Fertiliser Adviser Dairy - an expert system for dairy pastures in Tasmania

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Abstract

Fertiliser Adviser Dairy is an Expert System designed to provide advice about the rates and mixtures of fertiliser required for topdressing dairy pastures in Tasmania. As pasture nutrition for the dairy industry must give due attention to recycling of nutrients through animal excreta this is a feature of *Fertiliser Adviser Dairy*. In the program losses are calculated from production data which the farmer clients have at hand, and soil losses that relate to soil type and water run-off. The program offers advice with or without soil tests, but precision is improved with soil tests. Providing advice is complicated because animals move nutrients about the farm, and some paddocks will receive nutrients that have been removed from other paddocks. Excreta voided in laneways and the dairy are also lost to the pasture. Soil tests are used to re-allocate fertiliser distribution to restore a balance of fertility over the whole farm. *Fertiliser Adviser Dairy* is used successfully by fertiliser sales staff that advises Tasmanian dairy farmers.

Key Words

Expert system, fertiliser, dairy, pastures, nutrient balance.

Introduction

Fertiliser recommendations for dairy pastures used to be made on the evidence of soil analysis alone. The problem with this is that it places undue reliance on the soil analysis, which is subject to the inaccuracies of sampling and laboratory error. In the 1980's the New Zealand MAF adopted an approach that uses the nutrient cycle to make an estimate of the losses from a pasture (Cornforth and Sinclair 2).

Although the principle of using the nutrient cycle to estimate losses was attractive, translating the MAF model to Tasmania proved to be unsuccessful because that model relied on knowing a potential stocking rate for the district. We decided to build our own model for the nutrient cycle of P and K drawing heavily on Williams *et al* 4 for fresh ideas for treating the K losses and gains, and extending these to P. An improvement that we made was to use a water balance modelling analysis to make better estimates of losses through drainage.

The estimate of losses of P and K from the dairy agro-ecosystem provides the first approximation of how much fertiliser is needed for any dairy farm to maintain nutrient balance between inputs and outputs for a commercial level of productivity. The data needed to make the estimate is readily at hand for most dairy farmers.

Estimation of P and K losses

Estimates of P and K losses are calculated from the nutrient balance; the size of the nutrient outputs is derived from production data, particularly stocking rate and milk-fat production. We use a conversion of 25 kg of pasture dry matter to make 1 kg of milk-fat. Concentrates that have been fed are converted by calculation of their energy content into the equivalent of pasture dry matter. This is then subtracted from the pasture intake estimated for the herd, so that the pasture that was actually grazed can be used in the calculations for fertiliser requirements.

The sources of losses are:

- ***P and K losses in milk*** = (MF/ha*conc of nutrient)/MF test. Farmers know the yield of milk fat from their farms because that is part of the payment system. These losses are calculated from their concentration in the milk.
- ***P and K losses in body tissue***, (calves, cast for age cows, and dry stock) = ((Cows/ha/longevity)*conc of nutrient)+((Dry stock/ha/longevity)*conc of nutrient). An inventory of the stock on the farm is required as in-put, and from that it is possible to calculate losses in the body tissue. The longevity is calculated from the ages of the various stock classes, concentration of nutrients is taken from standard ARC measurements. (ARC 1)
- ***P and K losses in excreta deposited in laneways and the dairy*** =((MF*25*conc in pasture)-(Nutrient in Milk and body tissue))*((Time off pasture/24)*(length of lactation/365)). This is calculated from the time that the dairy herd spends away from the pasture. It is very sensitive to the number of hours per day that the animals are off the pasture, and this parameter is required as in-put. (this term could be mentioned in abstract because my judgement would be that it important and a feature of your program)
- **P losses in soil sorption** = (P in milk + P in body tissue + P in laneway) * (Fixation-multiplier dependant on soil-type). Soil sorption of phosphorus is important in reducing the effectiveness of fertiliser P on clay loam soils, and the programs takes this into account by increasing the amount of P required as fertiliser for pastures on these soils. The Fixation multiplier is 45% for clay soils with a high iron content, 20%, for clay loams, and 10% for other soil textures.
- **K losses in run-off and drainage water** = ((((MF*25*Conc K)-(Nutrient in Milk and body tissue))-Laneway loss)*proportion of K in the Urine)*(Run-off * Urine-loss fraction). Losses of K in run-off and drainage water can be substantial, and we have developed a new way of calculating this. When cattle urinate on pastures and the soil is saturated, the K already in solution is lost with water that either runs through the profile, or over the surface into drains. To estimate this loss, we calculate how much K is voided onto the pasture from the intake, less retention, and then estimate the fraction lost by using a function of run-off and a urine-loss factor. We calculated run-off from meteorological data for stations where dairy farming exists. The method used was a simple water balance model described by McAlpine (4). The urine-loss fraction is an estimate of the slope of the regression for K lost from urine as a function of the run-off and ranges from 8% on clay loam soils to 35% on sandy soils.

We have not taken P and K imported in concentrates and other feeds brought onto the farm into consideration. The reason is that we believe that reliance on imported feed as a source of fertiliser for pastures is unreliable, and in any case nutrients imported in feed is of the order of less than 5% in Tasmania. Imported feeds may be fed out on various parts of the farm, and not evenly distributed. Instead, the program relies on soil test to adjust the amount of fertiliser that is recommended.

Input requirements and fertiliser mixtures

In computer based electronic decision making, an important principle is that the client should have input and drive the decision. When the program has calculated the losses, the information is presented along with how much P and K might be required plus an estimate of the cost for the whole farm; the client then has to enter the actual amount that they intend to apply. This gives the client the opportunity to apply either more or less than is recommended. Budget restrictions may affect the decision and the client may be prepared to run –down the store of nutrient on the farm. In other circumstances the client may wish to apply additional fertiliser in the expectation of improved production or to build the nutrient status of the farm.

The fertiliser mixtures advised are always taken from the listed pre-mixes, rather than custom blends. This is because each paddock will probably require a special custom blend resulting in too many mixtures being advised, and farmers do not wish to bring too many individual mixes in one order. By restricting the mixtures to a specified range, the program reduces the number of mixtures, while the application rates for paddocks will vary according to decision.

Advice without a soil test

Where no soil test results are available, estimation of the losses of P and K provide the best estimate of fertiliser required to maintain the nutrient balance for the farm. Because the volume of losses is dependent on the level of production, soil and run-off, those farms that require most fertiliser, will have the largest losses.

Advice without a soil test does not take into account pastures where the soil fertility is below optimum. It also will not advise different rates of fertiliser on paddocks where nutrients have been moved from one part of the farm to another. The program does have a facility for users to indicate if paddocks are largely used for hay or silage and where these are not fed out. There is also provision for the user to indicate if there are paddocks that are irrigated. Irrigated paddocks are allocated additional fertiliser compared to paddocks that are not irrigated.

Improved precision of advice where soil tests are available

Where soil test for P, K and pH are available, the program offers more precise advice taking existing soil fertility and nutrient status/store into account.

The soil tests must be related to specific areas on the farm, typically a paddock, or group of paddocks on a similar soil type and management regime. Soil tests for only part of the farm are not useful for improving the advice because the calculations are based on a whole-farm estimate.

We have developed a set of criteria for interpreting the soil test information for each of the soil types used for dairy in Tasmania. These criteria place the test result into bands of “high”, “adequate”, “marginal”, and “deficient” for P and K separately. (For K there is also a band of “Excessive”, needed to identify paddocks that may be liable to cause grass tetany).

As the test results are entered, the program identifies the appropriate band, and makes a calculation if more or less of the particular nutrient is required. Where a test falls within the “adequate” band, maintenance application alone will be required, that is only the amount lost in the nutrient cycle. Where the test result falls in the “marginal” band, 25% more will be advised. Where the result falls in the “high” band, 25% less will be required.

Using an accounting procedure the program sums these estimates for the whole farm, and then re-allocate each nutrient so that blocks that have less than adequate amounts of P or K will receive more, while those that have more than adequate will receive less. Blocks that have adequate amounts of P or K will receive the amount that has been estimated to be lost from the nutrient cycle. The calculations for P and K are independent, so that each block will receive a tailor-made pre-mix and application rate.

The procedure will request more fertiliser if it happens that more of the farm is below adequate levels of soil fertility. We have adopted this philosophy, so that the soil nutrient store of the farm can be increased over several seasons, rather than in a single “Capital dressing”. Advice about capital dressings requires other financial and pasture information beyond the scope of this program. This idea of re-allocation of fertiliser is an original contribution to the intellectual effort of the program.

Conclusions

Fertiliser Adviser Dairy has been available and widely used in Tasmania for almost ten years. It is a program that is relatively simple and quick to use. With the relevant information at hand, a user can prepare a fertiliser program for a farmer client within 5 or 10 minutes. The program is constructed so that users and clients are asked questions for which they already have answers. Most clients do not know concentrations of the nutrients in pasture, but we have found that an average value for K and a simple model for P (based on production) is sufficient. Nor do they know the amount of run-off in their district. This parameter is taken from a location on a map, together with a water holding capacity taken with the soil texture. We believe that the approach of using the nutrient cycle to estimate losses is very powerful in

providing good advice. It is essential to establishing managing nutrients for a sustainable farming enterprise.

Initially the program was used, almost exclusively, by officers in the Tasmanian department, but in recent years, the department has withdrawn from fertiliser advice, and the program has now been adopted by the fertiliser industry.

The people in the department who are responsible for the dairy industry run an annual “Dairy Business Management” award. This is largely a benchmarking exercise, and it gives us the data to compare fertiliser use on dairy farms. We are able to calculate losses from the farm with actual amounts of applied P and K. Our finding was that too many dairy farmers apply more fertiliser than they need. Not only is this practice economically wasteful, but it may have unfortunate consequences of causing pollution of run-off water to streams and groundwater.

References

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