Agricultural Economics Journal of Student Papers

Volume 1 Number 1
December 1983

Student Section
AMERICAN AGRICULTURAL ECONOMICS ASSOCIATI

1983 — 1984

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Kelso L. Wessel
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PUBLICATION

The Agricultural Economic Journal of Student Papers is published once per year through funds made available from the American Agricultural Economics Association. Copies are sent free to current Charter Chapters of the SS-AAEA, the National Officers of SS-AAEA, the current advisors of SS-AAEA and the current AAEA Board Members. Other individuals and organizations may purchase a copy for $5.00.

Optimum Treatment Rate for Tebuthiuron on Rangeland Infested with Sand Shinnery Oak

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ABSTRACT

Tebuthiuron for control of sand shinnery oak on rangeland in the Texas Rolling Plains was evaluated. Grass yield was estimated to be a function of the treatment rate of tebuthiuron. The treatment rate of 0.478 kg/ha was found to be the optimum given representative livestock prices and costs of application used.

Key words: brush control, sand shinnery oak, tebuthiuron, optimum

OPTIMUM TREATMENT RATE FOR TEBUTHIURON ON RANGELAND INFESTED WITH SAND SHINNERY OAK

Over 4.2 billion pounds of beef were produced in Texas with a value of over $1.2 billion in 1971, which was the greatest for any of the fifty states. Texas production of range livestock is limited by the availability of rangeland. In 1967, over 53% of the land area in Texas was classified as rangeland and 82% of the grasslands of the state was infested with undesirable woody plants (Osborn and Witkoski).

Brush problems, for the most part, are brought on by man himself. Brush is a problem, because it competes with grasses needed for livestock grazing. Sand shinnery oak typically has a large root system which is extremely hard to kill. Top kill of the sand shinnery oak is relatively easy, but the root kill is usually low. Total plant kill from aerially applied liquid hericides are rare. New shoots may arise from buds along with the more shallow rhizomes following top growth disturbance resulting only in temporary control. Tebuthiuron has been used on sand shinnery oak, and rates above 3 kg/ha essentially "cleaned out" the plant community. Grass yields increased dramatically following oak kill; however, very judicious grazing management with occasional deferment would be needed to retain a healthy plant cover (Pettit). At the end of a third growing season after treatment with tebuthiuron at treatment rates of 0.0, 0.2, 0.4, 0.5, 0.7, and 0.9 active ingredient/acre, it was found that oak was reduced by 79, 97, 96, 99, and 99 percent, respectively, as the rate of hericide increased (Jones and Pettit). Tebuthiuron at a rate of 0.4 kg/ha or greater converted the sand shinnery oak community into a mid-grass prairie. At these rates, over 80% of the sand sagebrush was killed and the yield of sand shinnery oak was reduced by at least 90% (Jones).

One goal of a rancher is to utilize his land at the highest productive capacity. Today, more ranchers are achieving this goal through initiating some type of brush control program. Chemical control of sand shinnery oak through aerial application of tebuthiuron has been introduced as an effective brush control program. Little economic analysis has been done on the costs and returns associated with aerial application of tebuthiuron; therefore, this paper will attempt to explain those factors associated with determining the optimum treatment rate for aerially applied tebuthiuron on sand shinnery oak. The specific objectives of this paper are:

1) to develop an equation which estimates the total grass production associated with different treatment rates,
2) to estimate the annual revenue associated with each treatment rate,
3) to estimate the annual costs associated with application of tebuthiuron, and
4) to estimate the optimum treatment rate under current economic conditions in the livestock market and application costs to the Texas High Plains rancher.

Analytical Framework

For a brush control program to be economically feasible, the returns from that brush control must be greater than the cost of that control. In the control of sand shinnery oak, the total grass production is expected to increase as treatment rate increases. The higher the treatment rate the more oak is killed, and the oak is replaced with additional grass production. However, it is also expected that total grass production increases at a decreasing rate. This is because the chemical tebuthiuron is a soil sterilant which affects different vegetation at different treatment rates. The higher the treatment rate, the more oak is killed but also the chemical begins affecting other vegetatoin, such as grass, adversely. The grass production response also varies with time. Field trials indicate that the chemical tebuthiuron is effective in killing sand shinnery oak without reinfestation in later years. Therefore, grass production is expected to increase over several years and finally level off. Grass production is hypothesized to be a function of the following variables:

TGP = f(TRMT, TIME)

where TGP = total grass production associated with application of tebuthiuron on sand shinnery oak,

TRMT = rate at which tebuthiuron is applied to the rangeland,

TIME = years since application on sand shinnery oak.

Grass production is not marketable itself; therefore, it must be converted to a product, such as livestock production, which is marketable. The price per pound the rancher receives for his livestock is the value price of his grass production. A conversion factor for converting grass production to beef production should be used. To estimate what additional benefit (marginal grass production) is received from the application of tebuthiuron, the following relationship is utilized:

$$MLP = C(MGP)$$

where MGP = additional grass production associated with application of tebuthiuron on sand shinnery oak,

C = conversion factor of grass production to beef production to beef production (units of grass to produce a unit of beef),

MLP = additional livestock production associated with application of tebuthiuron on sand shinnery oak.

Since the relationship between the treatment rate, time, and grass production have been hypothesized, the economic variable-livestock prices-is incorporated into the relationship. The following relationship expresses the economics of the problem:

$$VMP = MLP(P_1)$$

where VMP = value of additional grass production (in terms of additional livestock pounds produced),

MLP = additional livestock production associated with use of tebuthiuron on sand shinnery oak,

P_1 = price received for the livestock marketed.

Livestock prices give a means of measuring revenues which are received on an annual basis from grass production. A net revenue figure would subtract variable costs, which are also on an annual basis, from revenue received from livestock marketed, i.e.,

$$Pn_1 = P_1 - VC_c$$

where Pn_1 = net price received per kilogram of livestock marketed,

P_1 = price received per kilogram of livestock at market time,

VC_c = variable costs associated with adding cow-calf units.

For an accurate and reliable decision over whether to introduce a brush control program (tebuthiuron on sand shinnery oak), the costs applying tebuthiuron on rangeland should be examined. The costs for applying tebuthiuron are incurred today; however, since the effects from the treatment occur over its useful life, estimated at approximately 20 years, the annual cost of the treatment is determined. The hypothesized equation which will estimate the annual cost of applying tebuthiuron on sand shinnery oak is:

$$AC = \frac{C_t \cdot I^n}{n}$$

where AC = average annual added cost associated with application of tebuthiuron on sand shinnery oak,

C_t = cost of application of tebuthiuron on sand shinnery oak,

I = real interest rate (adjusted for inflation),

n = useful life of treatment with tebuthiuron on sand shinnery oak.

This equation expresses the costs of application on an annual basis, so that it can be compared to annual net revenues. Since the price of the treatment is the price regardless of the treatment rate, the maximum amount applied would be where revenues equal costs, i.e.,

$$VMP = AC.$$

Therefore, it is hypothesized that there exists an optimum treatment rate for tebuthiuron on rangeland infested with sand shinnery oak, given the total grass and marginal grass production relationships, a conversion factor for converting grass production to beef production, prices for livestock, and costs of tebuthiuron application.

Methods and Procedures

The data for this study were collected from experimental plots set out near Plains, Texas by researchers in the Range and Wildlife Management Department at Texas Tech. The data were gathered over a five year period from the spring of 1978 through the fall of 1982. The chemical used in the experiment was tebuthiuron (Graslan) with five different treatment rates of application used--0.0 (control plot), 0.2, 0.4, 0.6, 0.8, and 1.0 kg/ha during 1978. Mean grass, oak, and forb yields were collected from the plots. After several conferences with Drs. Russ Pettit and Virgil Jones of the Range and Wildlife Department at Texas Tech University, some of the variables which are expected to affect the total grass production were determined.

A mathematical model was hypothesized which would give the total grass production. Treatment rate and time were defined as the independent variables and total grass production the dependent variable. The following equation was hypothesized:

$$TGP = a + b\ TRMT + c\ TRMT^2 + d\ TIME$$

where TGP = total grass production associated with application of tebuthiuron on sand shinnery oak in kg/ha,

TRMT = treatment rate of tebuthiuron application on sand shinnery oak in kg/ha.

TIME = 1/number of years after the application of tebuthiuron on sand shinnery oak.

The treatment rate and grass production relationship is hypothesized to be a quadratic, because, as stated earlier, grass production is expected to increase but at a decreasing rate. The quadratic equation expresses this relationship. Time is expressed as a reciprocal because, again, the expected relationship stated earlier was that total grass production increases and eventually levels off. The reciprocal expresses this type relationship.

Marginal grass production was calculated, which shows how much more grass production the rancher will realize with the addition of tebuthiuron application on sand shinnery oak:

$$MGP = \frac{\partial TGP}{\partial TRMT} = 1529.6 - (2)\ (975.1)\ TRMT$$

where MGP = additional grass production associated with application of tebuthiuron on sand shinnery oak.

Once the MGP was established, the conversion to marginal livestock produced (MLP) was accomplished by using a conversion factor for 1 lb. of grass. It was estimated that for the area of study 21,000 pounds of grass were required annually to support one animal unit (AU) (Ethridge, Dahl, and Sosebee). It was assumed that the livestock operation consisted of a cow-calf operation and that one animal unit consisted of one 1,000 pound cow, one 400 lb. calf, 5 percent of a 1,600 lb. bull, and 14 percent of a 650 lb. replacement heifer (Kennedy). A calving rate of 90 percent and marketing the calves at 400 lbs. were assumed. Therefore,

.90 calving rate - .14 heifer replacement = .76 marketable calf produced from AU

.76 x 400 lb. = 304 lbs. of marketable calf

1 lb. of grass = 0.0145 lbs. of marketable calf

In terms of kilograms,

1 kilogram of grass = 0.0145 kgs. of marketable calf

The net value of marketable calf would be calculated as follows:

$$Pn_1 = P_1 - VC_c$$

where Pn_1 = net price received in cents per kg for a 400 lb. calf,

P_1 = market price of 400 lb. calf in cents per kg,

VC_c = variable costs associated with producing a 400 lb. calf in cents per kgs.

All costs and prices were converted to $/kg, because the data for the grass response is in kg/ha. The variable costs are those costs which would be incurred if an additional animal unit was placed on the land.

These costs consist of supplemental feed and minerals, veterinarian costs, fuel, lubrication, and repair costs on equipment, marketing costs, depreciation, taxes, and insurance on livestock, and interest on operating capital, and investment on the cows, calves, bulls, and replacement heifers. The estimated costs were taken from enterprise budgets by the Texas Agricultural Extension Service. Only the added costs associated with increasing the stocking rate were used. The associated VC_c was estimated to be \$.235 per lb. or .518 per kg. The market price for calves, P_c which was a five year average price, was obtained from the Texas Livestock Market News. The costs associated with the aerial application of tebuthiuron were taken from Mike Simpson, an Elanco representative, Lubbock, Texas. He estimated the cost per acre of applying tebuthiuron to sand shinnery oak would be \$16.50/acre or 40.77 per kg. Along with this cost and useful life, a 7% real interest rate or opportunity cost is assumed (adjusted for inflation). To find the average annual cost incurred from applying tebuthiuron was calculated from the following equation:

$$AC = \frac{C_t \cdot I^n}{n}$$

where AC = average annual average cost associated with application of tebuthiuron on sand shinnery oak,

C_t = cost of application by tebuthiuron on sand shinnery oak,

I = real interest rate (adjusted for inflation),

n = useful life of treatment with tebuthiuron on sand shinnery oak.

Once this figure has been calculated, and the value of the marginal product is calculated, a comparison of the two would show the optimum treatment rate for the rancher.

FINDINGS

The following relationship was estimated using multiple linear regression:

$$TGP = 370.2 + \underset{(.00)}{1529.6}\ TRMT - \underset{(.00)}{975.1}\ TRMT^2 - \underset{(.05)}{347.6}\ TIME$$
$$\qquad\qquad (.03)$$

$$R^2 = .249 \qquad\qquad F\text{-value} = 7.53$$

The numbers in parentheses indicate the probability level at which the estimated parameter is statistically significant. The R^2 value is relatively low, indicating that other variables affect total grass production. The regression model included 72 observations based on data gathered over a five-year period. Utilizing the relationship, total annual grass production is increasing up to 0.8 kg/ha ($\partial TGP/\partial TRMT = 0$; $TRMT = .78$). Beyond the 0.8 kg/ha treatment rate the annual total grass production is decreasing. To convert this added grass production to added beef production, the conversion of 1 kg of grass = .0145 kg of marketable calf was used. To convert these values to dollar figures, the estimated cost of producing the marketable calf of .518/kg was used. The price of the beef was calculated by taking five year average price for 400 lb. feeder steers in late August from the San Angelo market. Based on these prices, a calf price of $1.428/kg was assumed. Therefore,

$Pn_1 = P_1 - VC_c$ or $Pn_1 = \$1.428 - \$.518 = \$.91/kg$. This $.91/kg is the additional income produced from an additional kilogram of marketable beef which is above added costs. Therefore, each added pound of grass produced has a value of: (.0145) ($.91) = .0132.

The value of the marginal grass production is therefore:

$$\begin{aligned} VMP &= (MGP)\ (Pg) \\ &= (1529.6 - 1950.2\ TRMT)\ (.0132) \\ &= 20.190 - 25.742\ TRMT \end{aligned}$$

where VMP = value of the marginal grass production associated with application of tebuthiuron on sand shinnery oak,

MGP = marginal grass production associated with tebuthiuron application on sand shinnery oak,

Pg = price received for the added grass production associated with tebuthiuron application on sand shinnery oak.

These calculations show the value for the marginal grass produced through use of tebuthiuron on sand shinnery oak on an annual basis. Since the value of the added grass production is on an annual basis, costs must be stated on an annual basis.

These costs of applying tebuthiuron on sand shinnery oak were calculated from the following equation:

$$\begin{aligned} AC &= \frac{C_T + I^n}{n} \\ &= 40.77 \cdot 1.07^{20} \end{aligned}$$

where C_t = cost of application of tebuthiuron on rangeland infested with sand shinnery oak,

I = interest rate adjusted for inflation,

n = number of years of useful life of the tebuthiuron on sand shinnery oak.

AC or the average annual added costs from applying tebuthiuron on sand shinnery oak was found to be $7.88 per hectare.

The optimum treatment rate was mathematically calculated by utilizing the following equation:

$$VMP = AC$$

$$20.190 - 25.742\ TRMT = \$7.88$$

$$TRMT = \frac{7.88 - 20.190}{-25.742}$$

$$= .478$$

Thus, for the above conditions (calf prices, calf production costs, and interest rate), the optimum treatment rate is about .5 lb/acre (converting kgs. to lbs.). However, if calf prices rise to $1.65/kg and variable costs remain the same, the optimum treatment rate increases to .539 kg/ha. If the calf price remains at $1.428/kg and variable costs rise to $.772/kg, the optimum treatment rate would decrease to .424 kg/ha.

CONCLUSIONS

The feasibility of controlling sand shinnery oak with tebuthiuron is influenced by many variables. The purpose of this paper was to determine the optimum treatment rate for applying tebuthiuron on rangeland infested with sand shinnery oak. To determine the optimum treatment rate, manipulation of the variable treatment rate along with deriving appropriate conversion factors produced a means of converting grass production; therefore, giving a means of marketing the grass production. The annual costs and returns were calculated to give the rancher the optimum treatment rate of 0.478 kg/ha. A treatment rate greater than 0.478 kg/ha no longer produces enough annual revenue to cover the annual costs associated with the tebuthiuron application. This particular treatment rate is only the optimum solution when certain conditions exist. The conditions included: 1) five years of data collected from a ranch located in the High Plains of Texas, 2) factors associated with price per pound of marketable calf (such as variable costs associated with adding cow-calf units and conversion factors figured for converting grass production to meat production), 3) a five-year average price for 400 lb. feeder steers taken in late August from the San Angelo market, 4) cost of applying tebuthiuron on rangeland infested with sand shinnery oak, and 5) calculations of costs and returns on an annual basis only.

The rancher must realize that, although this paper dealt with optimum treatment rate, it is by no means a complete study of the economic feasibility of tebuthiuron as a means of controlling sand shinnery oak. The environmental factor of rainfall is an influencing factor, along with time, because the effects of the treatment are realized over a number of production periods. With conditions given in this paper, the results reveal that there does exist an optimum treatment rate which 0.478 kg/ha. At this rate, the rancher realizes control of sand shinnery oak infestation given a price of $1.428 per kilogram of beef and a cost of $40.77 per hectare for applying tebuthiuron on sand shinnery oak infested rangeland. The optimum treatment is sensitive to livestock prices and variable calf production costs; therefore, these factors should be carefully analyzed before a reliable optimum can be determined.

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