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# Nitrogen Fixation and Seeding Rates of Common *vs.* Hairy Vetch for Interseeding Into Established Switchgrass Stands


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## Abstract


Interest in alternatives to synthetic nitrogen (N) fertilizer sources for switchgrass (*Panicum virgatum* L.) production, such as interseeding with N- fixing legumes continues to increase. Common vetch (*Vicia sativa*) is a N-fixing legume that occurs naturally throughout the U.S. and has less hard seed than hairy vetch (*Vicia villosa*), making it potentially less invasive, and it may fix N at similar rates to that of hairy vetch. However, little data exist to substantiate this. In this study, N-fixation rates via the N-difference method were determined to be 59.3 and 43.3 kg N ha$^{-1}$ for common and hairy vetch, respectively, when seeded at 6.7 kg ha$^{-1}$. At these rates, neither common nor hairy vetch significantly affected switchgrass yields. Based on the N-fixation rates and vetch plant masses, we estimate that minimum seeding rates of 7.6 and 10.4 kg PLS ha$^{-1}$ of common and hairy vetch, respectively are required to obtain plant stands needed to fix the current recommended rate of N for switchgrass biomass production.


## Objectives

- To determine and compare nitrogen fixation rates of common and hairy vetch when seeded into established stands of switchgrass cv. 'Alamo'.
- To estimate stand densities needed to fix the recommended N rate (67 kg ha$^{-1}$) for switchgrass biomass production.

## Materials & Methods

- Exp Design: Randomized Complete Block (3 Reps per locale)
- Locations: East TN Research & Education Center (ETREC)
  Plateau Research & Education Center (PREC), Fig. 1.
- Legumes treatments (planted Fall 09'):
  - Seeding rates: 6.7 kg PLS ha$^{-1}$ and 0 kg ha$^{-1}$ (control)
- Harvests:
  Two cut system: early boot (June) and post-dormancy (Oct.)
- N applications (67 kg ha$^{-1}$):
  1-cut system: Spring applied at SG green-up
  2-cut system: Spring applied at green-up & 2wks after 1$^{st}$ cut
- Quantification of N-fixation rates (N-difference method)$^{\dagger}$ :
  - Plant N= $\frac{\text{(Plant DM) x (\%N)}}{100}$
  - $N_2$ fixed= (Vetch shoot N) – [Control (wheat) shoot N]
  - Seeding rate for target N= $\frac{\text{(Target N kg ha}^{-1})}{\text{(Vetch N kg ha}^{-1})}$ x (6.7 kg PLS ha$^{-1}$)

[† Assumes 50% inorg. N bioavailable] (Danso, 1995; Peoples et al., 2009)

## Characteristics Measured

- Stand densities (Vogel and Masters, 2001) & heights (early summer)
- Biomass and forage yields (1&2-cut systems) 2010
- N-fixation rates of Common and Hairy Vetch (Danso, 1995; Peoples et al., 2009)

## Sites Histories and Management

| | Soil type | Annual precipitation (cm) | | Annual temperature (ºC) | | Previous field management | Switchgrass establishment |
|---|---|---|---|---|---|---|---|
| | | 2009 | 2010 | 2009 | 2010 | | |
| **ETREC** Knoxville | Huntington silt loam | 173 | 124 | 14.3 | 14.4 | Orchardgrass hay (4 yrs) | 2007 |
| **PREC** Plateau | Lily silt loam | 192 | 140 | 12.7 | 12.6 | Fescue pasture | 2007 |


Figure 1. Tennessee Research and Education Centers. Reading indicated centers left to right are PREC and ETREC. http://www.taes.utk.edu/centers/

## Results

Table 1. Nitrogen fixation rates for common and hairy vetch using the N-Difference method at Knoxville Plant Science Unit and Holston Unit of the East TN (ETREC) Research and Education Center.

| | Common vetch | | | | Hairy vetch | | | |
|---|---|---|---|---|---|---|---|---|
| **Control plants** | **N from control** | **N from vetch†** | **N-Diff. of vetch** | **Vetch shoot N plant$^{-1}$** | **N from control** | **N from vetch** | **N-Diff. of vetch** | **Vetch shoot N plant$^{-1}$** |
| | g kg$^{-1}$ | | g | | g kg$^{-1}$ | | g | |
| **Switchgrass** | 12.2 | 25.8 | 13.6 | 1.3 | 12.2 | 26.0 | 13.8 | 1.1 |
| **Wild barley** | 8.5 | 25.8 | 17.3 | 1.7 | 8.5 | 26.0 | 17.5 | 1.4 |
| **Daisy fleabane** | 9.0 | 25.8 | 16.8 | 1.6 | 9.0 | 26.0 | 17.0 | 1.3 |
| **Geranium spp.** | 1.2 | 25.8 | 13.7 | 1.3 | 12.1 | 26.0 | 13.9 | 1.1 |
| **Mare's tail** | 1.7 | 25.8 | 8.7 | 0.8 | 17.1 | 26.0 | 8.9 | 0.7 |
| **Venus looking glass** | 1.0 | 25.8 | 16.1 | 1.5 | 9.7 | 26.0 | 16.3 | 1.3 |

† Mean vetch sample weights 9.6 and 7.8 g were used for common and hairy vetch, respectively.

Table 2. Projected seeding rates for common and hairy vetch in order to obtain the recommended rate of nitrogen fertilizer for switchgrass using the N-difference method based on N-fixation rates of common and hairy vetch (ETREC).

| **Common vetch** | | | | | |
|---|---|---|---|---|---|
| **Control plants** | **Vetch shoot N plant$^{-1}$** | **Observed vetch density†** | **Total vetch shoot N** | **Bioavailable vetch N** | **Target-N** | **Vetch seeding to supply target-N** |
| | g | m$^{-2}$ | g m$^{-2}$ | kg ha$^{-1}$ | | kg PLS ha$^{-1}$ |
| **Wheat††** | 1.4 | 8.5 | 11.9 | 59.3 | 67 | 7.6 |
| **Switchgrass** | 1.3 | 8.5 | 11.0 | 55.2 | 67 | 8.2 |
| **Hairy vetch** | | | | | | |
| | g | m$^{-2}$ | g m$^{-2}$ | kg ha$^{-1}$ | | kg PLS ha$^{-1}$ |
| **Wheat** | 1.2 | 7 | 8.7 | 43.3 | 67 | 10.4 |
| **Switchgrass** | 1.1 | 7 | 7.5 | 37.6 | 67 | 12.0 |

† Common vetch plant density were averaged from both ETREC and PREC locations in 2010. Hairy vetch plant density was taken from ETREC due to no seedling emergence at PREC. Both common and hairy vetch densities were obtained with seeding rates of 6.7 kg ha$^{-1}$.
†† Wheat was used as the main control plant based on literature, and due to its intermediate N-range found in this study.

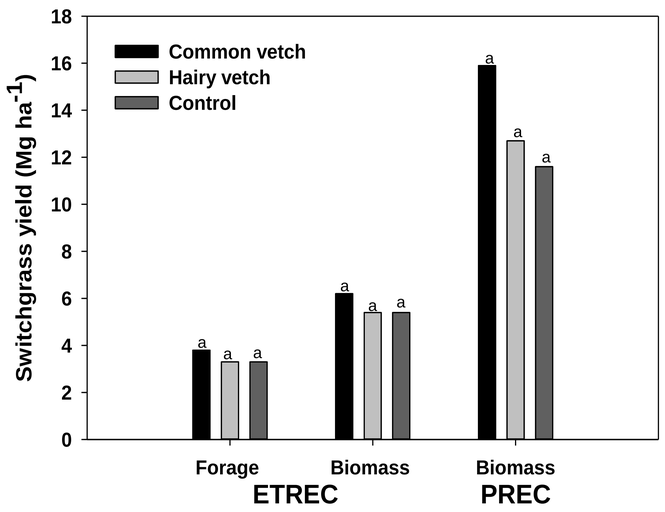


Figure 2. Average dry matter yields of switchgrass per common vetch or hairy vetch treatment from a one-cut biomass and two-cut forage/biomass harvest at East TN (ETREC) and Plateau (PREC) Research and Education Centers in 2010. Different letters indicate a significant difference ($P \leq 0.05$), based on Tukeys (across treatments).

Table 3. Average† common and hairy vetch legume (LG) plant densities‡ and heights and switchgrass (SG) plant heights at the East TN (ETREC) and Plateau (PREC) Research and Education Centers in 2010

| | Common vetch | | | Hairy vetch | | | Control |
|---|---|---|---|---|---|---|---|
| **Location** | **Plant density** | **Height** | | **Plant density** | **Height** | | **Height** |
| | | LG | SG | | LG | SG | |
| | No. m$^{-2}$ | cm | | No. m$^{-2}$ | cm | | cm |
| **ETREC** | 10 | 59 | 119 | 7 | 54 | 84 | 110 |
| **PREC** | 7 | 43 | 86 | 0 | 4 | 109 | 87 |

†Means across treatments and replications
‡Plant density = (frequency of occurrence * 0.4) x 100(Vogel and Masters, 2001)

## Summary

- Based on these results, estimated seeding rates of 7.6 and 10.4 kg PLS ha$^{-1}$ for common and hairy vetch, respectively would provide sufficient plant densities to enhance N-fixation and increase switchgrass yields, thereby achieving the recommended rate of 67 kg N ha$^{-1}$.
- Total switchgrass DM yield was not significant among common vetch (13.0 Mg ha$^{-1}$), hairy vetch (12.4 Mg ha$^{-1}$) or the control treatment (10.7 Mg ha$^{-1}$) for both harvests and locations (Fig. 2).
- The use of both dicot and monocot non-N fixing control plants revealed little difference in the N-fixation rates of common and hairy vetch at either location.
- Similar N-fixation rates (via N-Difference Method) of common and hairy vetch plants (59.3 and 43.3 kg N ha$^{-1}$), respectively were reported (avg. vetch density=8.5 plants m$^{2}$).
- Lastly, vetch spp. were seeded into switchgrass for only one year and neither legume spp. were inoculated; therefore, a longer-term study still needs to be conducted over a range of soils with inoculated seed in order to further track N-fixation rates.

## Future Research

- Phase II of this study is currently underway comparing hairy vetch, arrowleaf, ladino and red clover, and partridge pea for their ability to replace synthetic-N in switchgrass production. Results are forthcoming.

## Literature Cited


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