennial weeds are best controlled with postemergence applications from mid to late September. The selection of preemergence herbicides is very limited, offering few opportunities for control of broadleaf or grassy weeds. Another consideration is that volunteer and secondary Kentucky bluegrass plants are “weeds” themselves, since excessive populations of these inter-row plants will reduce row integrity and compete with in-row plants for production resources. In some instances, control of limited or isolated infestations of weeds, especially other grass species, may require hand roguing and spot treatment with glyphosate.

Guidelines for Maintaining Kentucky Bluegrass Seed Crop in Years 3-6

Calendar Year 3
1) Light, winter irrigations may be required during dry winter periods. Spring irrigate (March-April) with crop green-up.
2) Apply pendimethalin (Pendulum) prior to a spring irrigation (early-mid April) and treat broadleaf weeds with 2,4-D. Hand rogue fields in May to remove off-type grasses and noxious broadleaf weeds.
3) Based on a soil nutrient test, spring apply all phosphorus and 10-15 percent of the total recommended nitrogen.
4) Irrigate, based on soil moisture content, taking into account that during the growing season (late April-early July), water demand by the grass seed crop will increase to 1.0-1.5 inches a week.
5) Regularly monitor fields for insects and diseases (see disease and insect management sections, pages 8-9).
6) Swath and combine fields based on seed moisture content (see Table 5).
7) After harvest, remove threshed residue by baling and propane burn remaining stubble.
8) Immediately after burning, apply 1 inch of water with 20-30 lbs nitrogen per acre. Irrigate after grass green-up and maintain the soil water content near field capacity.
9) For control of broadleaf and winter annual grass weeds, apply pendimethalin (Pendulum) in mid-September and incorporate by irrigation before weeds germinate.
10) In the fall (mid-October), apply 100 lbs nitrogen per acre and immediately irrigate to ensure that the nitrogen is incorporated into the topsoil and that the water content in the top two feet of soil is between field capacity and 50 percent depletion.

Calendar Years 4 and 5
Same as Calendar Year 3, but apply additional nitrogen (25-60 lbs per acre) as the production stand ages (Table 2).

Calendar Year 6
Same as Years 3, 4, and 5 except, after harvest and grass green-up, spray grass with glyphosate (Roundup) in preparation for rotational crop.
A mixture of 2,4-D amine and dicamba (Clarity or Banvel) can be used as a postemergence treatment for broadleaf weed control, with dicamba providing some degree of residual control. In addition, clopyralid (Stinger), clopyralid + 2,4-D (Curtail), and bromoxynil (Buctril) can be used for broadleaf weed control, depending on the targeted weed, infestation level, and growth stage. Regardless of the postemergence herbicide used, control is best obtained when weeds are small, healthy, and actively growing. Do not apply postemergence herbicides to grass seed fields if weeds are under heat or drought stress. In order to avoid crop injury, herbicides should not be applied after grass has reached the boot stage of growth. Always follow label directions.

Pendimethalin (Pendulum) can be used as a preemergence herbicide for the control of annual grassy and broadleaf weeds. It can be applied in the spring and/or fall by irrigation, but must be applied before weed germination. Fall applications have had limited success, especially in the control of downy brome (Bromus tectorum). This limited success is likely the result of ineffective herbicide incorporation and/or deactivation of the herbicide by ash (charcoal) that remains on the soil surface after burning. The current recommendation for downy brome control is to apply glyphosate (Roundup) before spring green-up of the Kentucky bluegrass. Development of both the downy brome and grass seed crop need to be frequently monitored, since this treatment has a narrow time frame for effective control without causing crop damage. It should be noted that research is being conducted to determine the potential of various preemergence herbicides with in-row banding of activated charcoal as weed control measures for the establishment of grass seed crops in wheat stubble.

In western Nebraska and eastern Wyoming, methods for maintaining row integrity (eliminating volunteer or secondary grass plants in the inter-row area) have not been adopted. Preliminary findings indicate that paraquat (Gramoxone) or glyphosate (Roundup) can improve or maintain row integrity, but additional research is required to assess the effects of these herbicides on seed yield and stand longevity.

Irrigation Management

Established grass stands may require irrigations when warm and open periods occur during dry winters with minimum snow cover. The amount of water to be applied and the frequency of irrigations will vary, depending on factors such as climatic conditions, soil water content, and the depth of unfrozen soil. Even on frozen or slightly thawed soils, applying a light irrigation (less than or equal to 0.25 inch) will be beneficial.

Water usage by the established crop will gradually increase from approximately 1.0 inch per week (late April-early May) to 1.5 inches per week prior to flowering and pollination (late May-early June). After flowering and pollination, water demand by the crop will gradually decline (1.0-0.50 inch per week) until the crop is swathed (early-mid July).

During the active growing season (late April-early July), water use by the crop can exceed the delivery capacity of the irrigation system. Therefore, it is extremely important that the top two feet of the soil be near field capacity prior to this growth period. From mid-May to late June, in particular, the grass seed plant is likely to experience extended periods of moisture stress if the water content in the top two feet of soil decreases below approximately 50 percent of field capacity. Under these conditions, there is increased potential for significant reductions in seed yield and/or quality. Irrigations during flowering and pollination should be applied less frequently and at higher rates, in order to maximize pollen activity and minimize the spread of diseases (for example, ergot). Additional irrigations at seed dough stage (three to four weeks after pollination) may not be needed, if two to three inches of soil water is available for seed maturation.

Without significant precipitation, soil water content will gradually decline from harvest to the post-harvest burn. This depletion of soil water can prevent crop green-up because the grass plant is very shallow rooted and needs to be treated like a seedling after burning. Therefore, it is crucial that the water content in the top foot of soil be replenished to near field capacity as soon as possible after burning, to ensure rapid and sustained root regrowth and tiller development. Once this soil moisture level is reached, crop water demand can usually be met with less frequent irrigations. Avoid excessive irrigations after crop green-up since prolonged saturation of the topsoil can enhance the development of vegetative rather than reproductive tillers. The water content in the top two feet of soil must be between field capacity and 50 percent depletion after the last irrigation (mid-late October).
Crop Maintenance

Fertilizer Management
Nitrogen rate and application timing are critical for cost-effectiveness and sustainability of Kentucky bluegrass seed production. Too much nitrogen will cause excessive vegetative growth, while too little will result in plant deficiencies, both of which can have a negative impact on seed yield. Particular attention must be given to calibrating fertilizer delivery systems to ensure proper application rates and uniformity.

Fertilizer management for an established crop of Kentucky bluegrass needs to be based on soil nutrient tests (Table 1). Although nitrogen is usually the nutrient of primary concern, adequate levels of phosphorus, potassium, sulfur, and iron are also necessary to obtain maximum seed production. During seed production, nitrogen rates range from 160 to 250 pounds per acre, depending on cultivar, age of stand, soil type, irrigation practices, and field history. Nitrogen should be split applied (Table 2), with most (60-70 percent) of it applied prior to the last irrigation in the fall (mid-late October).

Depending on unit cost, the application time period, and the type of delivery system, nitrogen is most commonly applied as dry or liquid formulations. Dry materials (i.e., urea, ammonium nitrate, and ammonium sulfate) are broadcast applied, while nitrogen solutions (i.e., 32-0-0 w/12-0-0-265) can be broadcast or applied through an irrigation system. For best results, phosphorus and potassium applications should be applied after field burning but prior to, or in association with, a fall nitrogen application. Under conditions of sustained chlorosis, particularly for soils with pH greater than 7.5, applying 0.5-1.0 gallon of iron chelate per acre (approximately 0.5-1.0 pound of iron per acre) may benefit seed productivity.

Disease Management
Kentucky bluegrass cultivars vary in their level of disease resistance. A key to managing diseases is to frequently scout fields and properly identify the problem. The occurrence and severity of diseases are sporadic, depending on factors such as stand age and environmental conditions.

Primary diseases are stem rust (Puccinia graminis), stripe rust (Puccinia striiformis) and powdery mildew (Blumeria graminis). Symptoms of stem rust are brick-reel, oblong pustules on leaves and stems. The pustules of stripe rust are yellow and arranged in linear rows on leaves and panicles. Powdery mildew is identified by a grayish-white, powdery material on the leaf surface. Unless disease pressure is extensive, rusts and mildew are controlled with applications of triadimefon (Bayleton), propiconazole (Tilt), or pyraclostrobin (Headline). Consult the fungicide label for rates and timing.

Ergot, caused by the fungus Claviceps purpurea, has been observed to significantly affect seed yield and quality. Ergot is commonly seen as a large, cylindrical, purplish-black sclerotia (scaly hard mass of fungal filaments) that replaces the seed and serves to cycle the disease from year to year. These sclerotia contain alkaloids that are highly toxic to humans and livestock. Initial infection by ascospores (sexual fungal spores) occurs at flowering. The ascospores are formed in tiny, mushroom-like structures that form on the sclerotia at the soil surface. The first indication of ergot is the presence of a sticky, "honeydew-like" substance exuding from infected florets. This honeydew contains millions of secondary spores called conidia, which can be splashed onto other florets and initiate new infections. Under conditions of wet, overcast weather, infection of florets and subsequent sclerotia production can be extensive. Therefore, at flowering, reduced irrigations at higher application rates should be utilized to meet the water requirements of the crop and
Table 1. Phosphorus, potassium and sulfur recommendations for established seed production stands of Kentucky bluegrass.

<table>
<thead>
<tr>
<th>Soil Test (ppm)</th>
<th>Application (lbs/acre)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Phosphorus (Olsen)</strong></td>
<td><strong>P₂O₅</strong></td>
</tr>
<tr>
<td>0-10</td>
<td>40-60</td>
</tr>
<tr>
<td>10-20</td>
<td>30-40</td>
</tr>
<tr>
<td>Over 20</td>
<td>None</td>
</tr>
<tr>
<td><strong>Potassium</strong></td>
<td><strong>K₂O</strong></td>
</tr>
<tr>
<td>0-100</td>
<td>60</td>
</tr>
<tr>
<td>Over 100</td>
<td>None</td>
</tr>
<tr>
<td><strong>Sulfur</strong></td>
<td><strong>SO₄⁻S</strong></td>
</tr>
<tr>
<td>0-5</td>
<td>20-30</td>
</tr>
<tr>
<td>5-10</td>
<td>10-20</td>
</tr>
<tr>
<td>Over 10</td>
<td>None</td>
</tr>
</tbody>
</table>

minimize infection potential. Propiconazole (Tilt) has had mixed success in controlling ergot at approximately 10 percent bloom stage. It can be applied through a pivot irrigation system and, depending on degree of infection, more than one application may be required.

**Insect Management**

Although insect problems arise each year in grass fields, no single insect pest has been present in damaging levels on a consistent basis in western Nebraska and eastern Wyoming. Insects that have been present in grass seed fields in the region include foliage/seed feeders (grasshoppers, Banks grass mites, stem maggots and thrips) and soil/thatch-inhabiting insects (billbugs, cutworms and sod webworms). Other insects that have been identified as damaging to grass seed production in other regions include: aphids, mealy bugs, plant bugs, sawflies, white grubs and wireworms.

Because insect problems are sporadic, fields should be scouted regularly. The potential risk and probable times for the development of insect problems are

Table 2. Guidelines for nitrogen applications on one- and three-year-old seed production stands of Kentucky bluegrass.

<table>
<thead>
<tr>
<th>N Application Timing</th>
<th>One-Year-Old Field</th>
<th>Three-Year-Old Field</th>
</tr>
</thead>
<tbody>
<tr>
<td>Post-burning</td>
<td>40 lbs N/acre</td>
<td>60 lbs N/acre</td>
</tr>
<tr>
<td>Fall</td>
<td>100 lbs N/acre</td>
<td>130 lbs N/acre</td>
</tr>
<tr>
<td>Spring</td>
<td>20 lbs N/acre</td>
<td>30 lbs N/acre</td>
</tr>
</tbody>
</table>
Table 3. Potential risks and probable times for development of insect problems in grass seed fields.

<table>
<thead>
<tr>
<th>Time</th>
<th>Moderate Risk</th>
<th>Low Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>- problems have been seen</td>
<td>- problems not seen to date</td>
</tr>
<tr>
<td></td>
<td>- priority for scouting</td>
<td>- risk low or unknown</td>
</tr>
<tr>
<td>Fall</td>
<td></td>
<td>White grubs</td>
</tr>
<tr>
<td>Early spring</td>
<td>Banks grass mite (silvertop?),</td>
<td></td>
</tr>
<tr>
<td>(crop green-up)</td>
<td>army cutworms</td>
<td></td>
</tr>
<tr>
<td>Late spring</td>
<td>Billbugs, thrips (silvertop),</td>
<td>Aphids, mealy bugs,</td>
</tr>
<tr>
<td>(jointing to heading)</td>
<td>stem maggot (silvertop)</td>
<td>plant bugs (silvertop?),</td>
</tr>
<tr>
<td></td>
<td></td>
<td>sawflies, sod webworms,</td>
</tr>
<tr>
<td>Early summer</td>
<td>Grasshoppers</td>
<td>wireworms</td>
</tr>
<tr>
<td>(heading to harvest)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 4. Federally registered insecticides and targeted insect pests for Kentucky bluegrass seed production.

<table>
<thead>
<tr>
<th>Insecticide</th>
<th>Insect Pests Controlled</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chlorpyrifos</td>
<td>Billbugs, cutworms, grasshoppers, sod webworms, white grubs</td>
</tr>
<tr>
<td>Lorsban 50W (Restricted Use Pesticide)</td>
<td></td>
</tr>
<tr>
<td>Carbaryl (e.g. Sevin, multiple</td>
<td>Grass bugs, grasshoppers, thrips</td>
</tr>
<tr>
<td>formulations)</td>
<td></td>
</tr>
<tr>
<td>Lambda-cyhalothrin</td>
<td>Billbugs (adults only), cutworms, grasshoppers, mites, sod</td>
</tr>
<tr>
<td>Scimitar GC (Restricted Use Pesticide)</td>
<td>webworms</td>
</tr>
</tbody>
</table>
presented in Table 3. Insecticide options for treating economically damaging populations are limited (Table 4). At present, efforts are underway to label additional pesticides for the control of problem insects in the region.

**Banks grass mites** have been a problem in some seed production fields early in the spring. These mites overwinter in the crowns of several types of grasses. They appear in bluegrass early in the season shortly after regrowth begins. They are most likely to be severe after a mild winter and dry spring. Mites and their damage are first seen on the southern exposures of rows next to grass borders, drainage areas, and rights-of-way. Damage results from mites piercing plant cells and extracting plant juices. The first sign of mite damage will be yellow or whitish spots on the leaf surface, giving the leaf blade a speckled appearance. Moderately infested leaves remain folded, housing mite colonies inside, with leaf tips turning reddish. If infestation is severe and persists, leaves will turn brown and die.

The **army cutworm** is a common early spring insect pest in the region. It feeds on a wide variety of hosts, including most grasses. Eggs are laid and hatch in the fall. The larvae will continue development through the winter when temperatures are warm. Because of their larger size in the early spring, they can cause a good deal of damage in a short time. Fields should be checked for these cutworms and their damage just as the grass is breaking dormancy.

Two species of **billbugs** have been identified in the area, the **Denver billbug** and the **bluegrass billbug**. Billbug larvae feed on the roots and rhizomes of the bluegrass plant and kill individual tillers at the time seed heads are just emerging from the boot. The developing heads die and turn brown, similar in appearance to 'silvertop', but the stems of these killed tillers usually will be shorter. Affected tillers are easily pulled out of the ground with few or no roots attached.

**Silvertop** occurs when seed heads die and become papery white shortly after the stalks have emerged above the flag leaf. Damaged seed stalks are dead above the highest or second highest node and are easily pulled out of the sheath. Various insects have been suspected of causing silvertop, including **thrips**, **mites**, **stem maggots**, and **plant bugs** (e.g. Lygus). However, the extent, nature, and impact of these insects in the region are largely unknown. Thrips and stem maggots have been observed to cause some silvertop in the region; however, thrips appear to have a greater potential for damage because of their consistent presence in the fields. Another contributing factor to silvertop occurrence is moisture stress. Increased plant stress will likely increase the incidence of silvertop and its occurrence is likely to increase with field age and variety. Stubble management may provide some control of silvertop. If treatments for thrips are deemed necessary, treatment should occur during the early boot stage to prevent damage.

**Grasshoppers** can be a perennial problem in all grasses throughout the region. Damaging populations of grasshoppers are most likely to occur during outbreak years. Cool season grasses, such as Kentucky bluegrass, often escape the majority of grasshopper feeding because they are mature when adult grasshoppers are active in mid-summer; however, in mid-late summer plantings, high grasshopper populations can cause extensive stand loss by feeding on newly emerged plants. They also can affect seed yield by clipping seedheads from established plants.

**Harvest Management**

Swathing (windrowing) and combining of Kentucky bluegrass is primarily determined by the moisture con-
tent of the seed (Table 5). The moisture content at
swathing (late June-early July) approximates the hard
dough stage. Since seed heads mature from the top
down, another indicator that the crop is ready to swath is
when the upper florets are easily freed.

Seed moisture content can be calculated from weight
differences in a field sample by drying the sample in a
conventional oven (220°F for four to six hours) or in a
microwave oven. The same moisture content calcula­tions
apply for either drying technique. Since the micro­
wave oven is commonly used, guidelines for this
procedure follow:

1) Collect a representative seed sample from the
field by hand stripping seed heads.
2) Weigh out approximately 10 grams of seed (W1)
on to a paper plate and dry at a medium to high setting
for one to two minute intervals.
3) After the initial time interval, remove the sample
and weigh.
4) Continue to heat in 30 second to 1 minute
intervals, re-weighing each time, until the weight of the
sample (W2) does not change after two or three drying
intervals.
5) Calculate the seed moisture content using the
equation:

\[ \text{Moisture content (\%)} = \frac{(W1 - W2)}{W1} \times 100 \]

Swathing too early may terminate growth before
seeds are fully mature; cutting too late may result in yield
loss due to shattering. Seed loss from shattering can be
reduced by swathing at night or in the early morning
when increased humidity and the condensation of
moisture “toughens” the seed head. Either auger or
draper heads can be used for swathing, but swathers
should have a high-volume capacity, an operational sickle
speed of 1000+ strokes per minute, and be equipped with
a pick-up reel and self-cleaning stub guards. Wide
windrows, placed on stubble of 4-6 inches, will enhance
dry-down prior to combining and help minimize poten­tial
losses in seed yield and/or quality due to high winds
or heavy rainfall.

Combining of the grass seed crop should begin when
seed moisture is low enough for safe storage (Table 5).
The rate that the seed dries in the windrow is primarily
determined by humidity and ambient temperatures. The
relative humidity should be less than 40 percent at
combining, which is seldom a problem in this region. In
order to reduce seed loss, combines should be fitted with
belt or rake pickups. Also, because of its small seed size,
gaps or cracks in combine transfer/delivery systems must
be sealed with duct tape or by other means. Although
combine settings are obviously influenced by various
factors, guidelines for conventional combine settings are:
1) a cylinder speed of 800 rpm, 2) a fan speed of 600
rpm, 3) a chaffer setting of 1/4 inch, 4) a sieve setting of
1/8 inch, and a concave clearance of 1/8 inch (refer to

<table>
<thead>
<tr>
<th>Species</th>
<th>Moisture Content of Seed (%)</th>
<th>Moisture Content of Seed (%)</th>
<th>Moisture Content of Seed (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(Windrowing)</td>
<td>(Combining)</td>
<td>(Storage)</td>
</tr>
<tr>
<td>Kentucky bluegrass</td>
<td>28</td>
<td>12-13</td>
<td>10-12</td>
</tr>
<tr>
<td>Tall fescue</td>
<td>39-40</td>
<td>12-13</td>
<td>10-12</td>
</tr>
<tr>
<td>Perennial ryegrass</td>
<td>31-32</td>
<td>12-13</td>
<td>10-12</td>
</tr>
</tbody>
</table>

* Estimated moisture loss per day after swathing: Kentucky bluegrass = 3-4%,
tall fescue = 2.5%, perennial ryegrass = 3%.
** Windrows are allowed to cure approximately seven days before combining.
Residue removal by propane burning. 

Combine operator’s manual for detailed recommendations. Tank cross-augers should be removed to prevent “bridging” and enhance flow of threshed material from the grain tank. Improper combine settings will cause excessive chaff and/or unnecessary seed loss. Threshed Kentucky bluegrass seed material should yield 40-60 percent clean seed. In some instances, it may be economically worthwhile to combine windrows a second time as a secondary seed recovery operation.

It is of utmost importance that special attention be given to cleaning equipment prior to and during harvest operations. The presence of other seed grains, and seed from different grass species or cultivars, can be as detrimental to final certification as weed seeds.

Residue Management

The removal of residue from a seed production field, as soon as possible after harvest, is critical because sunlight must penetrate into the crown area of the plant to stimulate the regrowth of tillers and induce them to be reproductive rather than vegetative. Inducing the development of reproductive tillers will not only enhance seed yield the next year(s), but it also may prolong stand longevity. Excessive vegetative growth will encourage the development of secondary plants (by rhizomes) within the inter-row area, resulting in a “sod-bound” field that may be economically inefficient within two years.

Thermal (burning) and nonthermal “residue management systems” have been used in Kentucky bluegrass seed production. Thermal systems involve: 1) the removal of threshed straw by baling and propane burning of the remaining stubble or 2) removal of all crop residue by open-field burning. Nonthermal systems involve removal of threshed straw by baling and the mechanical flailing or chopping of the remaining stubble.

Thermal residue management systems usually result in higher seed yields and greater seed yield consistency, in comparison to nonthermal systems. Thermal systems have the advantage of destroying unharvested crop/weed seed and are effective in controlling various grass seed diseases and pests. However, the use of thermal systems can cause plant injury or death from excessive temperatures and cause carbon (soot) buildup in the upper layers of the soil, limiting herbicide activity. In addition, local and state fire regulations for burning in open areas must be addressed.
CROP MAINTENANCE

Nonthermal residue management systems eliminate potential air quality risks to human health and the environment; however, these systems are almost totally dependent on the use and availability of labeled herbicides for an effective weed control program.

It is currently recommended that threshed straw be removed by baling and the remaining stubble propane burned. Although additional cost is associated with propane burning, this method is usually more effective in residue removal and allows for some control of the burning temperature. Open-field burning can be used, but threshed straw must be evenly distributed across the field to provide a constant “fuel” source and uniform burn.

Seed Storage and Processing
Due to limited seed processing capabilities in the area, harvested Kentucky bluegrass seed is generally stored on farm until transported and cleaned at a local seed processing facility. The harvested seed is dry enough to store if it is dry enough to combine (12 percent or less seed moisture content). Due to convenience and economic considerations, flat storage is used for pre-cleaned or cleaned seed. Storage areas must be protected from the weather and maintained free of outside contamination and rodents. Again, with 1.5-2.0 million seeds per pound, sanitation and preparation cannot be stressed enough. Combines, trucks, tarps, augers, and storage areas must be properly sealed to avoid seed losses, particularly if cleaned seed is handled in bulk form. Even if bagged, extra caution should be exercised during handling and transport.

Processing Kentucky bluegrass seed is an art and requires experience and expertise to ensure maximum seed recovery and quality. Basic steps in seed processing (conditioning) include:

1) breakage of large stemmed and incompletely threshed materials into smaller pieces using a debearder;
2) initial separation of seed from larger and smaller foreign materials by air screening and scalping;
3) secondary separation of seed from larger and smaller foreign materials with indent (disc) separator(s);
4) weight separation of seed using air-gravity tables; and
5) bagging and labeling of cleaned seed.

Seed Certification
The Nebraska Crop Improvement Association (NCIA; P.O. Box 830911, Lincoln, NE 68583-0911; phone 402-472-1444) and Wyoming Seed Certification (WSC; P.O. Box 983, Powell, WY 82435; phone 307-754-9815) are the agencies responsible for administering seed certification programs in their respective states.

Some turfgrass markets prefer certified seed, while others require it. Seed certification is a relatively simple process based on seed stock documentation and inspections for off-type varieties, other crops, weeds, and diseases. Since the certification process starts when the field is planted, many potential problems can be avoided by contacting the certification agency prior to planting. A field must be enrolled in certification within 60 days of planting to allow for seedling inspection and to document planting stock and field history requirements.
Guidelines for Field Eligibility to Produce Certified Kentucky Bluegrass Seed

1) Inspection applications for eligible fields should be submitted to seed certifying agencies by appropriate date, with payment of applicable fees.

2) Prior to harvest, each seed production field should be walked by a representative of the seed certifying agency and evaluated for major factors affecting seed quality.

3) Proper isolation distance(s) from other varieties, non-certified fields, or any contaminating pollen sources should be maintained.

4) Objectionable and noxious weeds should be eliminated by roguing or other methods to prevent seed lot contamination.

5) Off-type plants in the variety, or other grass species, should be removed by roguing each field at the specific stage(s) when morphological differences can be observed.

For proprietary turfgrass cultivars, these certifying agencies are required to obtain a statement from the cultivar owner authorizing the contract grower to reproduce seed for planting purposes. If the contractor wants Certified and/or Sod Quality seed, those options should be specified in the production contract. Once a Kentucky bluegrass seed field has been established and found to meet eligibility requirements for seed certification, the grower will need to annually determine whether that field will stay in the seed certification program. For additional information regarding Nebraska grass seed certification standards, refer to the Nebraska Crop Improvement Association Web site at http://www.unl.edu/ncia.