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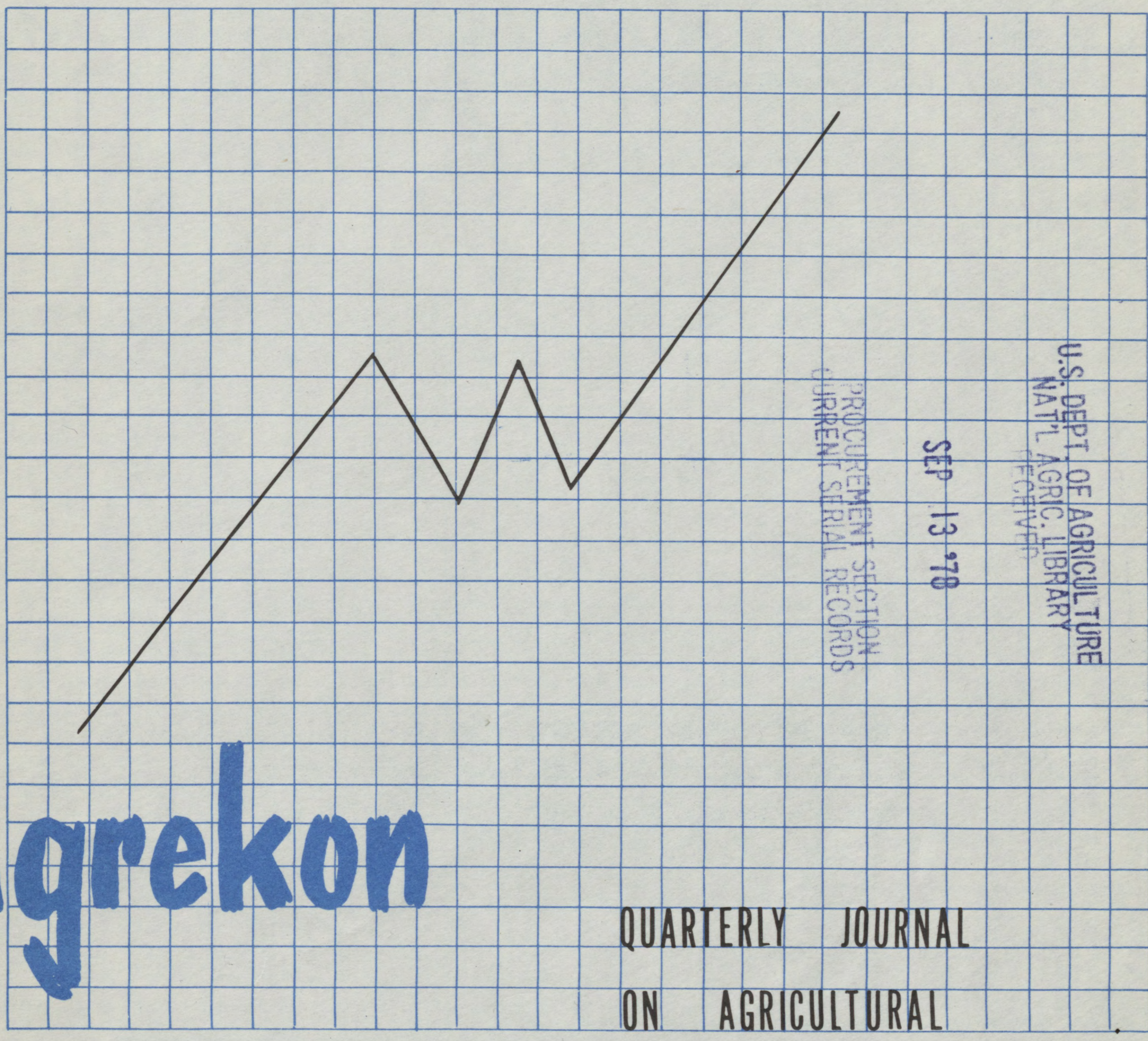

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VALUING OF DAIRY FARM FORAGES ACCORDING TO MARGINAL PRODUCTIVITY

by

P.J.R. COMRIE and H.I. BEHRMANN
University of Natal

Farm-grown feeds such as maize grain and lucerne hay can usually be assigned values based on what they would realise off the farm, less the costs of marketing from the farm. Silage, various green feeds, certain hay crops and pasture cannot be given any market value, and economic studies of dairy farming invariably encounter the problem of valuing these forages.

Dairy farmers grow a large variety of forage crops, and in the Natal Region, in one homogeneous area covered by a single economic study group, as many as 15 to 20 forage types may be grown. One farmer may grow up to 10 forages, and even if he is restricted to a small selection, he still has to choose which is the most profitable. If a value per unit could be attached to each forage crop type, the gross value per hectare could be calculated. By deducting the variable costs of production, the relative profitability or gross margin of each forage could be obtained, and superior forages could be selected.

One method has been to determine values according to the total digestible nutrients (TDN) and protein contents of forages, which are based on the values of these constituents in marketable crops such as lucerne hay and maize (Hattingh, 1968). This method is based on the assumption that a unit of TDN in one feed is a perfect substitute for a unit in another feed, which may not be the case.

A summary of values attached to more important forage crops in Hattingh's study is shown in Table 1. Silage has an average value of R4,42 and hay R14,90 per ton. Forage crops that are utilised in the unconserved form are grouped into summer pastures and winter greenfeed. The value per ton of green material of summer pastures in R5,24 and that of winter greenfeed R5,28 per ton, almost identical. A grazing month is taken as 455 kg of green material. This is in fact the expected consumption of a dry mature livestock unit in order to maintain body mass. A producing cow will consume much more.

TABLE 1 - Values of farm-produced forages based on farm management studies in the Highveld Region, 1961/65

Forage type	Value per ton	Value per grazing month
	R	
Silage		
Babala	4,49	
Millet	4,58	
Maize	4,20	
Average	**4,42**	
Hay		
Eragrostis curvula	13,04	
Lucerne	16,07	
Teff	13,20	
Average	**14,10**	
Summer pastures		
Eragrostis curvula	6,45	2,93
Lucerne	4,80	2,18
Rhodes grass	3,81	1,73
Clover	5,87	2,67
Average	**5,24**	**2,38**
Winter greenfeed		
Barley	4,14	1,88
Oats	5,68	2,58
Italian ryegrass	4,51	2,05
Wheat	6,78	3,08
Average	**5,28**	**2,40**

Another method of evaluating grazing forage crops is that developed by the British Grassland Society (1964) and known as the cow day method. A cow day represents the amount of bulk feed that the average lactating cow in the recorded herd will eat in 24 hours. The total number of cow days of any pasture per unit area simply reflects the effective or utilised output of grass per hectare. In calculating the number of cow days per field, the number of days and the number of cows (or cow equivalents) grazed each day must be recorded. Hay and silage are converted to cow day equivalents. The total number of cow days obtained in this way must be adjusted according to the level of other forages and concentrates fed during the period cows were grazing the particular field. By comparing the number of cow days per hectare of

* Based on an unpublished M.Sc. Agric. thesis by P.J.R. Comrie (1975). Peter Comrie now farms near Donnybrook in Natal.

the different grazing forages grown on his farm and the variable costs of production, the farmer can assess which forages are best under his conditions.

Perhaps the most satisfactory method of valuing or costing forages employed to date is that developed by Wallace and Burr (1963). This method values or costs forage to the dairy enterprise at the variable costs of production. The income from dairy products is treated as the income from the forage crops for comparison with cash crops. This method has been employed with considerable success in the analysis of farm records of study group members by the Department of Agricultural Economics of the University of Natal in the Natal Region. The system overcomes abnormalities such as the dairy enterprise showing a loss because of the high values of the forages, but the forage crops being highly profitable when forage crops are given arbitrary values. Forage crops that have no market cannot be profitable unless sold through the dairy enterprise.

The most desirable method of valuing forage crops is according to their net selling price, if there is a market for them. The market value of a factor under perfect competition equals the value of the marginal product (VMP). This is the value of the extra product from an extra unit of feed input. In other words, the price of a forage crop (the input) will increase to the point where it equals the value of the additional product produced by that forage crop.

Where perfect competition does not exist, as may be expected to be the case in South Africa where farmers do not have perfect knowledge and droughts are common, farmers may be expected to discount the VMP. Nevertheless, the market price of a forage crop would still be based on the discounted VMP if farmers are acting rationally. An attempt has therefore been made to estimate the VMP per R100 variable costs of production of the main forage categories in East Griqualand and the Natal Midlands, and thereby to assess the relative values of different feeds.

AREAS OF FORAGE CROPS

Table 2 shows the average areas of forage crops grown from 67 farm records in East Griqualand and 82 in the Natal Midlands, from 1964/65 to 1967/68. In both areas winter greenfeed constitutes the most important group of forages, and in East Griqualand this consisted mainly of oats and ryegrass on dryland. A few farms had irrigated ryegrass, choumoellier (marrow-stemmed kale) and root crops were still popular for on the average these crops occupied 6 of the total of 26 hectares under winter greenfeed. In the Midlands about half the area of winter greenfeed was under dryland oats and ryegrass, but irrigated ryegrass was a more important crop than in East Griqualand. Clover/grass and fescue pastures plus small areas of choumoellier constituted the balance of the winter greenfeed.

Hay, consisting mainly of teff with some lucerne and clover, and silage from maize and millet, were second in importance after winter

TABLE 2 - Areas of forages grown in East Griqualand and the Natal Midlands, 1964/65 to 1967/68 (ha)

	East Griqualand	Natal Midlands
No. of records	67	82
Hay	19	10
Silage	15	18
Greenfeed	26	20
Total winter forage	**60**	**48**
Summer pasture	8	9
Total forage	**68**	**57**

greenfeed in East Griqualand and the Midlands respectively. Summer pastures were mainly in the form of kikuyu and grass/clover mixtures.

PRODUCTION FUNCTIONS

Production functions using the various categories of forage, concentrates, other variable costs and numbers of cows were derived for East Griqualand and the Natal Midlands. The dependent variable was litres of milk produced per farm and the forage input was measured in hectares as it was considered of more practical use to compare forage types on a land use basis. Cost of producing various forages may be compared to yield of milk per hectare, before final selection of particular types. Fixed costs were not included in the regression analyses because the aim was to compare forages. The assumption was made that land preparation costs such as fuel, repairs, depreciation and labour were approximately the same for various forages, and fixed costs were indirectly incorporated in the models by measuring forages on a per-hectare basis.

Table 3 presents the linear multiple regression coefficients in respect of the two regions. The functions are of the form $Y = a + b_1 X_1 + b_2 X_2 + \dots + b_n X_n$, where Y is the expected number of litres of milk produced in the herd and the X_i are the inputs as shown in the table.

Because of limitations of the data a smaller selection of feeds was used for the East Griqualand model, but all the partial regression coefficients are highly significant as shown by the t values which are considered significant if they exceed unity. An extra expenditure of R1 on concentrates, according to the model, will produce 17,28 litres of milk when the effect of the other variables is eliminated. One extra cow, independently of the other variables, will add 790 litres to the total milk production. Similarly 1 extra hectare of hay will give an independent extra yield of 745 litres, and another hectare of summer pasture 2 115 litres.

An extra rand spent on concentrates in the Natal Midlands would have given 19 more litres of milk. One hectare each of legume hay and irrigated greenfeed would have added approximately 3 000 litres of milk, more than twice as much as a hectare of summer pasture. Non-legume hay has a negative coefficient in the table, and this finding cannot be considered significant because of the low t value.

The R^2 values show that in East Griqualand 82 per cent of the estimated output of milk could be accounted for by the variables under consideration, and 92 per cent in the model for the Natal Midlands. Very little of the variation in output from one farm to another is accounted for by other factors.

TABLE 3 - Coefficients derived from linear multiple regression for dairy farm records in East Griqualand and the Natal Midlands, 1964/65 to 1967/68

		East Griqualand	Natal Midlands
		(t values are shown in brackets)	
	Average number of cows per farm	56	89
$\bar{Y}$	Average output of milk per farm (ℓ)	171 100	262 400
a	Constant	28 878	-30 735
X_1	Concentrates (R)	17,28 (5,53)	19,02 (6,92)
X_2	Number of cows	790 (2,69)	1 165 (4,01)
X_3	Other variable costs (R)		27,80 (3,08)
X_4	Hay	745 (2,20)	
X_5	Silage	903 (2,30)	909 (1,70)
X_6	Summer utilized pasture	2 115 (4,81)	1 479 (2,49)
X_7	Non-legume hay		-767 (1,08)
X_8	Dryland greenfeed		1 251 (2,83)
X_9	Irrigated greenfeed		2 934 (4,52)
X_{10}	Winter pasture		1 049 (1,05)
X_{11}	Legume hay		3 037 (3,93)
R^2		0,819	0,917
	Degrees of freedom	62	71

VALUE OF MARGINAL PRODUCT

In linear production functions the marginal products may be derived from the partial regression coefficients themselves. The one extra rand spent on concentrates has a marginal product of 17,28 litres of milk which, at a value of 5,28c per litre is equal to 91c. This shows that farmers were feeding concentrates above a level that is profitable, for each extra rand spent on concentrates was making a loss of 9c.

In Table 4 the values of the marginal products are expressed in terms of the values of extra milk that are produced for extra expenditures of R100 on each input. The costs of cows per annum can be determined as a net cost per cow per annum after allowing for opening valuations, the costs of heifers coming into the herd, purchases and death losses, offset by sales and closing valuations. Expenditures are known for concentrates and other variable costs. All forages are charged at their variable costs per hectare. The values of the marginal products are high in relation to the unit expenditure of variable costs, and this may in part be because the variable costs of production only account for part of the total costs of growing these crops. If there is a high correlation between certain fixed costs and variable costs, part of the value of the marginal product may be attributed to the fixed costs. Nevertheless, the fixed costs are assumed to be constant for different forage crops. The relative values of the marginal products are a good index of the marginal productivities of the different feeds.

TABLE 4 - Values of marginal products (VMP's) per R100 input derived from multiple linear regression from dairy farm records in East Griqualand and the Natal Midlands, 1964/65 to 1967/68

	East Griqualand	Natal Midlands
	R	
Concentrates	91	135
Cows	285	481
Other variable costs	-	197
Hay	351	-
Silage	320	210
Total greenfeed	305	-
Summer pasture	740	286
Non-legume hay	-	-
Dryland greenfeed	-	289
Irrigated greenfeed	-	401
Winter pasture	-	207
Legume hay	-	849

Lowest values of marginal products are for concentrates, and in East Griqualand farmers have apparently been overfeeding with concentrates. Summer utilised pastures showed an exceptional return of R740 per R100 of input in East Griqualand. Although hay has a higher VMP than silage or greenfeed the difference is small and this may indicate that farmer's allocation of expenditure between forage crops is good. More should apparently have been spent on increasing the area of summer utilised pastures.

While concentrates gave the lowest VMP in the Midlands, farmers were still making a small profit on marginal expenditure at the average level of feeding. An exceptionally high return of R849 was earned on legume hay, the next highest VMP being R401 for irrigated greenfeed. The response of dairy cows to legume hay is good and irrigated greenfeed has today been recognised as an important contributor to dairy farm productivity. Dryland greenfeed and summer pasture also showed up favourably, followed by silage and winter pasture.

GROSS MARGINS

The gross margin per hectare of the different forages may be calculated from the marginal product per hectare. By multiplying the marginal product per hectare by the average price per litre, total income per hectare is obtained. The gross margins which are obtained by subtracting the variable costs of production are presented in Table 5.

Summer pasture in East Griqualand showed an excellent return of R94 per hectare, which was a great deal more than any of the other forage types and it compared favourably to the gross margin which could be expected from summer grown cash

TABLE 5 - Gross margins per hectare for different forages in East Griqualand and the Natal Midlands, 1964/65 to 1967/68

Area	Forage type	Yield (ℓ/ha)	Income (R)	Variable costs (R)	Gross margin (R)
East Griqualand	Hay	745	39	12	27
	Silage	903	48	15	33
	Greenfeed	513	27	13	14
	Summer pasture	2 115	109	15	94
Natal Midlands	Legume hay	3 040	211	27	184
	Silage	910	65	31	34
	Dryland greenfeed	1 250	89	31	58
	Irrigated greenfeed	2 930	208	52	156
	Summer pasture	1 480	105	37	68
	Winter pasture	1 050	75	36	39
	Roots, etc.	1 020	72	27	45

crops that are grown in the area. Of the winter utilised forages, silage had the highest gross margin per hectare of R33 compared to R27 for hay and R14 for greenfeed.

Farmers in the East Griqualand area would have, provided there were no capital limitations, benefited by substituting silage for the other two winter forages, particularly greenfeed. Where capital was severely limited, farmers would have been advised to increase the area of forage which showed the highest return per R100 input, *viz.* hay. Silage and greenfeed showed more or less the same return per R100 input (Table 4).

In the Natal Midlands legume hay and irrigated greenfeed showed a return of R184 and R156 per hectare respectively. No costs other than seed, fertiliser, weedicides and insecticides were included in the gross margin calculations. With irrigation costs estimated at R40 per hectare and haymaking costs using a baler also at R40 per hectare, it is obvious that higher margins on legume hay and irrigated greenfeed would have allowed such costs to be met and still return the most profit per unit area of land.

Dryland greenfeed gave a good return of R58 per hectare, which was greater than winter pastures and silage with respective gross margins of R39 and R34. Summer utilised pastures returned R68 per hectare, indicating that it is indeed profitable to plant summer pastures for dairy cows in milk, to supplement the natural veld grazing.

These returns per hectare in the Natal Midlands contrast markedly with those obtained by Hattingh (1968), who found that silage was the most profitable winter forage, followed by hay, and least profitable, dryland greenfeed, as well as with the results obtained in East Griqualand where silage was more profitable than greenfeed. It would seem that in warmer and moister Natal Midlands and with heavier applications of fertiliser, greenfeed grows more profusely than in other areas. The addition of this protein rich, succulent feed into the feeding programme for cows in milk during a protein scarcity period, does boost milk production and it is profitable.

THE UNIT VALUE OF FORAGE

The value of a forage per unit in ton or grazing months must be based on the marginal product. Using the linear production function the marginal products per hectare were calculated.

Table 5 gives the milk yields per hectare, and a hectare of hay in East Griqualand, for example, produced 745 litres. At an average yield of 6,5 ton per hectare one ton of hay produced 115 litres of milk which at 5,28c per litre was valued at R6,07.

TABLE 6 - Estimated unit values of forages in East Griqualand, the Natal Midlands, 1964/65 to 1967/68, and Transvaal Highveld, 1968

Area	Forage type	Yield (Tons or grazing months)	Value per unit of yield* Natal Region	Highveld (Hattingh 1968)
East Griqualand	Hay	6,5 t	6,07	14,10
	Silage	13,5 t	3,53	4,42
	Greenfeed	8,0 g.m.	3,59	2,40
	Summer pasture	23,0 g.m.	4,85	2,38
Natal Midlands	Silage	18,0 t	3,52	4,42
	Summer pasture	23,0 g.m.	4,54	2,38
	Dryland greenfeed	15,0 g.m.	5,89	2,40
	Irrigated greenfeed	30,0 g.m.	6,96	-
	Winter clover/grass pastures	15,0 g.m.	4,97	-
	Legume hay	9,0 t	25,00	16,07

*Milk value in c per litre:
E. Griqualand: 5,28
Natal Midlands: 7,10

Estimated values of silage at R3,53 and R3,52 per ton respectively in East Griqualand and the Natal Midlands are lower than Hattingh's estimate of R4,42 per ton. Hay in East Griqualand at R6,07 per ton has less than half the value that Hattingh derived for the Highveld. Silage and hay thus tended to be overvalued using the nutrient system of valuation.

Many farmers have not mastered the technique of making good-quality silage. The usual practice has been to use for silage the maize crop that failed as a grain crop with the result that a great deal of poor quality silage has been produced. Hay has frequently been of poor quality due to rain damage and other causes. Good-quality hay and silage, supplemented with the necessary protein, would probably have produced considerably more milk per hectare than what has been estimated.

Legume hay and irrigated greenfeed in the Natal Midlands with estimated values of R25,00 per ton and R6,96 per grazing month respectively were by far the most productive forage types. These two forages, as shown in Table 4, yielded the highest return per R100 input. Dryland greenfeed at R5,89 per grazing month has a higher value than summer pasture at R4,54 per grazing month. It must be remembered that summer pasture is an addition to veld grazing, which is utilised to varying extents but which could not be measured and therefore the flushing effect of moving cows in milk from veld grazing to summer pastures is not as great as when moved on to green grazing during the dry winter months.

Summer pasture in both East Griqualand and the Natal Midlands had estimated values that were twice as high as the Highveld figure of R2,38 per grazing month. Greenfeed similarly had higher values than Hattingh's estimate of R2,40 per grazing month. The higher values derived measure a qualitative effect that comes from the succulence of feeds, that is not accounted for when the values of feeds are determined according to values of TDN. It is common for farmers to say that there is a lot of milk in greenfeed.

REFERENCES

British Grassland Society (1964). Grassland recording. Hurley, Berks., U.K., 1-15.

Comrie, P.J.R. (1975). An economic analysis of dairy farm records in selected areas of the Natal Region. Unpublished M.Sc. (Agric) thesis, Univ. of Natal, Pietermaritzburg

Hattingh, H.S. (1968). Farm Management within certain homogeneous groups, Highveld Region, 1961-1965. Div of Agricultural Production Econ., Pretoria, Econ. Series 65, 1-50.

Wallace, D.B. and H. Burr (1963). Planning on the farm. Univ. of Cambridge. Farm Econ., Branch Rep., No. 60, 1-63.