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RESEARCH

# Soil Nutrient Mining and Switchgrass Management

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**Over the past several years,** U.S. national bioenergy policy has provided incentives for the development of large-scale production of bioenergy products produced from cellulosic biomass crops, such as switchgrass. As a result, farmers have expressed interest in understanding opportunities that may be available as this industry develops further. In response, the Noble Foundation has been conducting farm-scale research to address a number of agronomic and economic challenges associated with producing and managing switchgrass. Of particular interest are the agronomic problems (and consequent economic problems) associated with soil nutrient mining that can ensue with large-scale production of switchgrass.

Some research has been conducted that focused on determining the most economical time for farmers to harvest switchgrass and the most economical way to manage nutrients for that harvest system. However, the analytical methods used in this research do not consider the potential long-run agronomic problems associated with excessive nutrient removal from the soil. We used data collected from a three-year, two-location study to determine the most economical time of year for farmers to harvest switchgrass and to determine the rates of N, $P_2O_5$ and $K_2O$ necessary for long-run, economically sustainable production of switchgrass. Three independent harvest systems were evaluated: 1) a single cut in the fall prior to plant senescence (October), 2) a single cut in the winter after senescence (December), and 3) a summer cut (July) followed by a second cut in winter after senescence (December). Each harvest system received 0, 40, 80, 120, 160 and 200 pounds of N each year, and received 60 and 120 pounds of $P_2O_5$ and $K_2O$ each year, respectively. In addition, a standard forage analysis was used to determine the content of N, P and K nutrients for each plot in each year and converted to N, $P_2O_5$ and $K_2O$ (lbs/acre) equivalents. These data reflect the extent of soil nutrient mining, or the extent of soil nutrient recycling, depending on the harvest system.

Statistical methods combined with enterprise budgeting techniques were used to estimate and compare the effects of harvest system and nutrient levels on yield and economic net return for two separate models. Model 1 represents the conventional economic approach that uses the actual fertilizer

**Table 1. Agronomic and Economic Comparisons of Unsustainable (Model 1) and Sustainable (Model 2) Harvest System and Nutrient Management Strategy**

| Agronomic/Economic Variable | Model 1 Unsustainable | Model 2 Sustainable | Numerical Difference | Percent Difference |
|---|---|---|---|---|
| Optimal Harvest System | Two Cut | One Cut | — | — |
| Optimal Harvest Month | July and Dec. | Dec. | — | — |
| Expected Biomass Yield (tons/acre) | 10.5 | 7.50 | -3 | 29% |
| N Removed From Soil (lbs/ac/yr) | 220 | 67 | -153 | 70% |
| $P_2O_5$ Removed From Soil (lbs/ac/yr) | 72 | 26 | -46 | 64% |
| $K_2O$ Removed From Soil (lbs/ac/yr) | 324 | 53 | -271 | 84% |
| Optimal Level of N (lbs/ac/yr) | 158 | 89 | -69 | 44% |
| Optimal Level of $P_20_5$ (lbs/ac/yr) | 60 | 17 | -43 | 72% |
| Optimal Level of $K_20$ (lbs/ac/yr) | 120 | 60 | -60 | 50% |
| Price of Nitrogen ($/lb) | 0.54 | 0.54 | — | — |
| Price of $P_20_5$ ($/lb) | 0.55 | 0.55 | — | — |
| Price of $K_20$ ($/lb) | 0.49 | 0.49 | — | — |
| Price of Biomass ($/ton) | 75.00 | 75.00 | — | — |
| Gross Revenue ($/ac) | 788.00 | 563.00 | -225 | 29% |
| Total Cost ($/ac) | 558.95 | 381.99 | -177 | 32% |
| Net Return to Labor and Management ($/ac) | 230.00 | 181.00 | -49 | 21% |

treatments (N, $P_2O_5$ and $K_2O$) applied in the field experiments. Model 2 uses the biomass nutrient equivalents for N, $P_2O_5$ and $K_2O$ and represents the model that accounts for potential problems (benefits) associated with soil nutrient mining (recycling).

At present, no commercial biorefineries exist in the Southern Great Plains to purchase biomass from farmers. So we calculated expected net returns for each model assuming a number of different biomass price ($/ton) and nutrient price scenarios ($/lb). Table 1 reports the agronomic and economic results for the two models for a base price scenario that assumes a biomass price of $75/ton and 2011 prices for N, $P_2O_5$ and $K_2O$. Our results show the most economical system under the conventional approach (Model 1) was to harvest switchgrass biomass twice per year (July and December) and apply 158, 60 and 120 lbs of N, $P_2O_5$ and $K_2O$ per acre per year. In contrast, when the cost of soil nutrient mining (or recycling in the case of the winter system) is considered (Model 2), the results show that the winter system is most economical when 89, 17 and 60 lbs of N, $P_2O_5$ and $K_2O$ were applied each year. The $49/acre difference in net return between the two models reflects the economic trade-off between short-run, unsustainable profitability and long-term economic sustainability. ■