Test Plots Show How Perennial Grasses Can be Grown for Biofuels

Use these protocols to set up test plots of perennial grasses to demonstrate to producers the potential for growing bioenergy feedstocks.

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Researchers, farmers, and industry representatives across the country are interested in testing the performance of energy crops. Setting up a test plot in your region can be useful in showing producers their potential for growing bioenergy feedstocks on their farms. The test plot can demonstrate best management practices and yield potential as well as how to establish perennial grasses quickly and economically. It can also show differences between the forage and bioenergy strains of perennial grasses.

Choose and Set up a Test Plot Site

Each site should be a size that would work on a farm. As such, there are no standard dimensions, but CenUSA, a bioenergy research project initiative, recommends a minimum plot

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size of one acre for each species. Planting and harvesting are facilitated best by planting long narrow strips such as are planted in most row crop yield trials.

Select the species and cultivars of perennial grasses you are interested in testing—one species of grass or mixtures of grass species. Seed each one-acre plot with high-quality, certified seed. The interest of your audience and geographic location will determine which perennial grasses to plant and which cultivars to select, but a good selection of perennial grasses for the Great Plains and Midwest should include:

- Switchgrass
- Big bluestem
- Indiangrass
- A low-diversity mixture, such as switchgrass, big bluestem, indiangrass, and sideoats grama
- A high-diversity mixture of approximately 10 species including native grasses, legumes, and forbs. [1]

Figure 1. CenUSA Bioenergy Crop Field day at USDA-ARS plots.
Photo: John Hay University of Nebraska

Switchgrass (L. Panicum virgatum) is a warm-season perennial grass native to the tall-grass prairie region. It is considered the leading grass energy crop because of its ease of propagation, high yield potential, compatibility with conventional farming, low input requirements, and excellent conservation attributes (Kszos et al., 2000). Other perennial grasses being evaluated for energy use include big bluestem (*Andropogon gerardii*), Indiangrass (*Sorghastrum nutans*), and prairie cordgrass (*Spartina pectinata*). (See

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CenUSA Bioenergy Fact Sheet *Switchgrass (Panicum virgatum) for Biofuel Production.*
Miscanthus (Miscanthus x giganteus)
https://cenusa.iastate.edu/files/cenusa_2019_008.pdf) is a high-yielding, non-native perennial grass feedstock that may fit well in many areas. However, it may not offer as many conservation attributes as one of the native perennial grasses. (See https://farm-energy.extension.org/miscanthus-miscanthus-x-giganteus-for-biofuel-production)

Establishment

In the central Great Plains and Midwest, time planting for two to three weeks before or after the optimum corn-planting date—earlier is better than later. Seed at a rate of 30 pure live seed (PLS) per square foot planted 1/4- to 1/2-inch deep in 6- to 7-inch rows. This is typically 4 to 6 pounds per acre of PLS. If you're doing small plots, consider lowering the seeder outside the plot in the alley and seeding through the plot beyond to the next alley to ensure complete seed coverage in the plot. Make sure the drill is calibrated accurately. (See CenUSA Instructional Video *Drill Calibration Walk Through*, https://www.youtube.com/watch?v=izBHivo5xfw&feature=youtu.be.

For plantings that include big bluestem or indiangrass, which have fluffy seeds, use a no-till drill with a chaffy seed box. Switchgrass seed doesn't require a chaffy seed box. No-till seed into soybean stubble or clean-tilled field and pack firmly enough to leave a faint footprint in the soil when you walk on it. If tillage is used, prepare the seedbed as you would for alfalfa.

If you don't have grass-seeding equipment, contact your local Extension office, a USDA Natural Resource Conservation Service or a local equipment dealer. Conservation organizations such as Ducks Unlimited, Pheasants Forever, or The Nature Conservancy may also have information on equipment you can borrow or rent. (See CenUSA Bioenergy Instructional Video: *Switchgrass Planting Practices for Stand Establishment*. https://www.youtube.com/watch?v=vwBQ3aYpfmM)

Managing Weeds in a Test Plot

Compared to cool-season grasses, establishing a warm-season grass stand takes more weed management. Weed competition is one of the biggest reason warm-season grass seedings fail, so weed control in the seeding year is very important, both during and after seeding.

Manage weeds in switchgrass with a pre-emergent application of 1 quart of atrazine plus 8 ounces per acre of quinclorac (Paramount®). On big bluestem, indiangrass, and sideoats grama, use a pre-emergent application of 4 ounces per acre of imazapic (Plateau®). On all plots, control broadleaf weeds in the seeding year by mowing in July and/or spraying with one to two quarts per acre of 2,4-D.

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Biomass grown during the seeding year can be harvested or grazed after a killing frost or left standing in the field over winter. If the residue is left standing over winter, mow the residue for hay or burn before spring greenup.

Always read and follow label directions, and contact your local Extension agent for issues specific to your area—pesticides may not be approved in all states for these purposes.

Harvest after a Killing Frost

It is recommended to harvest perennial grasses used for biomass in the fall, after a killing frost. Waiting until after frost allows carbohydrates and nitrogen to be translocated from leaf and stem tissue to roots, increasing plant winter hardiness and reducing future nitrogen fertilizer needs.

Mow alleys to less than a 4-inch stubble height and trim plots to a 10-inch height. Determine biomass by cutting and weighing a 3-foot wide swath the length of each one-acre plot, using a flail-type plot harvester with a cutting height of 4 inches. Do not harvest the outer edges of the plots, to reduce border effects. Weigh the harvested material immediately in the field.

To determine dry matter weight, take a subsample of each plot, weigh the "wet" sample, then dry each sample at 50 degrees C (122 F) for at least 72 hours in a forced-air oven. Then reweigh to determine the dry matter (DM) concentration. Mean DM concentration of these samples will be used to adjust field biomass to an oven dry basis.

Test Plant Quality

If you are interested in sampling the plant tissue from your plots for plant analysis, collect subsamples prior to harvest, using hand clippers. Clip samples from multiple locations within each plot, dry the samples for 72 hours at 50 degrees C (122 F). Then grind the samples to pass a 2-millimeter screen in a Wiley mill. Store each sample in a 4-ounce (approximately), sealed container and send it to a plant analysis laboratory for testing. The oven-dry weight of the hand-collected material will be added back to the harvested material to accurately represent plot biomass.

How Well is the Stand Doing?

Immediately after harvest, evaluate plant populations using a frequency grid (Vogel and Master, 2001). Make a frequency grid from a piece of concrete remesh with 6-inch-by-6-inch squares. Cut the remesh into a 5-by-5 grid containing a total of 25 squares. (See CenUSA Instructional Video: *How to Measure Stand Establishment Using a Grid*

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https://www.youtube.com/watch?v=AXZN7-PmldU&feature=youtu.be)

Figure 2. UNL's John Gueretzky demonstrates the frequency grid method of determining establishment quality. Photo: CenUSA Bioenergy

When grass seedlings have three to four leaves and are easy to see, choose at least 10 different locations in your field. Place the frequency grid on the ground at each location and count the number of the 25 squares that have a grass seedling rooted inside. Record that number. Flip the frequency grid and repeat three more times for a total of 100 squares. Add the number of squares that contained at least one seedling to come up with the percent frequency of grass seedlings for that location. For example, if there are 50 squares with at least one seedling, the stand frequency is 50 percent. Repeat the process at nine other locations in the field and calculate the average stand frequency for the 10 locations.

A stand frequency of 50 percent or greater (two or more plants per square foot) indicates a successful stand. Stand frequency between 25 and 50 percent is marginal to adequate, and stands with less than 25 percent frequency may need to be over- or re-seeded.

[1] In terms of sustainability, ecologists are interested in maximizing the diversity of seeding mixtures for energy crops.

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- Vogel, Kenneth P. & Robert A. Masters. Frequency Grid: A Simple Tool for Measuring Grassland Establishment. Journal of Range Management, Vol. 54, No. 6 (Nov., 2001), pp. 653-655.

For Additional Information

CenUSA Project Resources - Research-based information on the opportunities and challenges in developing a sustainable system for the thermochemical production of biofuels from perennial grasses grown on land marginal for row crop production is available at www.cenusa.iastate.edu

- **CenUSA Fact Sheet: Switchgrass (Panicum virgatum) for Biofuel Production**. Rob Mitchell. 2016. https://cenusa.iastate.edu/files/cenusa_2019_008.pdf

CenUSA Instructional Videos

- **Drill Calibration: No Till Drill Calibration Training Video** https://www.youtube.com/watch?v=7TPLfWLkd_U&feature=youtu.be
- **Drill Calibration Walk Through** https://www.youtube.com/watch?v=izBHivo5xfw&feature=youtu.be
- **Harvest: Optimizing Harvest of Perennial Grasses for Biofuel** https://www.youtube.com/watch?v=NMt5Ct-65-Y&feature=youtu.be
- **Harvesting a Native Grass for Biofuel Production** https://www.youtube.com/watch?v=_RcJBURXwKc&feature=youtu.be
- **Frequency grid: How to Measure Stand Establishment Using a Grid** https://www.youtube.com/watch?v=AXZN7-PmldU&feature=youtu.be

CenUSA Project Resources – information on the opportunities and challenges in developing a sustainable system for the thermochemical production of biofuels from perennial grasses grown on land marginal for row crop production.

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