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Production, Economic Performance and Optimum Stocking Rates of Holstein-Friesian and Jersey Cows

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ABSTRACT

Stocking rates for maximum production and economic performance of Holstein-Friesians and Jerseys were predicted by calculating response curves from the regression equations of stocking rate on cow performance. Holstein-Friesians produced higher yields, gross milk incomes and net incomes per cow while Jerseys produced higher milkfat and protein yields, gross milk incomes and net incomes per ha when both breeds were stocked at the same liveweight or for maximum production or optimum economic performance. Maximum net income based on 1990/91 costs and prices occurred at 3.0 and 3.7 cows/ha for Holstein-Friesians and Jerseys respectively. At these stocking rates net income for Jerseys was 5% higher than for Holstein-Friesians.

Keywords Milk production, economic performance, stocking rate, Holstein-Friesian, Jersey.

INTRODUCTION

Similar phenotypic levels of milkfat production per cow for Holstein-Friesians and Jerseys under New Zealand grazing conditions have been observed (Ahlborn-Breier, 1989; Ahlborn and Dempfle, 1992) despite differences in genetic levels between these breeds (Ahlborn-Breier and Hohenboken, 1991). Since differences in stocking rate, or other breed specific management, might be one of the major management effects contributing to this situation, an evaluation of the per cow and per hectare performance of both breeds under the same management conditions is required. This is particularly so because of the recent introduction of a payment system based on milkfat and protein with a penalty for volume. A four year experiment to evaluate per cow and per ha performance of Holstein-Friesians and Jerseys at two stocking rates commenced in June 1990 at the Dairying Research Corporation. This report, based on the first year's data, derives the stocking rate at which maximum production, maximum gross and net income and maximum energy output in milk per cow and per ha is achieved.

MATERIAL AND METHODS

Experimental

In a 2 x 2 factorial arrangement dairy production of Holstein-Friesian and Jersey cows was determined at the stocking rate of 3.2 and 3.98 cows/ha and 3.57 and 4.53 cows/ha, respectively. The four farmlets consisted of 18 paddocks of 0.405 ha evenly allocated according to soil type. Herds within breeds were balanced for expected calving date, age, liveweight, condition, payment breeding index and production index at the start of the experiment. The mean calving date was the first week in August and the mean payment breeding index was 136. Milk yield and composition was measured weekly at two consecutive milkings. Cows were weighed and scored for condition fortnightly. The culling rate was 20% and replacements were taken off the farmlets after birth, entering the herds on 1 June. Management decisions regarding conservation, culling and drying off were based on a series of objective decision rules aimed at optimising the performance of individual herds. Cow performance data were adjusted for calving date and age. Gross milk income was calculated using prices of \$ 2.21 /kg milkfat, \$4.00 /kg protein and -\$0.03 75 /l milk which were indicative of those paid for milk components in the 1990/91 season.

Predicted response curves

The experiment provided estimates of performance per cow at two different stocking rates for Holstein-Friesians and Jerseys. The regression of stocking rate (x) on cow performance ($\hat{p}$) was calculated for each response variable.

$\hat{p} = \alpha + \beta x \rightarrow$ performance/cow = $\alpha + \beta$ cows/ha for $x > 0$ and $\alpha \geq 0$.

The response function for performance per ha ($\tilde{P}$) was predicted by multiplying the predicted performance per cow ($\hat{p}$) by the stocking rate (x) as validated by Jones and Sandland (1974) and Sandland and Jones (1975).

$$\tilde{P} = x\hat{p} = x(\alpha + \beta x) = \alpha x + \beta x^2 \text{ for } x > 0 \text{ and } \alpha \geq 0.$$

This estimated quadratic function exhibits the typical shape of a response function with diminishing returns: performance per ha increases initially with increasing stocking rate (number of cows per ha or liveweight per ha) up to a maximum and decreases thereafter with increasing stocking rate. The slope of the performance per ha response function estimates the rate of change in performance per ha at a given stocking rate and is defined by its first derivative $d\tilde{P}/dx$

$$d\tilde{P}/dx = d/dx\,(\alpha x + \beta x^2) = \alpha + 2\beta x.$$

The maximum performance per ha is the point at which the slope, and thus the first derivative, equals zero:

$$d\tilde{P}/dx = 0 \rightarrow d/dx\,(\alpha x + \beta x^2) = 0 \rightarrow \alpha + 2\beta x = 0 \rightarrow x = -\alpha/2\beta$$

This critical point constitutes a maximum since the second derivative $d^2\tilde{P}/dx^2$ of this function is negative (the regression coefficient β is negative):

$$d^2\tilde{P}/dx^2 = d^2/dx^2\,(\alpha x + \beta x^2) = d/dx\,(\alpha + 2\beta x) = 2\beta$$

The methodology of Hildreth and Riewe (1963) was modified to include costs of production in the model. This allowed the net income response curves and the economically

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optimum stocking rate to be estimated for current prices. Costs per ha ($\tilde{C}$) were calculated as the product of variable costs per cow (v) and stocking rate (x). It was assumed that fixed costs would be the same for all stocking rates and thus could be ignored in comparative calculations. Income from meat, which accrues on a per cow basis, reduced variable costs per cow as shown in Table 1. Variable costs per cow were derived from an economic survey of 276 dairy farms (Livestock Improvement, 1991). Net income per ha ($\tilde{N}$) was defined as the difference between gross milk income per ha ($\tilde{G}$), which was the product of milk price (p) and yield per ha ($\tilde{P}$), and costs per ha ($\tilde{C}$):

Net income/ha $= \tilde{G} - \tilde{C} = p(\alpha x + \beta x^2) - vx = (p\alpha - v)x + p\beta x^2$

The slope of the net income per ha response curve is then defined as:

$d\tilde{N}/dx = d/dx\,(p\alpha - v)x + p\beta x^2 = p\alpha - v + 2p\beta x$

with the maximum net income at the point:

$d\tilde{N}/dx = 0 \rightarrow p\alpha - v + 2p\beta x = 0 \rightarrow x = -\alpha/2\beta + v/2p\beta$.

This indicates that the stocking rate for maximum gross milk income ($-\alpha/2\beta$) differs from the economically optimum stocking rate by the variable costs per cow divided by the product of twice the regression coefficient and milk price.

TABLE 1 Variable costs and income from meat per cow (1990/91 season).

Variable Costs:		
Health	$28	
Electricity	$18	
Herd improvement (Artificial breeding, herdtesting)	$21	
Shed expenses	$18	
	Friesian	Jersey
Interest (12%)	@ $800/cow = $96	@ $700/cow = $84
Total Variable Costs	$181	$169
Income from Meat:		
Cull Cow[a]	$83	$65
Bobby Calf[b]	$49	$31
Total Income from Meat	$132	$96
Income from Meat - Variable Costs	$-49	$-73

[a] 20% culling rate, 50% killing out rate, carcass: $2.00/kg Friesian, $1.95/kg Jersey.

[b] 77% calves sold, $1.50/kg liveweight (27 kg Jersey, 34 kg Friesian), 20% of Friesian calves sold for rearing @ $110.

It is emphasised that the prediction of the performance per ha response curve is based on only two data points (two stocking rates) and thus does not allow the calculation of standard errors or confidence intervals. While these theoretical calculations provide valuable insights into the expected response curves, the results should be interpreted with caution. Results presented here are based on data from one season, however, part lactation data for the second season which are not reported here confirm our observed trends.

RESULTS

Performance per cow at the low stocking rate was higher for Holstein-Friesians for all variables except energy content of milk (Table 2). These differences were reduced at the higher stocking rate. In contrast, performance per ha was higher for Jerseys for all variables except for lactose and milk yield (Table 3). Protein yield was very similar for both breeds at the low stocking rate. Performance per ha decreased at a slower rate for Jerseys as stocking rate increased. This is evident in Table 4 by the smaller regression coefficients for Jerseys than Holstein-Friesians.

Predicted stocking rates for maximum performance per ha (Table 5) were 23% to 32% higher for Jerseys than for Holstein-Friesians depending on the variable with an average of 27%. The optimum stocking rate, i.e. the stocking rate for maximum net income for these conditions was estimated as 3.0 and 3.7 cows/ha for Holstein-Friesians and Jerseys, respectively. At this stocking rate net income for Jerseys was 5% higher than for Holstein-Friesians. The difference between gross milk income and net income was slightly larger for Jerseys due to their lower income from meat.

Predicted mean cow liveweights at these optimum stocking rates were 437 kg and 339 kg for Holstein-Friesians and Jerseys. In contrast, means for liveweight per ha were very similar with 1311 kg for Holstein-Friesians and 1254 kg for Jerseys.

DISCUSSION

The predicted stocking rates for maximum production per ha are lower than previously reported (Holmes and Macmillan, 1982). This might partly be explained by a higher genetic merit of cows in this experiment compared to previous studies. Indeed, calculations show a stronger effect of increased stocking rate on per cow performance at a higher production level as experienced

TABLE 2 Performance per cow for Friesians and Jerseys at two stocking rates (1990/91 season, least square means adjusted for calving date and age).

Stocking Rate	Low			High			
Cows/ha	3.0 F	3.6 J	J-F/Fx100	4.0 F	4.5 J	J- F/Fx100	SED
Milkfat (kg)	212	201	-5	148	158	7	9.4
Protein (kg)	162	139	-14	112	105	-6	6.6
Lactose (kg)	213	155	-27	153	124	-19	8.0
Milk (kg)	4,632	3,306	-29	3,350	2,646	-21	175
Gross milk income ($)	949	829	-13	653	675	3	-
Net Income ($)	900	756	-16	604	602	-0.3	-
Energy output in milk (MJ)	15,759	13,580	-14	11,092	10,659	-4	641
Mean liveweight	436	341	-22	397	322	-19	8.6
Mean Condition Score	4.52	4.34	-4	3.83	3.89	2	.09
Energy content in milk (MJ/kg)	3.40	4.11	21	3.32	4.02	21	.051

TABLE 3 Performance per ha for Friesians and Jerseys at two stocking rates (1990/91 season, least square means adjusted for calving date and age).

Stocking Rate	Low			High		
Cows/ha	3.0	3.6	J-F/Fx100	4.0	4.5	J-F/Fx100
	F	J		F	J	
Milkfat (kg)	636	704	11	592	711	20
Protein (kg)	486	487	0	448	473	6
Lactose (kg)	639	543	-15	612	558	-9
Milk (kg)	13,896	1 1,571	-17	13,400	11,907	- 11
Gross milk income ($)	2,847	3,077	8	2,612	3,038	16
Net income ($)	2,700	2,822	5	2,416	2,710	12
Energy output in milk (MJ)	42,277	47,530	12	44,368	47,966	8
Mean liveweight	1,308	1,194	- 9	1,588	1,449	-9

TABLE 4 Intercept (a) and regression coefficient (b) for effect of stocking rate (cows/ha) on per cow performance.

	Friesian		Jersey	
	a	b	a	b
Milkfat (kg)	413	-67	359	-44
Protein (kg)	320	-52	263	-35
Lactose (kg)	402	-63	273	-33
Milk (kg)	8,665	-1,335	5,760	-688
Gross milk income ($)	1,878	-308	1,635	-212
Net income ($)	1,829	-308	1,562	-21 2
Energy output in milk (MJ)	30,421	-4,852	24,616	-3085
Liveweight (kg)	559	-41	412	-20

with cows of high genetic merit. This indicates that the genetic merit of cows needs to be considered for stocking rate recommendations. Stocking rates for maximum performance also differed slightly for each performance variable. The difference in predicted stocking rates for maximum performance per ha between breeds ranged from 23% to 32%. These results indicate that stocking rate comparisons should be considered with caution if breed is not specified.

Costs per cow are mainly covered by income from meat under current prices. Therefore any increase in production per ha constitutes additional net income. This explains the small difference between the stocking rate for maximum production and the optimum stocking rate, i.e. the stocking rate for maximum net income. While the milk price varied as much as 37% during the last six years variable costs per cow corresponded to only between 8% and 10% and income from meat to only between 13% and 15% of the gross milk income per ha (Livestock Improvement, 1991). This agrees well with results from a cost/price structure study by Wright and Pringle (1983) and indicates that the optimum stocking rate will be relatively unaffected by changes in the milk price. Since the effects of costs on the optimum stocking rate are negligible stocking rate is one of the management variables with a large influence on net income and is thus an important management tool.

The smaller regression coefficients for Jerseys compared to Holstein-Friesians obtained in both years indicate that the Jerseys were better able to maintain per cow performance as stocking rate increased. We conclude that any management input for either breed that acts to maintain cow performance as stocking rate increases will make an important contribution to achieving high performance per ha at high stocking rates.

TABLE 5 Predicted stocking rates for maximum performance/ha and performance at these maximum predicted stocking rates.

	Stocking rate for maximum performance/ha			Performance/ha at predicted stocking rate		
	F	J	J-F/ Fx100	F	J	J-F/ Fx100
Milkfat (kg)	3.1	4.1	32	641	726	13
Protein (kg)	3.1	3.8	23	489	497	2
Lactose (kg)	3.2	4.1	28	646	566	-12
Milk (kg)	3.2	4.2	31	14,036	12,065	-14
Gross milk income ($)	3.1	3.9	26	2,866	3,151	10
Net income ($)	3.0	3.7	23	2,717	2,866	5
Energy output in milk (MJ)	3.1	4.0	29	47,683	49,104	3

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