Nitrogen Application to Summer Annual Forages May be Uneconomical

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Introduction

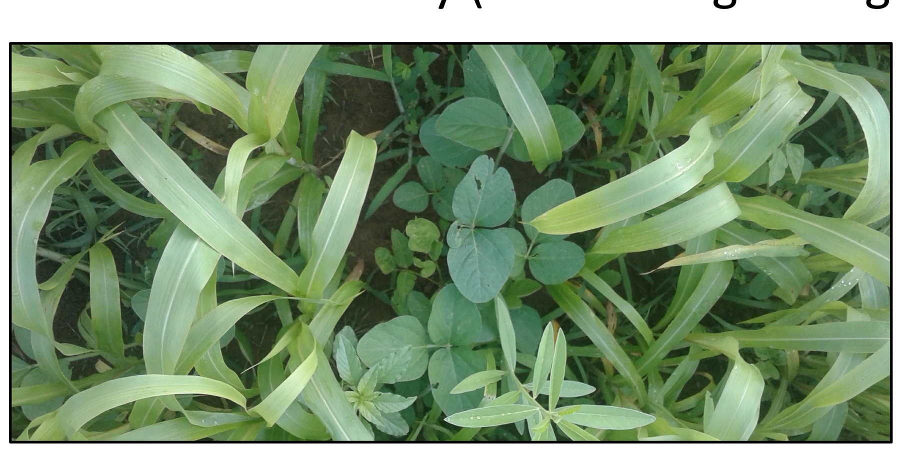
- Biodiversity in perennial systems often results in increased productivity and is commonly driven by nitrogen fixation by legumes
- Benefits are less clear in annual systems as N sharing between annual grasses and legumes is not well understood (Fujita et al., 1992; Layek et al., 2018)
- Economics of annual systems are often "breakeven" (Ball et al., 2007)
- Reducing N costs by including legumes may improve profitability of summer annual systems (Tracy et al., 2010)
- This study was designed to evaluate the effects of species diversity and N fertility on summer annual forage mixtures

Objective

To determine the impact of species diversity and N fertilization on the productivity and economics of summer annual forages

Materials & Methods

- Three forage mixtures planted at University of Kentucky research farms in Lexington and Princeton, KY in 2018 and 2019
  - **MONOCULTURE** = sudangrass
  - **SIMPLE MIXTURE** = sudangrass, pearl millet, & soybean
  - **COMPLEX MIXTURE** = Simple + corn, sudangrass, crabgrass, cowpea, sunn hemp, Korean lespedeza, forage rape, daikon radish, & sunflower
- Total N rates of **0 – 200 lb N/A** was split-applied at planting & after 1st and 2nd harvests
- RCBD with 4 reps
- Harvested 3x annually (30-40" target height)



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Ramer Seed, Sharon Grove, KY

High quality forages for high producing animals!!!

A special thank you to Jesse Ramer for supplying the seed for this study.

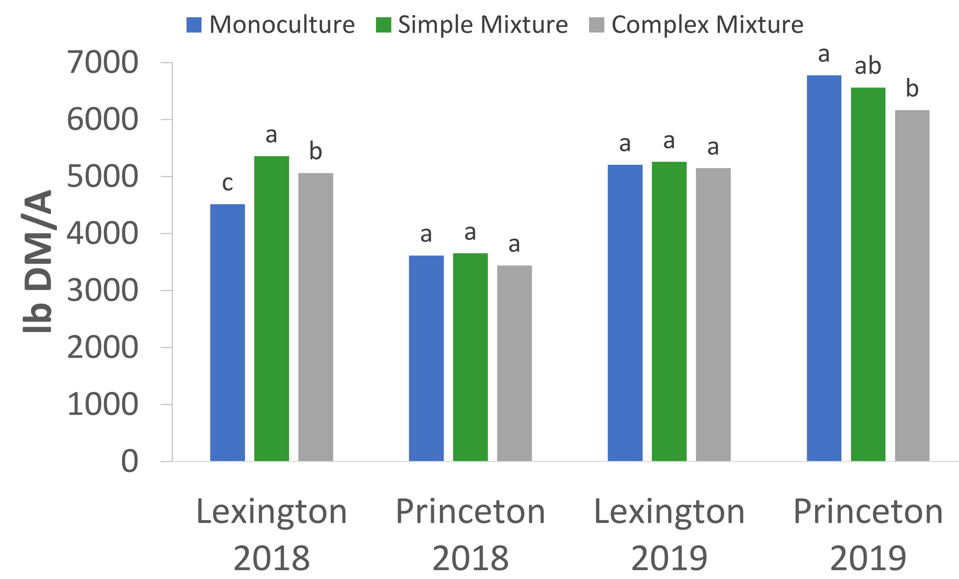

Figure 1. Impact of mixture on annual forage yield for each environment, averaged across N rate. Treatments within an environment with the same letter are statistically similar (α = 0.05).

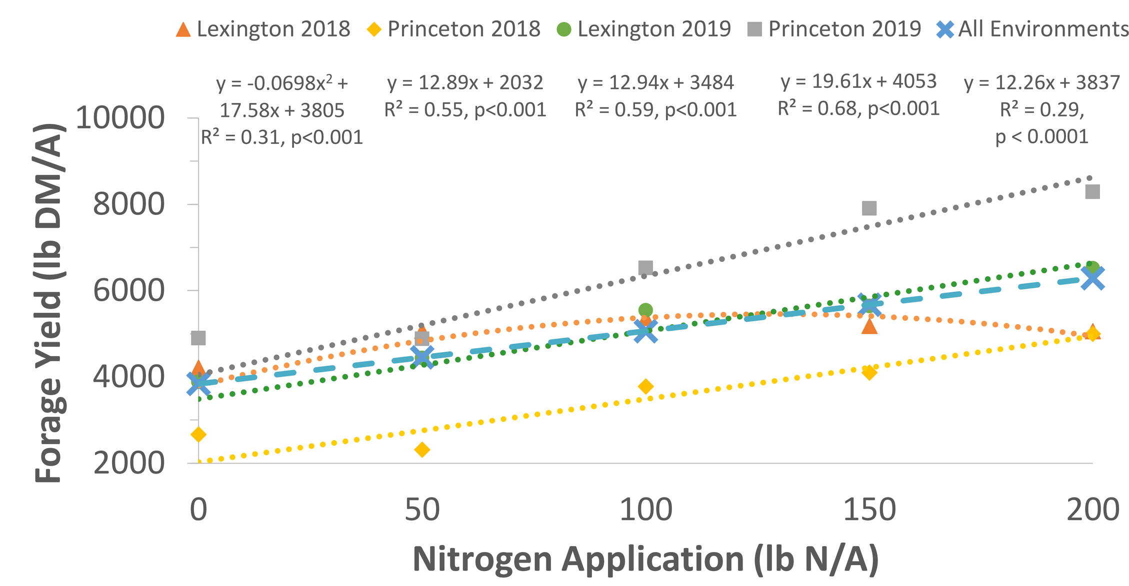

Figure 2. Impact of N rate on annual forage yields for each environment, averaged across mixture.

Figure 3. Princeton 2018 plots showing visual response to N application.

Table 1. Economic advantage of applying N to summer annual forages at varying hay and N prices, as compared to no N applied, calculated based on predicted yields from all environments (Figure 2). Scenarios resulting in a positive marginal return as compared to applying no N are bolded.

N Price $/lb N	Hay Price $/T	N Application (lb/ac) 0	50	100	150	200
0.40	60	-	-$20.26	-$47.32	-$74.08	-$94.64
	80	-	-$13.05	-$32.90	-$52.44	-$65.79
	100	-	-$5.84	-$18.47	-$30.81	-$36.94
	120	-	**$1.38**	-$4.05	-$9.17	-$8.10
	140	-	**$8.59**	**$10.38**	**$12.46**	**$20.75**
0.50	60	-	-$25.26	-$57.32	-$89.08	-$114.64
	80	-	-$18.05	-$42.90	-$67.44	-$85.79
	100	-	-$10.84	-$28.47	-$45.81	-$56.94
	120	-	-$3.62	-$14.05	-$24.17	-$28.10
	140	-	**$3.59**	**$0.38**	-$2.54	**$0.75**
0.60	60	-	-$30.26	-$67.32	-$104.08	-$134.64
	80	-	-$23.05	-$52.90	-$82.44	-$105.79
	100	-	-$15.84	-$38.47	-$60.81	-$76.94
	120	-	-$8.62	-$24.05	-$39.17	-$48.10
	140	-	-$1.41	-$9.62	-$17.54	-$19.25

Note. Economic advantage calculated as (hay revenue at specific N rate – hay revenue at 0 lb N/ac) –(production costs at specific N rate – production costs at 0 lb N/ac). Production costs include 1) N, P, and K fertilizer needed to achieve yield at a specific N rate, 2) additional N application fees for 100, 150, and 200 lb N/ac rates because they utilized split applications for N, and 3) additional harvest costs in relation to greater yields when applying N.

Summary & Implications

- Increasing mixture complexity did not increase yield in 3 out of 4 environments
  - All treatments were comprised of >95% grasses
  - Most legumes and forbs did not perform well in mixtures
  - Crabgrass filled in lower canopy of complex mixtures
  - If choosing to plant a mixture, it is recommended to plant morphologically and developmentally compatible species to limit competition for resources
- Average forage response to N was 12 lb DM/lb N applied
- Limited yield response to N in Lexington 2018 possibly due to more plant available N in soil
- Applying N to summer annuals was only profitable when N prices were low and hay prices were high
- Grazing summer annuals was more economical than haying due to reduced harvest and fertilizer costs

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Table 2. Costs of sudangrass haying and grazing.

HAYING *Inputs*	*$/ac*	GRAZING *Inputs*	*$/ac*
Site Preparation		**Site Preparation**	
Disk-tandem	$15.50	Self-propelled sprayer (2x)	$15.00
Field cultivator	$14.50	Herbicide 2x	$14.00
Fertility		**Fertility**	
N	$100.00	N	$100.00
P	$14.10	P	
K	$45.50	K	
Application	$19.50	Application	$19.50
Planting		**Planting**	
Drill	$18.00	No-till drill	$19.50
Seed cost	$90.00	Seed cost	$90.00
Harvest		**Harvest**	
Cut, rake, bale (net wrap)	$158.84	Bush hog (2x)	$34.00
Moving Bales	$25.86	Cattle management	$18.00
Total	*$501.80*	*Total*	*$310.00*
Per DM Ton	*$159.81*	*Per DM Ton*	*$98.73*
Per Hay Ton	*$135.84*	*Per Hay Ton Equivalent*	*$83.92*
Per DM Ton Utilized	***$199.76***	***Per DM Ton Utilized***	***$164.54***

[1] Machinery and harvest costs derived from Halich (2020).
[2] Fertilizer prices of $0.50/lb N, $0.30/lb P, and $0.25/lb K were used. 200 lb N/ac was used as it showed the greatest increase in profit as compared to 0 N/ac. Phosphorus and K rates were calculated based on removal rate of forages in the hay scenario (Eberly & Groover, 2007). Soil pH was assumed to be adequate (no lime applied).
[3] Split application of N was used: one application before planting and once each after first and second harvests. Prior to planting P and K would have been blended with N.
[4] Seed cost of $100 for the monoculture was used, as additional seed costs of mixtures did not result in increased yields.
[5] Hay harvest costs were computed for the entire season on a 'per bale' basis and converted to total costs per acre based on yield.[6] 85% DM was used to convert hay on a DM basis to a 'hay ton' basis.
[7] 20% storage and feeding loss was used for hay production.
[8] Soil P and K were assumed to be adequate and not applied as most nutrients are returned to the soil through manure and urine deposition.
[9] Cattle management, such as labor for pasture rotation, was calculated as follows: 16 weeks grazing * 3 hours/week checking cattle and moving temporary fence * $15/hour labor / 40 acres = $18 per acre of grazing management. Grazing infrastructure was not included as an expense as it was assumed fencing and water systems are already established.
[10] Additional cost of clipping pastures was included, to more closely reflect management of experimental plots and would have occurred following first and second grazing events in a rotational grazing system.
[11] Includes labor for pasture rotation. It is assumed that fence and water infrastructure are already established.
[12] 60% utilization rate was used for forage consumption.

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