Nitrate Toxicity in Bermudagrass Hay and Its Effect on Net Returns

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Abstract

Profit-maximizing nitrogen rates were determined for two bermudagrass hay producers, one who considers nitrate toxicity to cattle and one who does not consider nitrate toxicity. Producing bermudagrass hay with a reduced probability of nitrate toxicity requires a $6.02/ton premium to breakeven with hay produced without considering nitrate toxicity to cattle.

Introduction

In hay production, nitrogen (N) is a vital input to increase yields and to produce uniform yields across multiple harvests within a given year (Connell et al., 2011; Woodard and Sollenberger, 2011). Furthermore, bermudagrass converts N fertilizer into proteins, which increases the quality and value of the hay if used as a feedstuff (Johnson et al., 2001; Prine and Burton, 1956; Woodard and Sollenberger, 2011). Despite the benefits of increased yields and hay quality from N fertilizer, it can be problematic for hay producers because high levels of nitrates in plant tissue prior to harvest can be poisonous to cattle and cause what is commonly referred to as nitrate toxicity (Allison, 1998; MacKown and Weik, 2004; Strickland et al., 1996). Therefore, it is important to consider nitrate levels when managing N fertilizer applications in hay production.

Many factors can impact the accumulation of nitrates in several kinds of hay (Bergareche and Simon, 1989; Connell et al., 2011; Gomm, 1979; Lovelace et al., 1968; Rudert and Oliver, 1978; Thomas and Langdale, 1980; Veen and Kleinendorst, 1985). For example, excessively low and excessively high temperatures, relative humidity, and rainfall can influence nitrate accumulation in plant tissue (Gomm, 1979). Nitrates have been found to accumulate in the plant tissue when plants are grown under low light (Veen and Kleinendorst, 1985). Bergareche and

Simon (1989) used data for bermudagrass in a Mediterranean climate, and found nitrate levels to be highest in the fall and spring and lowest in mid-summer months. Environmental factors such as short day length, low light intensity, rainfall and low temperatures are commonly found to explain the accumulation of nitrates in plant tissue (Bergareche and Simon, 1989), which makes it difficult to manage nitrates since environmental factors are uncontrollable.

The primary cause of nitrate accumulation in hay is attributed to over application of N fertilizer (Rudert and Oliver, 1978; Thomas and Langdale, 1980). If high levels of nitrates are available in the soil, hay could accumulate high levels of nitrates. In fact, Veen and Kleinendorst (1985) found hay grown under low light accumulates nitrates when an ample supply of nitrate is available in the soil. Combining environmental factors that change across the harvests months with over application of N fertilizer, nitrate accumulation could become a problem for producers in harvest months when high levels of nitrates are available in the soil and environmental factors favor nitrate accumulation.

When nitrates are ingested by cattle, nitrates are reduced to nitrite by rumen bacteria (MacKown and Weik, 2004; Strickland et al., 1996) and then are converted to ammonia (Crowly and Collings, 1977; MacKown and Weik, 2004; Woods, 2008). Nitrite enters the bloodstream where it converts blood hemoglobin to methemoglobin (MacKown and Weik, 2004; Strickland et al., 1996; Woods, 2008). Methemoglobin is not able to transport oxygen to various body tissues so the animal suffers from hypoxia resulting in animals dying from oxygen starvation or causing bred cows to abort their fetuses (Allison, 1998; MacKown and Weik, 2004). Debate continues about the nitrate level in feed that is toxic to cattle, but most literature agrees that levels less than 5,000 ppm are safe for cattle feed (Connell et al., 2011; MacKown and Weik, 2004; Strickland et al., 1996; Undersander et al., 1999). When nitrate levels slightly exceed this threshold, limited amounts of hay could be fed to cattle by mixing the high-nitrate hay with other feeds to dilute nitrate levels (Strickland et al., 1996; Undersander et al., 1999). However, the safest action is to not use the hay as feed.

Cattle production in the southeastern United States is centered on cow-calf operations (McBride and Mathews, 2011). Cow-calf operations depend on forage production to provide the majority of the feed ration. Forage is harvested through grazing or mechanically as hay to be fed when forage available for grazing is limited. In the southeastern United States, bermudagrass is the most common warm-season grass for hay production and pasture (Connell et al., 2011; Overman et al., 1988), and cattle producers depend on bermudagrass as a primary forage (Agyin-Birikorang et al., 2012; Lacy and Hill, 2008). Bermudagrass is drought tolerant, responsive to N fertilizer, and has a high water use efficiency, which makes it ideal for the southeastern United States (Connell et al., 2011). Bermudagrass is not considered a high-risk forage for producing nitrate levels toxic to cattle (Burns et al., 2009; Evers et al., 2004; Strickland et al., 1996); however, research has shown bermudagrass in the southeastern United States can accumulate nitrate levels beyond the toxic threshold of 5,000 ppm (Carter, 2011; Connell et al., 2011).

Several papers have analyzed the economics of hay production and marketing (Blank et al., 2001; Hopper et al., 2004; Smith et al., 2012; Ward, 1994), but no existing economic research has determined how nitrate levels in hay might influence hay producers' net returns and N fertilizer applications. The ability of a hay producer to control environmental factors influencing nitrate accumulation is limited, but the producer can control the quantity of nitrates available to the plant by controlling the quantity of N fertilizer applied. Testing for nitrates in hay can provide producers the necessary information to consider nitrate levels when choosing an

N fertilizer rate. This information might have value if the producer can market the hay as low-nitrate, cattle-safe hay.

The objectives of this research were to determine: 1) the effects of N fertilizer, rainfall, average daily maximum and minimum temperatures, irrigation, and harvest month on the probability of nitrate levels in bermudagrass hay exceeding levels toxic to beef cattle; 2) the net returns for a bermudagrass hay producer who considers nitrate levels when choosing an N fertilizer rate, and the net returns for a bermudagrass hay producer who does not consider nitrate levels when choosing an N fertilizer rate; and 3) the value of information from testing for toxic nitrate levels. We estimated bermudagrass yield response to N fertilizer for four harvest months using data from a three-year hay experiment and used a logit model to predict the probability of nitrate levels exceeding the toxic threshold. The results present a unique economic perspective on determining the profit-maximizing N rate for bermudagrass hay.

Data

Vaughn's No. 1 hybrid bermudagrass hay yields were collected for three years (2008-2010) from an experiment conducted at the University of Tennessee Highland Rim Research and Education Center located near Springfield, TN. The soils are well drained, dark brown, slightly sloped, and classified as Crider silt loam (fine-silty, mixed, active, mesic Typic Paleudalfs). The experimental design was a split plot, Latin Square with five replications. The main plots were irrigated and non-irrigated and the subplots were five N rates. The bermudagrass plots were harvested each year in June, July, August, and September. N was applied in April and reapplied after the June, July, and August harvests at rates of 0, 50, 100, 150, and 200 lb./acre, giving total annual N fertilizer treatments of 0, 200, 400, 600, and 800 lb./acre. Elemental and nitrate analyses were performed at the Soil, Plant, and Pest Center in Nashville, TN for each N treatment after each harvest. Table 1 shows average yields by N rate and harvest month.

The average price of N ($0.60/lb), calculated using ammonium nitrate prices from 2008 to 2010 (USDA NASS, 2012b), and the average price of bermudagrass hay ($90/ton) in Tennessee from 2008 to 2010 (USDA NASS, 2012a) were used to calculate net returns for bermudagrass hay production. Harvest costs of $104.80/acre were obtained from the University of Tennessee Bermudagrass Hay Budget (University of Tennessee, 2007). The cost of testing forage for nitrates at the University of Tennessee Soil, Plant, and Pest Center (2012) was $6 per sample, with a recommendation to submit one sample per 10 bales (assuming 1200 lb. bales). Therefore, the cost of testing the hay depends on the number of bales produced per acre.

Profit Maximizing Levels of Nitrogen Fertilizer

Partial budgets were constructed to calculate expected net returns for the profit-maximizing N fertilizer rates by harvest month for the hay producer who does consider nitrate levels when choosing an N fertilizer rate and for the hay producer who does not consider nitrate levels when choosing an N fertilizer rate. The expected net returns are:

$$(1) \qquad \max_{x_{i\lambda}} \mathrm{E}(\pi_{i\lambda}) = \mathrm{E}[p(y_{i\lambda})(1-\lambda\Phi(NT)) - rx_{i\lambda} - h - \lambda w],$$

where $\mathrm{E}(\pi_{i\lambda})$ is the producer's expected net returns in $/acre for harvest month i; p is the bermudagrass hay price in $/ton; $\mathrm{E}(y_{i\lambda})$ is the expected bermudagrass hay yield in ton/acre; $\Phi(NT)$ is the probability of the hay exceeding the toxic nitrate threshold; λ is binary variable equal one for the producer who considers nitrate levels when choosing an N fertilizer rate and zero for the producer who does not test for nitrates; r is the price of N fertilizer in $/lb of N; $x_{i\lambda}$ is the quantity of N fertilizer applied in lb/acre; h is the harvest costs in $/acre; and w is the cost of testing hay for nitrates in \$/ton. Testing hay for nitrates provides producers with information about nitrate levels for each harvest month.

The two profit-maximizing bermudagrass hay producers were evaluated. We assumed the producer, who does not consider nitrate levels, sells all hay after each harvest regardless of the nitrate level. We assumed the other producer tests hay for nitrates and consider this information when selecting an N fertilizer rate. This seller refrains from selling hay if nitrate levels exceed the toxic threshold of 5,000 ppm, and adjusts the optimal N rate to reduce the probability of toxic nitrate levels. The latter producer chooses an N fertilizer rate that maximizes expected net returns while reducing the probability of producing hay exceeding the toxic nitrate threshold. This producer can guarantee buyers cattle-safe hay. The difference in the expected net returns between the two producers divided by the annual yield of the nitrate-testing producer is the value of knowing the bermudagrass hay is safe for cattle feed. This value is the price premium a bermudagrass hay producer needs to breakeven with the producer who does not test hay for nitrates.

Estimation

Yield Response Function

The linear response plateau function assumes yield responds linearly to additional N until a yield plateau is reached. At the plateau, N is no longer a limiting factor in maximizing yield; thus, additional N does not increase yield. The response function was expressed as:

(2) $$y_{itj} = \min(\beta_0 + \beta_1 x_{itj}, \mu_i) + e_{itj},$$

where y_{tij} is bermudagrass hay yield in ton/acre for harvest month i on plot j in year t; β_0 and β_1 are intercept and slope parameters, respectively; x_{tij} is the quantity of N applied in lb/acre; μ_i is the plateau yield during harvest month i in ton/acre; and $e_{tij} \sim N(0, \sigma_e^2)$ is the random error term.

Equation (2) was estimated using the NLIN procedure in SAS 9.2 (SAS Institute Inc., 2004). The derivative with respect to N exists for this response function but not at the plateau; thus, the profit-maximizing N rate is a corner solution at the N rate required to reach the plateau if the marginal value product of N (p*dy/dx) below the plateau is greater than the marginal factor cost of N (r). Conversely, if the marginal value product of N is less than the marginal factor cost of N, a profit-maximizing producer would not apply N (Tembo et al., 2008).

Logit Model

Most research analyzing factors influencing nitrate accumulation in hay used an analysis of variance approach (Burns et al., 2009; Evers et al., 2004; Osborne et al., 1999). The results from these models are limited to determining how discrete levels of N fertilizer influence nitrate accumulation. Since nitrate accumulation in bermudagrass is influenced by several environmental factors, predicting nitrate accumulation as a function of N fertilizer using response functions such as a plateau function is difficult. To meet our objectives, a logit model was used to predict the impact of N, rainfall, average daily maximum and minimum temperatures, irrigation, and harvest month on the likelihood of nitrate levels exceeding the threshold dangerous to cattle. The logit model includes N as a continuous variable instead of considering the effects of N at discrete levels. This modeling approach is new to the nitrate-toxicity literature, and reveals information about variables not examined before.

The dependent variable in the logit model equals one for nitrate levels greater than or equal to 5,000 ppm and equals zero for levels less than 5,000 ppm. The assumed nitrate toxicity threshold is based on the literature (Connell et al., 2011; MacKown and Weik, 2004; Strickland et al., 1996; Undersander et al., 1999). The logit model was specified as:

$$(3) \qquad \mathrm{P}(NT = 1) = \frac{e^{\boldsymbol{\delta}_i' \boldsymbol{\alpha}_{NT}}}{1 + e^{\boldsymbol{\delta}_i' \boldsymbol{\alpha}_{NT}}} \ ,$$

where NT=1 if the nitrate level is greater than or equal to 5,000 ppm and zero otherwise; $\boldsymbol{\delta}_\mathbf{i}$ is a vector of explanatory variables including N, rainfall, temperature, irrigation, and harvest month; and $\boldsymbol{\alpha}$ is a vector of parameters. The explanatory variables N, rainfall, average maximum and average minimum daily temperatures for the harvest period are continuous variables while irrigation and harvest month are indicator variables. A positive (negative) parameter estimate for a variable indicates that an increase (decrease) in a continuous variable, or the presence of an indicator variable, increases (decreases) the probability of nitrates exceeding the threshold. The logit model was estimated with the LOGISTIC procedure in SAS 9.2 (SAS Institute Inc., 2004).

Parameter estimates from the logit and yield response models were used to calculate the probability of exceeding the nitrate threshold at profit-maximizing N levels by harvest month. The estimated logit model was used to calculate the odds ratio for exceeding the threshold at the optimal N rate for each harvest month:

$$(4) \qquad \mathrm{Odd}_i = \exp(\hat{\alpha}_0 + \hat{\alpha}_1 x_i + \sum_{i=2}^{4} \hat{\alpha}_i \gamma_i + \hat{\alpha}_5 Irg + \hat{\alpha}_6 \overline{T}max_i + \hat{\alpha}_7 \overline{T}min_i + \hat{\alpha}_8 R_i),$$

where Odd_i is the odds ratio for harvest month i, x_i is the N rate for harvest month i; γ_i is an indicator variable for harvest month i; Irg is an indicator variable for irrigation application; $\overline{T}max_i$ is the average maximum daily temperature in harvest month i; $\overline{T}min_i$ is the average minimum daily temperature in harvest month i; R_i is total rainfall in harvest month i; and $\hat{\alpha}_0,\ldots,\hat{\alpha}_8$ are parameter estimates. Given the calculated odds ratios, the probability of nitrate toxicity was found for each harvest month:

$$(5) \qquad \mathrm{Prob}(NT = 1 \mid x_i) = \frac{\mathrm{Odd}_i}{1 + \mathrm{Odd}_i} = \Phi(NT).$$

The parameter estimates from equation (2) and those from equation (3) through equation (5) were then substituted into equation (1) to determine the profit-maximizing N fertilizer rates for each harvest month with and without considering the probability of nitrate toxicity.

Results

Yield Response Function

Parameter estimates from the linear response plateau model were significant at the 0.05 level (Table 2). The intercept represents the expected yield if no N was applied and the plateau estimate represents the expected yield beyond which N was no longer a limiting input. The expected plateau was the highest in July and August and lowest in September. Bermudagrass is a warm-season grass so yields were expected to be highest in the warmest months. The slope parameter estimate represents the yield response in ton/acre to an increase of one lb/acre of N applied. Yield response to N was fairly similar for June, July and August but was less in September. The yield-maximizing N fertilizer rate was highest for the July and August harvests and lowest for the June harvest (Table 2). The variation in yield-maximizing N fertilizer rates demonstrates that application of a uniform rate across all harvest months would result in over or under application of N fertilizer in some months.

Logit Model

The N fertilizer rate, rainfall, and average maximum daily harvest-month temperature were positive and significant at the 0.05 level (Table 3). The results show that an increase in N fertilizer application increases the probability of nitrates exceeding the toxic threshold. Previous research found that higher N fertilizer rates result in higher nitrate levels in bermudagrass (Osborne et al., 1999; Westerman et al., 1983) but, in contrast to their results, our results are expressed as the probability of nitrates exceeding the toxic threshold.

Contrary to expectations, an increase in rainfall increases the probability of nitrates exceeding the toxic threshold. This result was unanticipated since drought is commonly found to explain high nitrate levels (Connell et al., 2011). However, some soil moisture must be available for the plant to take up and accumulate nitrates. Plants surviving drought are often higher in nitrates for several days following the first rain (Stoltenow and Lardy, 1998). Therefore, rainfall close to harvest can increase N uptake by bermudagrass. Depending on the timing of harvest after the first rain during drought stress, the plant may not have time to reduce nitrate levels by converting nitrates into proteins. Thus, the implication is that the timing of harvest after the first rain following a drought period is integral to determining nitrate levels in bermudagrass hay.

An increase in the average maximum daily temperature increases the probability of nitrate levels exceeding the toxic threshold, while an increase in the average minimum daily temperature decreases the probability of nitrate levels exceeding the toxic threshold. Gomm (1979) found excessively low and excessively high temperatures result in higher nitrate levels, which corresponds to our results. Irrigation decreased the likelihood of nitrate levels exceeding the toxic threshold at the 0.10 level. Irrigation rates and timing were controlled in the experiment so the bermudagrass that received irrigation never was drought stressed and could continually convert nitrates to protein. Conversely, rain-fed bermudagrass would not necessarily be able to continually convert nitrates to proteins due to intermittent moisture availability. The probability of nitrate levels exceeding the toxic threshold was greater for the July harvest than the June, August and September harvests. We found no significant differences in nitrate accumulation in the plant tissue for the June, August and September harvests. The finding for July implies more N may have been taken up by the bermudagrass before the July harvest than was converted to protein, resulting in excessive nitrate accumulation.

Economic Analysis

The yield- and profit-maximizing N fertilizer rate for the hay producer who does not consider nitrate levels were the same for all harvest months (Table 4). The profit-maximizing N fertilizer rate varied across harvest months from 64 lb/acre in June to 108 lb/acre in July. Applying a uniform N fertilizer rate across multiple harvests would reduce the bermudagrass hay producer's net returns, relative to a variable-rate N fertilizer application across harvest months. Yields varied from 1.07 ton/acre in September to 2.40 ton/acre in July (Table 4). The probabilities of bermudagrass hay exceeding toxic nitrate levels for the June, August and September harvests at the profit-maximizing N fertilizer rates were low (3%, 2% and 0%, respectively), but the probability of exceeding the nitrate threshold was higher (37%) for the July harvest (Table 4). Expected net returns also were highest for the July harvest and lowest for the September harvest (Figure 1). Given the estimated probabilities of exceeding the threshold, this producer likely would be selling hay that was toxic to cattle.

The yield- and profit-maximizing N fertilizer rate for the hay producer who considers nitrate levels were the same for the June, August, and September harvests, and were no different from profit-maximizing rates of the producer who does not consider nitrate levels. However, the profit-maximizing N rate decreased by 45 lb/acre for the July harvest and the expected yield decreased by 0.58 ton/acre to 1.82 ton/acre (Table 4). With the decrease in the N fertilizer rate, the probability of producing hay exceeding the toxic nitrate threshold decreased from 37% to 11% (Table 4). Furthermore, expected net returns decreased for the June, July and August harvests because the producer was not selling the hay with nitrate levels exceeding the toxic threshold and because of nitrate testing costs (Figure 1). The largest decrease in expected net returns occurred for the July harvest, resulting from the reduced N fertilizer rate and subsequent reduction in expected yield. However, given the lower probability of exceeding the toxic nitrate threshold, this producer might be justified in guaranteeing the hay as safe for cattle feed, especially if some mixing of the hay harvested in July were undertaken. The total decrease in expected net returns for the producer who tests for nitrates was $40/acre/year. Total hay production over the four harvests for the producer who considers nitrate levels was 6.61 ton/acre/year. Dividing the revenue loss by total expected yield, gives a reduction in expected net returns, compared with the other producer, of $6.02/ton. Thus, this producer must receive a price premium of $6.02/ton for guaranteed cattle-safe hay to break even with the producer who disregards the potential for nitrate toxicity to cattle and to financially justify continuing the testing of bermudagrass hay for nitrates.

These results also have economic implications that cannot be measured in this study. The hay producer unconcerned with nitrate levels risks hurting his or her reputation by selling hay with high nitrate levels. Hay buyers might avoid purchasing hay from this producer because of past experiences with purchasing high nitrate hay. On the other hand, the hay producer who does test for nitrates can market his or her hay as cattle-safe hay. Hay buyers might be willing to pay more for the information about the nitrate levels in this hay.

Conclusions

The objectives of this research were to determine: 1) the effects of N fertilizer, rainfall, average daily maximum and minimum temperatures, irrigation, and harvest month on the probability of nitrate levels in bermudagrass hay exceeding levels toxic to beef cattle; 2) the net returns for a bermudagrass hay producer who considers nitrate levels when choosing an N fertilizer rate, and the net returns for a bermudagrass hay producer who does not consider nitrate levels when choosing an N fertilizer rate; and 3) the value of information from testing for toxic nitrate levels.

A linear response plateau function was used to determine yield response in four harvest months and a logit model to estimate the probability of hay exceeding the nitrate toxicity threshold found in the literature. These estimates were used to calculate expected net returns for both producers and the value of nitrate-testing information.

Findings indicate profit-maximizing N fertilizer rates vary across harvest months. Thus, profit-maximizing bermudagrass hay producers should apply N fertilizer at variable rates across harvest months, and avoid applying a uniform N rate that would over or under apply N in some harvest months, and reduce profits.

The logit model indicates that N fertilizer, rainfall, average daily maximum and minimum temperatures, irrigation, and harvest month significantly affect nitrate accumulation in bermudagrass hay. The results from the estimated models show that both producers have the same profit-maximizing N fertilizer rates for the June, August, and September harvests because the probability of exceeding the toxic nitrate threshold is small for those harvests. In contrast, the profit-maximizing N rate for the producer who considers nitrate levels when choosing an N fertilizer rate decreases by 45 lb/acre for the July harvest. The total loss in revenue from guaranteeing safe hay for cattle consumption was $40/acre/year. A hay producer would need to receive a price premium of $6.02/ton for guaranteed safe hay for cattle consumption to justify continued testing of bermudagrass hay for toxic nitrate levels.

This approach to analyzing nitrate accumulation in hay production has not previously appeared in the literature. Earlier economic research has examined quality and quantity issues, but no paper has presented the value of testing bermudagrass for toxic nitrate levels. Our methods provide a new economic framework to help hay producers choose optimal N fertilizer rates when nitrate toxicity to cattle is an issue. Additionally, a modeling approach not used before to predict the probability of hay exceeding nitrate thresholds toxic to cattle is presented.

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Table 1. Average Yield (ton/acre) by Nitrogen Rate and Harvest Month.

	Month				
N (lb/acre)	June	July	August	September	Total
0	0.834	0.931	0.809	0.490	3.063
50	1.364	1.756	1.793	0.886	5.799
100	1.497	2.226	2.129	1.024	6.876
150	1.408	2.392	2.218	1.064	7.082
200	1.635	2.404	2.286	1.125	7.450

Table 2. Parameter Estimates for the Linear Response Plateau Function (ton/acre).

	Month			
Parameter	June	July	Aug	Sept
Intercept	0.833**	0.989**	0.811**	0.489**
Slope	0.011**	0.013**	0.019**	0.008**
Plateau	1.514**	2.397**	2.210**	1.071**
Random error	0.313**	0.947**	0.554**	0.187**
Yield Max N Rate (lb/acre)	64.13	108.39	71.36	72.96

** Significant at the 0.05 level.

Table 3. Parameter Estimates for the Logit Model.

Variable	Parameter Estimate
Intercept	−16.176**
N	0.027***
Harvest-June[a]	0.119
Harvest-July[a]	3.699***
Harvest-August[a]	0.641
Irrigation	−0.605*
Rainfall	0.888***
Max Temperature	0.404***
Min Temperature	−0.459***

*, **, *** Significant at the 0.1, 0.05, and 0.01 level, respectively.
[a] Harvest month of September is dropped so significance is determined relative to the September harvest.

Table 4. Profit-maximizing N rates (lb/acre), profit-maximizing expected yields (ton/acre), and probability of exceeding nitrate levels toxic to cattle by harvest month.

Result	June	July	August	September
	Not concerned with nitrate toxicity			
Optimal N rate (lb/acre)	64.13	108.36	71.36	72.96
Optimal yield (ton/acre)	1.51	2.40	2.21	1.07
Probability of exceeding toxic nitrate threshold	3.0%	37.0%	2.0%	0.0%
	Concerned with nitrate toxicity			
Optimal N rate (lb/acre)	64.13	63.68	71.36	72.96
Optimal yield (ton/acre)	1.51	1.82	2.21	1.07
Probability of exceeding toxic nitrate threshold	3.0%	11.0%	2.0%	0.0%

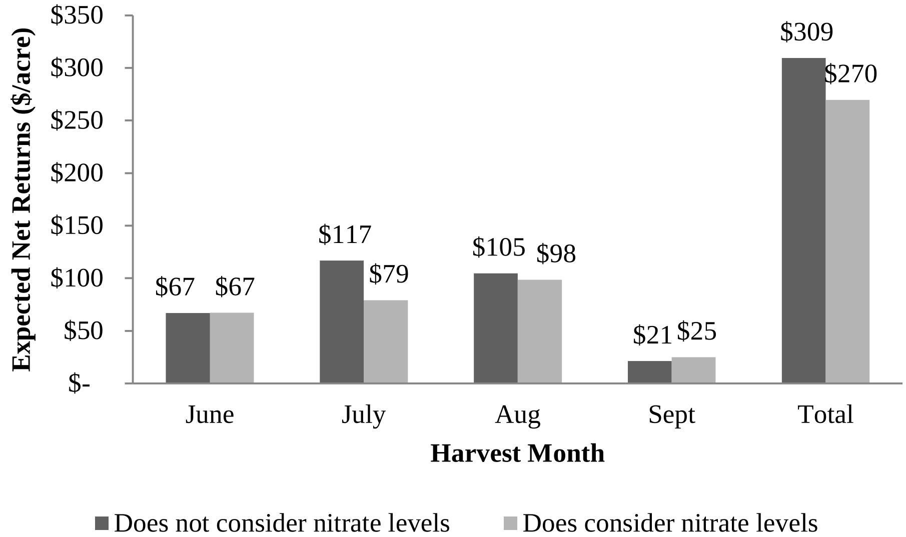

Figure 1. Expected Net Returns by Harvest Month for a Producer who Considers Nitrates when Selecting an N Fertilizer Rate and a Producer who does not Consider Nitrates when Selecting an N Fertilizer Rate.