THE USE OF A MODEL TO ASSESS THE FINANCIAL BENEFIT OF A DRAINAGE SYSTEM FOR IRRIGATED DAIRY FARMS IN WESTERN AUSTRALIA

G.R. OLNEY* and D.A. FALCONER*

SUMMARY

A mathematical programming model was used to estimate the financial benefit to dairy farmers of implementing a drainage system to overcome salinity and waterlogging in irrigated pastures. The model predicts the management strategies required to maximise profit. Responses in pasture growth following drainage increased the optimum number of cows milked and the proportion of cows calving in January-February to take advantage of bonus prices paid for milk between February and May in Western Australia. Greater clover content of pasture resulted in higher peak milk yield of cows. The expected financial benefits to dairy farmers were similar to the expected costs of the proposed drainage system. (Keywords: mathematical model, dairying, irrigation, drainage).

INTRODUCTION

The problem of depressed pasture growth due to waterlogging and salinity in parts of the Collie Irrigation District in the south west of Western Australia could be reduced by drainage. The Western Australian Public Works Department (PWD) is investigating the feasibility of constructing a borefield network and controlling the watertable by groundwater pumping (Gugich 1984). Before evaluating the technical feasibility of the drainage system the PWD wished to know if the likely financial benefit would justify the costs involved.

A whole farm mathematical programming model has been developed which determines the management strategies which will maximise profit on a dairy farm (Olney 1985). This paper examines predictions of the model of the likely financial benefit to dairy farmers compared to the expected costs of establishing and maintaining a borefield (Olney and Falconer 1985a) and the predicted management strategies necessary to maximise profit.

BRIEF DESCRIPTION OF THE MODEL

The model is in the form of a general linear programme matrix with 440 variables and 330 constraints (Olney and Falconer 1985b). The year is divided into six periods with cows calving in any period and milking for a maximum of ten months. The potential lactation curve is specified. Metabolisable energy, protein and fibre requirements are included for maintenance, milk production and liveweight change during the year subject to a dry matter intake restraint. Feed sources include pasture, fodder crops, hay, silage and purchased feeds. Physical limits such as the area of each type of pasture, milk quotas and the maximum number of cows that could be milked are specified.

The model reflects the interdependency of activities and optimises the use of resources within the specified constraints. The calving pattern, herd size, milk production, pasture utilisation, fodder conservation and feeding strategies that will maximise profit are determined.

Validation of the whole model requires validation of each individual assumption. Parts of the model have been tested, e.g. milk yields obtained in herds under controlled feeding situations have been similar to the predicted

* Department of Agriculture, South Perth, W.A. 6151

yields while other assumptions have been reviewed by relevant specialists. Some components of the model such as the efficiency of utilisation of pasture have not yet been validated. Confidence in the whole model can be obtained if the level of production from farms is similar to the predicted yields from model runs in which the management strateqies have been constrained to those currently used on the particular farms. Work is proceeding on this aspect.

METHOD

The mean total pasture area and milk quotas for 13 farms at Waterloo in the area most severely affected by waterloqqinq and salinity were determined. The mean area of pasture, market milk quota and special products milk quota were 75 ha, 650 L/d and 150 L/d respectively. The maximum irriqable area per farm was assumed to be 25 ha.

Data on pasture growth and composition were obtained from experiments which investigated salinity and drainage at Benger (George, unpublished data). Pasture growth increased due to drainage by about 10% and this response was assumed to last for 20 years, the expected life of the drainage system. The clover (mainly Trifolium repens) content on the undrained area decreased from November to February (mean 14% during summer), whereas the clover content on the drained area was close to 50% throughout this period (mean 48% during summer). The other major species was Pennisetum clandestinum (kikuyu) which has a lower diqestibility than clover. Clover content on the drained area declined in later years and would probably be similar to the undrained area after five years. It was therefore assumed the clover content of drained pasture for the first five years would be midway between the first year response and undrained pasture (mean 32% during summer).

Model runs were carried out using data for undrained pasture and pasture which included increases of 10, 20 and 50% in pasture growth and mean summer clover contents of 14, 32 and 40%. The maximum milk yield potential in early lactation was 25 L/cow/d and the maximum level of concentrate feeding allowed was 8 kg/cow/d.

The manaqement strategies required to maximise profit for the various responses in pasture qrowth and composition following drainaqe were determined. The present value of the benefit from drainage and the present value of the estimated cost of drainaqe, over a 20 year period, usinq a discount rate of 5% were calculated.

RESULTS

Chanqe in profit, calvinq pattern and fodder conservation areas for the various responses in pasture growth and clover content are shown in Table 1.

The peak milk yields in the optimum solution for undrained pastures were 21, 25, 23 and 22 L/cow/d for the January-February, March-April, September-October and November-December calving qroups respectively. The July-Auqust calving qroup when included had a peak yield of only 18 L/cow/d. An increase in the clover content resulted in milk yield in early lactation beinq 1 to 2 L/cow/d higher for all calvinq groups excepting when already at the maximum yield potential. There were no changes in peak milk yield per cow following increases in pasture qrowth.

Lupin qrain was fed at close to the maximum level of 8 kg/cow/d for the first four months of lactation except when there was a July-August calvinq qroup which was fed 1 to 2 kg/cow/d. There were only minor deviations in the feeding levels for lupins with changes in pasture growth or composition.

Table 1 Change in profit, number of cows calving in each period and area conserved for hay and silage necessary to maxim&e profit with increases in pasture qrowth and/or clover content on a dairy farm with 75 ha pasture, market milk quota of 650 L/d and special products milk quota of 150 L/d

	Increase in pasture dry matter production (%)					
	0	10	20	50	10	10
Mean summer clover content (%)	14	14	14	14	32	40
Increase in profit						
($/yr)		1572	2666	5517	2906	3508
($/ha)		21	36	74	39	47
No. cows calving						
Jan - Feb	30	32	35	51	38	37
Mar - Apr	27	24	23	20	25	27
May - June	0	0	0	0	0	0
July - Aug	0	7	10	8	0	0
Sept - Oct	10	4	0	0	5	4
Nov - Dec	20	24	27	30	25	26
Total cows	87	91	95	109	93	94
Hay Area (ha)	5.0	4.0	4.9	8.3	5.9	5.9
Silage Area (ha)	14.2	16.1	13.4	0	10.7	9.7

The present value of the expected benefit was $348.00/ha assuming a pasture qrowth response of 10% lasting 20 years and an increase in the mean summer clover content from 14 to 32% lasting 5 years. The present value of the estimated cost of constructing and operating the drainaqe system for 20 years was $365.00/ha qivinq a net present value of - $17.00/ha, a benefit cost ratio of 0.95.

DISCUSSION

The model determined the most profitable combination of strategies to take advantage of changes in pasture qrowth and composition while including the biological technological and financial constraints of the dairy farm. Mathematical proqramminq models are suited to this type of task when it is necessary to know the likely benefit of a procedure that will probably require different management strategies in order to obtain the greatest benefit. This approach overcomes the problems referred to by Auld et al. (1979) in assessing the economic benefits in contrast to the physical changes.

There are still difficulties with mathematical proqramminq models as the accuracy of the solution is dependent on the accuracy of the assumptions in the model. These are based on the best knowledge currently available and the validation of individual components. Mathematical programming and simulation models can be complementary when the simulation model generates data to be used in the mathematical proqramminq model.

The optimum solution for all runs had a heavy concentration of cows calving in the summer months taking advantaqe of the bonus price paid for above quota milk supplied from February to May. Lupin grain was fed at close to the maximum rate of 8 kg/cow/d for the first four months of lactation to take advantage of the higher milk yield potential in early lactation.

The model indicated additional pasture growth following drainage would be most profitably used by milking more cows and calving a greater proportion in January-February. In all cases dry matter intake was limiting so additional pasture could only be utilised by feeding more cows and not by increasing the milk yield per cow. A greater clover content resulted in hiqher milk yield per cow due to the higher diqestibility of the pasture with only small increases in the number of cows milked. Increases in pasture'qrowth of 10 and 20% had only small effects on fodder conservation. When the clover content of the pasture was higher there was a slight increase in hay and a marked reduction in silage. This was probably due to the more highly digestible silage not being required when the digestibility of the pasture available in summer was improved.

The net revenue was sensitive to increases in pasture qrowth. The main change in manaqement required was to increase the number of cows milked and not change the calving pattern. The optimal solution was less sensitive to changes in clover content.

The present value of the benefit of drainage usinq the expected responses in pasture growth and clover content based on the data from Benger was slightly less than the expected cost of drainaqe. As the area beinq considered for drainage is more severely affected by waterlogging than the site from which the data were obtained it is quite possible that the benefits would exceed the costs. Further investiqation of the technical feasibility of the proposed drainage method has commenced following this study.

The dairy farm model is still being developed and revised. Coefficients for pasture utilisation, maximum intake, milk yield potential and liveweiqht change are currently being reviewed. The documentation (Olney and Falconer 1985b) is being widely circulated inviting comments from specialists on the various components of the model. This will assist in improving the model.

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