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Economic Evaluation of Irrigated Dairy Forage Production.

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Abstract
An optimisation model was developed to compare the profitability of different forage species on irrigated dairy farms. The model is driven by the energy and protein requirements of the milking cow. The objective of the model is to maximise income, after herd and feed costs, by selecting the area of the farm sown to particular forage species. Different forage species may require different animal production systems to optimise their profitability. In order to achieve this, the model can alter the herd size and structure, level of production, concentrate feeding regime and forage conservation and feeding on a monthly basis.

Keywords: Dairy cows; Modelling; Forage.

Introduction

A feature of the different forages and forage management options is the variation in total dry matter produced and the timing of this dry matter production. Valuing the total DM production of forage is relatively straightforward however valuing the timing of that production is more involved. The contribution of the forage to the daily ration of the cow and the value of the milk produced from that ration both play a role in the determination of profitability. A model is currently being tested which attempts to capture the effect of the timing of pasture production on the profitability of the farming system. The model does this by balancing metabolisable energy (ME) and crude protein (CP) supply and demand while keeping dietary neutral detergent fibre (NDF) below a stated threshold, on a monthly basis.

The monthly ME, CP and NDF balance works in the following manner. Energy, protein and fibre can be supplied into a particular month (let's say November) as Fodder grown in November, fodder grown in October and transferred into November, Fodder conserved in a previous month and fed in November, or purchased hay, silage and concentrate fed in November. The number of milking cows and their level of production, change in liveweight, stage of gestation and environmental factors set energy and protein requirements for the herd for each month. Energy protein and fibre can also leave a month as pasture transferred to the next month or in conserved fodder, which can be fed in a later month or sold.

The model is a simulation model constructed in Excel spreadsheets and uses What's Best! ®[1] to optimise the results. What's Best! is a solver and when applied to the simulation model it uses liner and non-linear optimisation to find the combination of inputs that produces the maximum return to total capital.

The Herd

The value of milk produced varies throughout the year and this variation is region specific. In northern Victoria incentives are paid to encourage farmers to produce milk in winter. To achieve high milk production during the winter incentive period some farmers calve a portion of, or even all of the herd in autumn instead of the more traditional spring calving date, resulting in different energy and protein requirement patterns. The profitability of different fodder species will therefore depend on their relationship with the calving pattern of the dairy system. To accommodate this, the model can be allowed to select the proportion of the herd calving in each of two calving periods. The user must enter production details, litres, fat and protein production per month, for a representative cow for each calving period.

Herd size and per cow production is another variable that can be controlled by the model within the restrictions set by the user. When the production is varied the fat and protein percentages remain constant. By varying the calving pattern, herd size and production level the model is able to generate a wide range of dairying systems from low intensity, low per cow production systems to high intensity, high per cow production systems, with either split or seasonal calving herds. This provides the model the flexibility to find the most appropriate animal system for a particular fodder production system, within the limits of the infrastructure of the farm. By restricting these parameters the model can be used for case study analysis.

The herd generates income through milk production and through profits from the livestock trading schedule. Each calving period has a separate livestock-trading schedule and these are aggregated together in the case of a split calving herd.

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[1] Lindo Systems Inc., Chicago

Forages

The model has the capacity to assess up to 8 forage options at a time, five permanent pasture and three double cropping options. The production information that the model requires for each on a monthly basis is DM available for consumption, digestibility, CP % and Neutral Detergent Fibre (NDF) content. It has been documented that dairy cows are able to select a diet higher in ME and CP and lower in NDF than the pasture on offer (Jacobs et al 1999). A study by Wales et al, (1998) found that the nutrient selection differential varied between different pastures. To allow for this, the model requires the user to enter selection differentials for each grazed fodder.

The double cropping options are included in the model so that options like shaftal and maize can be incorporated. Monthly production data will be required for the crops if the model is able to graze them, alternatively the user can nominate that a portion or all of the crops is conserved as hay or silage.

The energy supply figures used in the model are for established pastures. During perennial pasture establishment the energy supplied from the pasture is reduced. In accounting for this the model assumes that any shortfall in energy supply must be compensated for by purchased supplements. The user nominates production shortfall and then the energy density and cost of the supplements used to replace this. The longevity of the pasture stands is also considered with provision made for reducing the level of production as the pasture reaches the end of its productive life. The shortfall is again compensated for with supplement.

Fodder produced in one month can be consumed by the milking herd, conserved as hay or silage, or transferred as standing feed into the next month. When standing feed is transferred into the next month the quality of that feed is reduced. The rate of this reduction can be set for each month for each fodder option.

Pasture cost

Annual costs include topping, irrigation water, fertiliser, insecticide and herbicide. These costs are assumed to be the same each year. For the double cropping options, all the costs are considered annual. Non-annual costs are mainly establishment costs.

Non-annual costs for establishment of perennial pastures include herbicide, cultivation and sowing as well as supplement costs for reduced pasture production in at the start and end of the pasture stands life. Oversowing is another non-annual cost common to perennial ryegrass pasture. In order for these non-annual costs to be incorporated into the annual cost for each pasture option the present value of the non-annual costs occurring after year 1 is calculated. This present value of future non-annual costs is added to the year 1 non-annual costs and the total is annualised over 7 years at a rate of 10%. This annualised cost is then added to the true annual costs such as irrigation and fertiliser, to give a totalled annual cost for each pasture.

Different forage options will require different quantities of water for production. The user will set the farm water allocation and the market price for water. The model is then able to buy water to satisfy the needs of the farm or sell any surplus water at the market rate. By allowing the model to do this the value of the water use efficiency of the pastures and crops is being taken into consideration.

Labour

Labour requirements and costing are sometimes points of contention. In an attempt to retain flexibility the model requires the user to enter the operator allowance and the number of cows that the operator can handle on their own. The user then nominates the number of labour units that would be required for 100 additional cows calving in spring and for 100 additional cows calving in autumn, as these requirements may be different. In general the rule of thumb of 100 cows per labour unit seems to hold true.

Supplementation.

Up to six sources of supplementary feed can be entered into the model. The user sets the level of wastage, purchase price and feeding cost for each supplement as well as a purchase limit for each of the supplements to simulate the possibility of a limited supply. What's Best! can then select the timing and quantity of feeding for each within limits on daily intake set by the user.

When a cow is grazing pasture *ad libitum* and is then offered 1 kg of dry matter of grain supplement she will consume the grain supplement and reduce her intake of pasture. This is referred to as substitution and the amount of pasture, in kilograms, that is forgone per kilogram of supplement is dependent on the quantity of supplement being fed. Substitution provides for the effect of diminishing returns to feeding supplements. The model assumes that substitution occurs according to an equation taken from Stockdale (2000). Supplementation varies between the seasons and with the maximum pasture intake of the cattle.

The model uses a series of linear segments to approximate the substitution effects of supplementary feeding. This is similar to the approach used by Hulme et al (1986). The substitution rates presented in Table 1 are for a 550kg cow with a pasture intake of 3% of live weight in summer.

Table 1: Substitution rates for a 550kg cow with a pasture intake of 3% of live weight in summer.

% of diet as supplements	0 to 10	10 to 20	20 to 30	30 to 40	40 to 50	50 to 60	60 to 70	70 to 80	80 to 90	90 to 100
Incremental sub. rate	0.44	0.54	0.64	0.74	0.84	0.93	1.03	1.13	1.23	1.33
Net Substituion Rate	0.44	0.49	0.54	0.59	0.64	0.69	0.74	0.79	0.84	0.89

The Net substitution rate is calculated for a cow receiving 40% of her diet as supplements in the following example.

Net substitution rate = (10% x 0.36)+(10% x 0.46)+(10% x 0.56) + (10% x 0.66))/0.4) = 0.51

The Model

The model uses a series of Excel spreadsheets to enter and calculate the data that is used to make up a matrix which can be optimised using What's Best. Income is generated from milk sales and the livestock trading schedule as well as selling water, hay and silage. Activities such as making hay, feeding concentrate, producing pasture or fodder crops, purchasing water and purchasing hay and silage contribute to variable costs along with variable herd costs. To optimise the model in terms of return to total capital it is reasonable to use case study data to fix farm size and capital value. That way the capital value of the farm and its infrastructure can be considered along with a realistic limit on the maximum herd size possible included.

The capital value of the herd changes with the herd size according to the livestock trading schedule.

Outputs.

The first output of the model is a graph that gives the daily ration composition on a monthly basis. This is important in checking that the model is producing feasible answers. The model is designed so that four scenarios can be compared simultaneously. The “Report” worksheet is set up so that the user can keep track of which of the variables have been altered between the scenarios, the variables that are different from the baseline become highlighted. All of the variables that the user sets appear on this worksheet. Profitability of dairy farming systems is strongly linked to milk price. For this reason the model is constructed to automatically carry out a price sensitivity analysis when a scenario is to be tested. The “Results” worksheet records the changes in important model controlled variables that occur with different milk prices. Graphs showing the area used for each fodder option, water sales and purchases, the herd size and composition in terms of calving periods, silage use, hay use, annual ration per cow, milk production and farm income are produced for the price sensitivities for each of the scenarios.

Future.

This model is currently being tested on a dairy farm in south west Victoria in preparation for use in the economic analysis of a pasture grazing management experiment. The experiment in question looks at 6 different strategies for grazing a ryegrass based pasture so the nutritional value of the pasture will be similar between the strategies and the difference occurs in the total DM produced and the timing of the DM production. Preliminary results suggest that the while DM production is the more important factor in determining the most profitable strategy, the timing of that production also plays a role.

This model has been developed as a research tool and not as a decision support tool for farm managers.

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