The effect of selenium supplementation on milk production in dairy cattle

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ABSTRACT

Milk responses to selenium supplementation were measured in 12 dairy herds of low selenium status as indicated by blood selenium concentrations of less than 150 nmol/l (<12 ug/l). In 4 of the herds milk responses were measured for 2 successive seasons. Milk volume responses to selenium varied from −2.6% to +10.4% (mean +4.6%) and milk fat responses from −4.0% to +10.2% (mean +3.7%). Significant ($P<0.05$) milk volume responses occurred on 2 farms in the first season and milk fat responses on 2 farms in the second season. A negative relationship ($P<0.01$) was found between milk fat response (%) to selenium (FatSe) and blood selenium concentration (nmol/l) (BSe) for herds in their first season of supplementation of:- FatSe = 9.6 − 0.059 BSe. There was no relation between these parameters in the second season of supplementation.

Keywords Selenium; dairy; cattle; milk; production; blood.

INTRODUCTION

It has been well established that low selenium intake in New Zealand can cause reduced growth rate and illthrift in young sheep and cattle, and infertility in adult sheep (Andrews *et al.*, 1968). Further the measurement of selenium concentration in blood is a useful guide to the likelihood and degree of selenium deficiency in sheep (Andrews *et al.*, 1976; Sheppard *et al.*, 1984) and in cattle (Fraser and Wright, 1986).

It is unclear to what degree selenium intake affects milk production and fertility in adult dairy cattle. Hupkens Van der Elst and Watkinson (1980) have monitored milk production in dairy herds following selenium supplementation on peatlands with somewhat variable results. In the second season of their trials using 7 herds, and measuring blood selenium concentrations throughout the milking season, a statistically significant increase in milk fat production of 7.4% was found in 1 herd, which had the lowest seasonal average blood selenium level of 6.4 μg/l (80 nmol/l).

To better define the conditions for which milk production responses to selenium in dairy cows occur, we carried out trials in 12 herds on the alluvial pumice and peat soils of the Rangitaiki Plains, where similarly low blood selenium levels are commonly found.

MATERIALS AND METHODS

Trials were conducted with 7 herds in the 1982-83 season, and with 8 herds in the 1983-84 season. Three herds were used in both seasons. Trial herds were selected on the basis of mean blood selenium levels of 5 animals being less than 150 nmol/l (12 μg/l) at initial sampling in July, and individual animals being production tested by the Livestock Improvement Association. Animals older than 2 years were randomised into control and selenium groups on the basis of breed, expected calving date, production index and age. Two-year-old animals were randomised by breed only. Herds that were continued for a second season were not rerandomised. The selenium group received 40 mg selenium subcutaneously at intervals of 2 months between August and the following April. In the second season an additional selenium treatment was given in September and treatments continued at 2 monthly intervals, thereafter.

Ten animals from the control group and 5 animals from the selenium group were randomly selected for blood sampling. Blood samples were taken into evacuated blood sampling tubes (Becton Dickinson EDTA) prior to each selenium treatment. The selenium concentration of the samples was determined by the method of Watkinson (1979).

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The calving date, total milk volume for the season, total milk fat, and time in lactation for each animal was obtained from Livestock Improvement Association records. The difference in milk and fat production for the 2 treatments was determined by analysis of variance of the ratio of milk production to days in lactation in the first season, and by regression analysis using prelactation calving date, length of lactation, breed and age group as covariates in the second season.

RESULTS

Blood Selenium Measurements

The results of blood selenium analysis for the first season (1982-83) are given in Table 1 and for the second season (1983-84) in Table 2.

Blood selenium values for the control groups showed some evidence of a time of year variation in the first season with values generally being lowest for the October to February period. This was less evident in the second season. The marked increases in control group blood selenium levels for farm B in December and farm C in October are due to these farmers having applied selenium prills. (The owner of farm B applied selenium prills to one fifth of his farm in November 1982 and the owner of farm C applied selenium prills to the whole of his farm in August 1982.) The blood selenium concentrations in the treated groups were maintained at significantly higher levels than the control groups throughout the trial periods.

Milk Production

The data for milk volume and milk fat response to selenium treatment for the first season are given in Table 3 and for the second season in Table 4.

TABLE 1 Herd mean blood selenium concentrations (nmol/l) for 1982-83 season. Selenium treatment mean in parenthesis below control mean.

	Sampling Date					
Farm	August	October	December	Feburary	April	Mean
A	61	48	68	61	—	60
	(73)	(154)	(250)	(241)	—	
B	71	51	263	203	219	161
	(61)	(187)	(425)	(372)	(484)	
C	129	570	589	396	343	405
	(101)	(823)	(987)	(597)	(639)	
D	122	92	100	106	143	118
	(118)	—	(258)	(234)	(342)	
E	49	52	58	67	119	69
	(56)	(142)	(192)	(220)	(424)	
F	71	39	67	68	103	70
	(78)	(132)	(334)	(339)	(544)	
G	72	71	48	61	106	72
	(68)	(134)	(228)	(230)	(438)	

TABLE 2 Herd mean blood selenium concentrations (nmol/l) for 1983-84 season. Selenium treatment mean in parenthesis below control mean.

	Sampling Date							
Farm	July	September	November	January	March	May	July	Mean
E	83	48	77	103	106	85	90	84
	(269)	(314)	(162)	(294)	(286)	(312)	(472)	
F	106	72	99	109	107	101	85	97
	(374)	(380)	(328)	(416)	(338)	(444)	(248)	
G	202	140	116	112	124	100	121	119
	(552)	(412)	(344)	(360)	(338)	(316)	(428)	
H	164	123	128	125	130	112	—	130
	(385)	(356)	(386)	(446)	(434)	(436)	—	
I	106	72	127	165	126	121	150	124
	(102)	(268)	(314)	(396)	(452)	(340)	(450)	
J	94	72	—	95	93	102	99	93
	(89)	(286)		(292)	(313)	(360)	(478)	
K	116	81	120	133	118	119	101	112
	(122)	(328)	(330)	(330)	(375)	(428)	(470)	
L	154	112	141	138	144	174	174	148
	(154)	(276)	(344)	(380)	(307)	(426)	(542)	

TABLE 3 Milk volume and milk fat response to selenium supplementation in 1982-83.

Farm	No of cows	Control milk volume (*l*/d)	Milk increase to Se (%)	Control fat (kg)	Fat increase to Se (%)
A	130	11.6	−2.6	139	−4
B	212	17.2	+7.0*	170	+5†
C	130	12.3	+4.1	163	+3
D	229	14.7	+2.3	185	+1
E	130	17.1	+2.9	158	+4
F	250	13.9	+5.7*	136	+7†
G	138	17.2	+7.5	157	+7

TABLE 4 Milk volume and milk fat response to selenium supplementation in 1983-84.

Farm	No of cows	Control milk volume (*l*)	Milk increase to Se (%)	Control fat (kg)	Fat increase to Se (%)
E	112	3997	+ 8.2†	164	+10.2**
F	213	3736	+ 3.8	176	+ 1.8
G	87	4212	+10.4**	188	+ 8.7**
H	59	2182	+ 3.7	116	− 0.9
I	136	3192	+ 4.0	137	+ 2.7
J	127	3871	+ 4.6	175	+ 4.0†
K	217	3431	+ 3.8	148	+ 4.2
L	166	4395	+ 3.2	198	+ 1.4

Significant milk volume responses ($P<0.05$) were obtained on 2 farms in the first season and 1 farm in the second season. Significant milk fat responses were obtained on 2 farms in the second season. Overall the farms there was a significant effect of selenium on milk volume production ($P<0.01$) and on milk fat production ($P<0.01$). The average increases in milk volume and milk fat due to selenium treatment were 4.6% and 3.7% respectively.

Relationship between Milk Production Response and Blood Selenium Level

There was no significant relationship betweeen milk volume response and blood selenium level.

The relationship between milk fat response to selenium and the seasonal average blood selenium concentration are given in Fig 1. Farms B and C which inadvertently applied selenium prills during the trials have been excluded. Linear regression analysis of milk fat response to selenium (FatSe) as the dependent variable and blood selenium concentration (BSe) as the independent variable did not show a significant relationship. However, if farm A which showed both a −4% response ($P<0.01$) and a large difference in mean calving dates for the control and selenium groups was rejected as an outlier, then a relationship of:-

$$\text{FatSe} = 10.4 - 0.059\text{BSe} \quad (P<0.1)$$

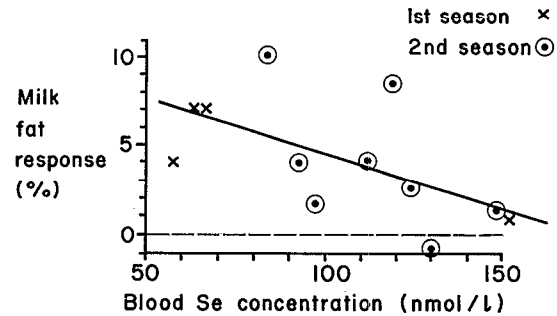

FIG. 1 Relationship between milk fat response to selenium supplementation and blood selenium concentration in 1982-83 (first season) and 1983-84 (second season). Farms A, B and C excluded.

was obtained. If the data was restricted to include only results for a farm during its first season of selenium treatment, then a significant relationship of:-

$$\text{FatSe} = 9.6 - 0.059\text{BSe} \quad (P<0.01)$$

was obtained.

DISCUSSION

Ryan *et al.* (1984) in a study of 100 dairy herds on the Rangitaiki Plains found an association between herd selenium status as determined by blood selenium levels and milk fat production. Herds with blood selenium levels less than 125 nmol/*l* produced on average 5% less milk fat/ha than herds with blood selenium levels greater than 125 nmol/*l*. The results of the trials reported here confirm that milk production responses to selenium supplementation of this order do occur in herds in this district with blood selenium levels in the range of 50-150 nmol/*l*. There is also good evidence that the amount of response increases with decreasing blood selenium level. The high degree of variability about the regression line (Fig. 1) is partly due to trial error in measuring the amount of milk fat response to selenium supplementation (approximately 3%).

It is a possibility that the selenium responses obtained in the first season following supplementation were less than optimal as the blood selenium levels of the treatment groups were not maintained within the intended limits during early lactation (>250 nmol/*l*). Blood selenium levels during early lactation are possibly more important in influencing milk production response to selenium supplementation than later in the season. The significant response in milk yield obtained on Farm B which applied selenium prills in November is consistent with this hypothesis. This may also explain the large responses obtained for Farms E and G in their second season of selenium treatment.

A similar series of trials was carried out by Hupkens Van der Elst and Watkinson (1986) during 1975-76 in 7 herds on Waikato peatlands. They

found a significant milk fat response in 1 herd of 7.4% for an average blood selenium level over the season of 86 nmol/*l*, which is consistent with our findings. For their other 6 herds where average blood selenium levels for the season ranged from 110 to 200 nmol/*l* the amount of milk fat response to selenium supplementation averaged −2.1%.

Based on these and our own findings we suggest a tentative critical value for blood selenium concentration in dairy cattle below which a milk fat response to selenium supplementation may occur to be about 150 nmol/*l*.

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REFERENCES

Andrews E.D.; Hartley W.J.; Grant A.B. 1968. Selenium responsive diseases of animals in New Zealand. *New Zealand veterinary journal* **16**: 3-17.

Andrews E.D.; Hogan K.G.; Sheppard A.D. 1976. Selenium in soils, pastures and animal tissues in relation to the growth of young sheep on a marginally selenium deficient area. *New Zealand veterinary journal* **24**: 111-116.

Fraser A.J.; Wright D.F. 1986. The relationship between blood selenium levels and calf growth responses to selenium supplementation. In *Proceedings of the Conference of the New Zealand Trace Element Group*. Massey University. p. 89-95.

Hupkens Van der Elst, F.C.C.; Watkinson J.H. 1980. Selenium deficiency in stock grazing on peat soils. In *Soil groups of New Zealand: Part 4 Organic soils.* New Zealand Society of Soil Science. p. 85-89.

Ryan T.J.; Sproule R.A.; Fraser A.J.; Anderson D.C.; Clark R.B.; Pederson E.D. 1984. The association between selenium status and milk production in dairy cattle. *Proceedings of the New Zealand Society of Animal Production* **44**: 153.

Sheppard A.D.; Blom, Lucy; Grant A.B. 1984. Levels of selenium in blood and tissues associated with some selenium deficiency diseases in New Zealand sheep. *New Zealand veterinary journal* **32**: 91-95.

Watkinson J.H. 1979. Semi-automated fluorimetric determination of nanogram quantities of selenium in biological material. *Analytica chimica acta* **105**: 319-325.