Economic Analysis of Replacing Wild-Type Endophyte Infected Tall Fescue with Novel Endophyte-Infected Fescue

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Situation

The beef cattle industry plays an important role in the agricultural economy of most southeastern states. According to USDA-NASS, cattle and calves cash receipts totaled almost 2.9 billion dollars in these states in 2001 (Table 1). The predominant beef cattle production system in the South is cow-calf, where calves are raised to about 450-500 pounds and then weaned. After weaning, these calves will typically enter a stockering phase for about 120-180 days where they put on approximately 200-300 pounds. After the stockering phase, the stockers are sold (or placed) as feeders in a commercial feedlot in the Midwest or Plains and fed to around 1100-1200 pounds and slaughtered.

Most of the cow-calf and stocker production in the South occurs in pastures containing tall fescue (*Festuca arundinacea* Schreb). According to Browning et al., there are over 14 million hectares or 35 million acres of tall fescue in this region. Tall fescue is the predominant forage in this region because it is easily established, is widely adapted, has a long grazing season, is tolerant to poor management, and is a good seed producer (Stuedemann and Hoveland). Despite these desirable characteristics, tall fescue is associated with fescue toxicosis, a condition that can cause adverse performance in beef cattle.

The literature on fescue toxicosis is fairly extensive and most studies report reduced weight gains in calves and stockers and reduced conception and weaning rates in cows. The culprit in fescue toxicosis is reported to be toxic alkaloids produced by fungal endophyte

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(*Neotyphodium coenophialum*). The toxicosis problem is paradoxical in that that the troublesome endophyte is also responsible for improving agronomic aspects of the plant.

One proposed solution to this problem was the introduction of an endophyte-free fescue plant (E-). Resulting research and producer adoption of this plant has shown that although animal performance is improved, endophyte-free fescue requires more management and is less drought tolerant than the fescue infected with the toxic endophyte (E+). As a result, many producers have been reluctant to convert existing fescue stands from E+ to E-.

A promising recent development for beef cattle producers has been the introduction of novel non-toxic endophytes into tall fescue plants (NE+). Put succinctly, when fescue plants are infected with these non-toxic endophytes they possess the desirable agronomic qualities mentioned by Stuedemann and Hoveland without the adverse animal effects associated with fescue toxicosis. In essence, the novel endophyte provides the best of both worlds, plant sustainability and animal performance.

Currently, this novel endophyte fescue is being marketed under the trade name Max-Q™ by Pennington Seed, Inc. (Madison, GA). Although numerous university trials have demonstrated production advantages to using the NE+, producer adoption has been slow. This could be due to several reasons, namely high establishment cost (approximately $200 per acre, Parrish) and producers having to forego production during the establishment period.

Another significant factor has been the recent drought experienced by many producers in the Southeast. Typically most cool-season grasses are established in the fall. Throughout much of the South this is often the driest time of year, which makes establishment difficult. Thus many producers are reluctant to take land out of production to take a chance on establishing a new variety when the current variety is performing adequately in their view. That is, many producers would rather "deal with the devil they know than the one they don't".

The problem then can be summarized as such, are the costs from renovating infected fescue pastures worth more than the lost production associated with cattle grazing these infected pastures?

Objectives

The objectives of this paper are to:

1. Analyze the relative profitability of renovating an existing stand of endophyte infected fescue (E+) and replacing it with a novel endophyte infected fescue (NE+) within an expected utility (EU) framework
2. Determine the breakeven persistence period for NE+ compared to E+.

Procedures

To examine this problem, Net Present Value analysis is used. Net present value (NPV) analysis is the preferred method for comparing two alternatives with differing net cash flows over a specified period. This is accomplished by taking a future series of cash flows and discounting them to today's dollars. The alternative with the highest value is the most profitable or preferred alternative. NPV can be calculated (modified from Barry, et al.) as:

(1) $$NPV = -INV + \sum_{j=1}^{n} \frac{NCF_j}{(1+i)^j}.$$

Where:

INV = the amount of the investment

i = the discount rate

n = the number of periods

j = the j^{th} period

and NCF_j = the Net Cash flow for the jth period

To calculate the relative profitability of these two fescues, a simulation analysis was conducted for stocker steers. The simulation compared the discounted net cash flows of two groups of calves, one grazing E+ and the other grazing NE+. This simulation consisted of a sample population of 2,000 steers each year for ten years divided evenly into the two grazing groups. Ten years was chosen as the evaluation period because that is a conservative stand persistence estimate of NE+.

Investment cost for stand renovation to the novel endophtye is assumed to take place in year 1 (Y1) with no calves stockered in that year. In this analysis, the value for INV is the cost of converting the infected stand to a stand containing the novel endophyte. The value in this study was assumed to be $157.54 (Parrish). Since the comparison is made to the infected stand, INV for the infected stand is assumed to be zero and calf sales occur in all ten years of the analysis. Thus for the infected stand sales occur in 10 of 10 years (Y1-Y10) while for the NE+ stand sales occur in nine of 10 years (Y2-Y10) with stand renovation occurring in Y1. It was assumed that the stand was fully established by Y2.

The net cash flow from stockering can be expressed as:

$$(2) \qquad NCF_j = (EndWt * EndPrice) - (BegWt * BegPrice) - (Pasture\ Cost/Hd).$$

Where:

EndWt is the weight of steers after the stockering period,

EndPrice is the ending price ($/Cwt.) for the steers,

BegWt is the weight of the steers at the beginning of the stockering period (SP),

BegPrice is the price ($/Cwt.) for the steers at the beginning of the stockering period, and

PastureCost/Hd is pasture cost per acre divided by the stocking rate per acre.

Ending weight (EndWt) of the steers was calculated as:

(3) $EndWt = BegWt + ADG * SP.$

Values for average daily gain (ADG) came from the individual animal observations from the study conducted by Duckett, et al. that compared steers and heifers grazing toxic fescue with those grazing endophyte-free and novel endophyte fescues. In their study, steers and heifers grazing the endophyte-free and novel endophyte fescues had significantly better ADG (1.2 lb/day more) than animals grazing the toxic fescue (P<.05)

Beginning weight (BegWT) was assumed to be 500 pounds (the weight at which most stockering programs begin) and the stockering period (SP) was assumed to be 120 days, which is a typical stockering period. A stocking rate of 1.8 head per acre was assumed for the E+ and NE+ forages.

Prices for beginning and ending weights are Georgia prices for medium frame number one and two steers for 1992-2001 (USDA-AMS). The prices are reported in 50 pound increments (500-550, 550-600, etc). Prices for beginning weights were calculated as the average price of 500-550 pound steers for October-December from 1992-2001. Prices for ending weights were calculated as the average price of steers in the respective weight classes from February through April from 1992-2001.

In Georgia, prices for feeder steers are typically reported only up to 800 pounds. In this analysis, a significant number of the calves stockered in the NE+ system had an ending weight of more than 800 pounds. To arrive at price, Oklahoma City (OKC) feeder cattle prices, which report feeder cattle prices up to 1,000 pounds, were used to calculate a price differential for calves weighing 750-800 pounds and calves in different weight classes in excess of 800 pounds.

These differentials were calculated by regressing the OKC prices for each weight class (800-850, 850-900, 900-950, and 950-1,000 pounds) from 1992-2001 on the OKC prices for 750-800 pound steers for the same period (equation 4)

(4) $$Y_{\text{OKC 800-850}} = \beta_0 + \beta_1 X_{\text{OKC 750-800}}.$$

The resulting regression coefficients (Table 2) were then used to predict the GA price for these heavier cattle by substituting the GA 750-800 pound steer price for the X values of the regression equation. The GA price model for 800-850 pound steers is given below.

(5) $$Y_{\text{GA 800-850}} = \beta_0 + \beta_1 X_{\text{GA 750-800}}.$$

Prices for weights within the 50 pound increments were assumed to be the same, i.e. calves weighing 715 pounds and 735 pounds were both given the same price which was the average price for feeder steers weighing 700-750 pounds. The full list of assumed production values and prices is presented in Table 3.

Pasture costs for E+ and NE+ were assumed to be \$37.21 and \$41.55. These costs include seed, fertilizer, chemicals, and other production expenses for both systems.

Results

In this simulation, calves grazing the novel endophyte fescue gained considerably better (2.45 ADG) than those grazing the infected stand (1.47 ADG). As a result, ending weights, 720 pounds and 868 pounds, respectively; were higher, as were net values at \$145.60 and \$89.06, respectively. Summary statistics for animal performance and values are presented in Table 4.

NPV analysis (Table 5) reveals that is profitable for producers to renovate their endophyte infected fescue stands and replace them with a novel endophyte fescue. The NPV of the NE+ is almost 50 percent more that of the toxic fescue. Also, the standard deviation of the simulated net present values is smaller for the novel endophyte fescue, indicating there is less variability in performance among stockers in this system.

The concern for many producers in converting to NE+ is uncertainty of rainfall and resulting risk of crop failure when attempting to establish a stand of fescue. Furthermore, although most knowledgeable plant scientists indicate that that a useful life of ten years is reasonable, there is no definitive research regarding stand life of novel endophyte fescue particularly in commercial situations. Thus producers are not sure how often the NE+ will need to be reseeded.

To account for this uncertainty and resulting risk, the two fescue grazing systems were evaluated in an expected utility (EU) framework. The model for calculating NPV within an EU framework with imperfect capital markets can be generally expressed as:

$$\text{(6)} \quad \begin{array}{l} E[U\{u_1(r_1),\ldots u_t(r_t)\}]; \\ E[NPV\{u_1(r_1),\ldots u_t(r_t)\}] \end{array}$$

Where:

NPV = Net Present Value,

i=time preference rate,

r_t is stage return for stage t,

U is a total utility function,

$u_t(r_t)$ is the t-th stage utility function,

and E is the Expectation operator.

Provided U is a monotone of NPV, as is likely (Hardaker, Huirne, and Anderson).

Assuming Constant Relative Risk Aversion (CRRA), the model can further be specified as:

(7) $$E(U)_r = \sum_{i=1}^{n} \omega_i \frac{W_i^{1-r}}{1-r}, r \neq 1$$

or

(8) $$E(U)_r = \sum_{i=1}^{n} \omega_i \ln(W_i), r = 1.$$

where $W_i = W_0 + NPV_i$, r is a risk aversion coefficient, and ω_i is the weight associated with each observation i. Simulated ending wealth is represented by W_i, and initial wealth is represented by W_0. Since the analysis is on a per acre basis, initial wealth is assumed to be zero. Utility values are calculated for risk aversion coefficients 1, 2, and 3, with r=1 representing slightly risk averse and r=3 representing extremely risk averse.

By solving equation 8 for NPV, certainty equivalents (CE) can be calculated for each level of risk aversion. The CE represents the lowest sure price for which a decision maker would be willing to sell a risky prospect (Hardaker, Huirne, and Anderson). For any two alternatives i and j, if $CE_i > CE_j$, then alternative i is preferred to j.

Calculated CE values are presented in Table 6. These results indicate producers at all levels of risk aversion prefer renovating their existing toxic fescue stand to replace them with the novel endophyte fescue. It is interesting to note that as the level of risk aversion increases, difference in CE increases for the NE+.

Currently there has not been an immediate adoption of replacing E+ with NE+. Given the results of this analysis begs the question: why the conflict? Although several reasons are possible, the main reason may be a discrepancy between the assumption of a stand-life and producer experience. This analysis assumes that the producer is able to fully utilize the NE+ stand in Year 2 (Y2) and need not reseed for 10 years. During the past four years, much of the Southeast has been under a severe drought that has made the establishment of cool-season forages difficult if not impossible. Furthermore, producers may still be uncertain of the exact stand-life of NE+.

To examine the effects of stand-life on CE, differing periods of stand longevity and the associated capital outlay were evaluated. According to these results (Table 7) a stand of novel endophyte fescue must last at least five years to have the same CE as toxic fescue.

Summary and Conclusions

Many beef cattle producers in the Southeast have fescue as their primary forage base because of its many desirable agronomic characteristics. However, most of this fescue is infected with a wild-type endophyte that produces toxins causing reduced animal performance. A recent technological breakthrough has allowed researchers to develop a fescue that has the desirable agronomic characteristics of the infected fescue without the associated animal performance issues. However, producer adoption of this novel endophyte has been slow due presumably to the high cost of renovation and uncertainty of rainfall during the establishment period.

This paper has analyzed the feasibility of renovating endophyte-infected fescue and replacing it with this novel endophyte fescue. According to this research, renovating existing stands of toxic fescue with novel endophyte fescue is a profitable alternative for producers. NPV of NE+ is 50 percent more than E+. Expected utility analysis shows that producers at any risk aversion level prefer renovating to maintaining their existing stand assuming the stand is available in Y2 and lasts for ten years. If stand-life is less than ten years, then producers at all risk aversion levels prefer the toxic fescue to the novel endophyte at years less than five.

If the widespread adoption of the novel endophyte fescue occurs across the region, it could have substantial positive implications for the net farm income of many beef cattle producers

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Table 1. Cash Receipts from Farm Marketings, Cattle and Calves From Selected States 2001

State	Thousands of Dollars
Alabama	362,500
Georgia	347,677
Florida	360,516
Kentucky	499,782
Mississippi	196,774
North Carolina	231,667
South Carolina	128,916
Tennessee	409,572
Virginia	349,753
Total	2,887,157

Table 2. Regression Coefficient Estimates from Regressions Used to Calculate Higher Weight Price Differentials

Weight Range	Adjusted R^2	F-Value	Intercept	B_1
800-850	.994	1235.3	2.569	.945
850-900	.978	305.6	5.527	.884
900-950	.975	308.3	5.962	.860
950-1000	.937	121.0	4.780	.853

Table 3. Values Used in Analysis

Item	Toxic Fescue	Novel Endophyte
Beginning Weight	500	500
Stockering Period (days)	120	120
Stocking Rate (Calves/Acre)	1.9	1.8
Renovation Cost/Acre		$157.84
Annual Variable Costs/Acre	$37.21	$41.55
Stocker Variable Costs/Acre	$121.53	$121.53

Note: N=1,000

Table 4. Summary Statistics from Simulated Comparison of Toxic Fescue and Novel Endophyte Fescues

	Toxic Fescue				Novel Endophyte			
Item	ADG	Ending Wt.	Wt. Gain	Net Value	ADG	Ending Wt.	Wt. Gain	Net Value
Mean	1.47	720	220	$89.06	2.45	868	368	$145.60
Standard Deviation	.47	68.34			.34	59.69		
Min.	.26	539	39	($11.17)	1.77	766	266	$95.62
Max.	2.02	803	303	$150.11	3.48	1,022	522	$275.18

Table 5. Simulated Net Present Values for Toxic Fescue and Novel Endophyte Fescue

	Toxic Fescue	Novel Endophyte
Mean	$581.70	$870.06
Standard Deviation	92.966	65.281
Min.	$764.51	$1,028.32
Max.	$330.98	$717.30

Table 6. Simulated Certainty Equivalents for Toxic Fescue and Novel Endophyte Fescue

r	Toxic Fescue	Novel Endophyte
1	$592.25	$726.61
2	$583.49	$722.06
3	$575.47	$718.44

Table 7. Impact of Novel Endophyte Stand Life on Certainty Equivalent NPV

	Stand Life in Years		
R	3	4	5
1	$282.97	$484.34	$658.94
2	$274.88	$478.69	$654.26
3	$267.07	$473.85	$650.48