WOOL RESPONSE TO SUPERPHOSPHATE APPLIED TO PASTURE

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Summary

A relationship between wool production per sheep and annual pasture production is presented. This forms the basis of a derived relationship between wool production and the rate of superphosphate applied to grazed pasture. The use of this model in making fertilizer recommendations is discussed.

I. INTRODUCTION

Recent increases in the price of superphosphate have forced farmers to review their fertiliser strategies, and advisers to review the basis of their advice. DECIDE - a model for predicting superphosphate requirements (Bowden and Bennett 1975) was released for use in 1974 in response to expected demand for fertilizer advice.

DECIDE uses the "average value of pasture" approach of Moyle (1961) which assumes a constant level of product per animal. Stocking rate and superphosphate rate have to be adjusted simultaneously in response to relative price changes. The alternative, of adjusting the wool production per animal in response to changes, was initially avoided in DECIDE to maintain model simplicity.

This paper describes a relationship between wool production and superphosphate rate which allows stocking rate and the level of wool production per animal to be adjusted separately in response to changing economic circumstances.

II. WOOL AS A FUNCTION OF SUPERPHOSPHATE

(a) The wool-pasture component

The hypothesis proposed is that the amount of wool produced by a sheep is related to the share the sheep gets of the total annual pasture production.

\[ W = X S \left( 1 - M \exp \left( - \frac{KD}{S} \right) \right) \]  

where \( W \) is the weight of wool per hectare (kg/ha/yr), \( X \) is the maximum wool production per sheep with feed not limiting (kg/sheep/yr), \( S \) is the stocking rate (sheep/ha), \( M \) is a constant, \( K \) is the coefficient of curvature (yr ha/kg), and \( D \) is the pasture dry matter produced per hectare (kg/ha/yr). Average values are assumed for pasture quality and the seasonal distribution of pasture.

Clearly this model is a gross simplification of the integrated effects of many factors such as intake, utilisation, digestibility, wastage, etc. However, between the point of minimum wool production per sheep (the threshold of death from starvation) and the point of maximum wool production per sheep, it is hypothesised that the law of diminishing returns will operate (equation 1).

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(b) The pasture-superphosphate component

The pasture-phosphate relationship used here is that proposed by Bowden and Bennett (1975) and is the form currently used in DECIDE. The pasture response curve equation is:

\[ D = A(1 - \exp(-CP)) \]  

where \( A \) is the maximum yield of pasture dry matter with \( P \) non-limiting (kg/ha/yr), \( C \) is the coefficient of curvature of the pasture dry matter response to applied phosphorus (yr ha/kg) and \( P \) is the rate of "applied" plus "residual" phosphorus (kg/ha/yr).

(c) The wool-superphosphate model

A relationship between wool and phosphorus can be derived by substituting for \( D \) in equation (1) to give:

\[ W = XS(1 - M\exp[- \frac{KA}{S}(1 - \exp(-CP))] \]  

III. ESTIMATION OF PARAMETERS

Carter and Day (1970) and Drake and Elliott (1960) have published mean annual pasture production data together with mean annual wool production data. These data provide the means of estimating parameters \( M \) and \( K \) of equation (1). Figure 1 shows these data with the equation fitted to Carter and Day's (1970) data. A notable feature is that when the sheep were on the threshold of death due to starvation, wool production was at about 80% of maximum.

IV. THE WOOL-PHOSPHATE MODEL AS PART OF THE OVERALL "DECIDE" METHODOLOGY

The "wool model" was developed to improve the usefulness of DECIDE as a decision making tool. With DECIDE as a computer based service, no major adaptation of the "wool model" is necessary, but hand calculation can only be done with difficulty. Mathematical complexity dictates a graphical approach for field use. Figure 2 depicts a graphical
approach for use in the field. Each production curve is labelled at intervals with the value of the derivative (cost-price ratio) enabling the optimal economic superphosphate rate to be read directly from the graph. This approach is only one of many alternative approaches and may not be ideal for all situations.

Using DECIDE's present approach a farmer currently has only two choices:

(i) If he insists on maintaining his stocking rate fixed at a certain (e.g., current) level, DECIDE can only calculate the amount of fertilizer required to maintain a given level of production per animal. Obviously this approach is insensitive to price relationships.

(ii) If the farmer accepts DECIDE's recommendation then he should calculate the consequences on his carrying capacity and vary his stock numbers to maintain per animal performance.

The model shown in Figure 2 offers a wider range of alternatives than the present approach because stocking rate and wool production per sheep can both be optimised. The minimum rate of fertiliser for sheep survival is also indicated.

![Figure 2](image)

Fig. 2. A graph for use in the field showing wool per hectare versus superphosphate. The cost-price ratio is labelled at intervals along each curve. Residual phosphate is deducted to produce a recommended rate.

A major disadvantage of this model for field use lies in the number of graphs required to cover a useful range of situations. A range of X values (maximum wool production per sheep), a range of A values (maximum pasture production) and a range of C values (soil type) are needed. However in a particular region (e.g., the Esperance sandplain) four A values and two C values (i.e., 8 graphs) cover most contingencies. The optimal superphosphate rate is relatively insensitive to changes in X.
V. FUTURE REFINEMENTS OF THE MODEL

(a) Sheep products other than wool

The "wool model" was derived from data of experiments with wethers. Clearly there is a need to develop a sheep meat model along the same lines as the wool-pasture model above and to incorporate the two into a single model.

In view of the improving demand for young lean sheep for Middle East markets, it seems likely that fertility will be of major importance. A simple relationship between fertility and nutrition must therefore be sought. Further modifications will be necessary for sheep grazing highly oestrogenic subterranean clover cultivars, where pasture composition will also be important.

(b) Effect of stocking intensity on pasture production

Ozanne and Howes (1971) have shown that the shape of the superphosphate response curve is different for a grazed and ungrazed pasture. If stocking rate is fixed, grazing pressure will change as more superphosphate is applied and as the grazing pressure changes so does the response curve.

A preliminary study has shown that the wool model is quite sensitive to the effects of changes in "C" at low stocking rates but at high stocking rates the model becomes less sensitive. Work on this aspect of the model is proceeding.

VI. CONCLUSION

The largest single factor hindering the further development of this model is the absence of annual pasture production data from published accounts of stocking rate experiments. However the model presented is a start and does illustrate the value of collecting such pasture data from sheep grazing experiments.

The model does not stand alone but rather it is a new element of a continuously evolving overall model - "DECIDE".

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VIII. REFERENCES


