Technical Note 4

SOLID | Sustainable Organic and Low Input Dairying

Minerals and trace element management for dairy cows

Introduction

Minerals, including macro and trace elements are essential for the health of the dairy cow, notably affecting immunity and growth, production and reproduction while influencing the nutritional quality of the milk supplied to the consumer.

The challenge is to ensure that the cow is able to access and assimilate optimum mineral levels and is neither under-supplied nor over-supplied.

Organic and low-input management, which requires a high forage diet mainly sourced from the farm, is based on the principle that a natural diet of whole and minimally processed feeds will supply the necessary minerals to meet the needs of the cow. Generally milk yields are slightly lower than conventional. Various forms of mineral supplementation are permitted where there is a demonstrable deficiency, which may well happen, for example due to the characteristics of the local soil type and the effect of antagonists on uptake.

Data from individual herds in the UK show that some organic and conventional herds are being under-supplied with minerals and others are being over-supplied. Further, as normally organic milk contains less iodine than conventional milk, it triggers discussions about the factors that can most affect the concentrations of iodine in milk.

This technical leaflet reports on the actual mineral levels of organic milk, reviews the SOLID research on iodine in milk and summarises the management and supplementation options available to organic and low input dairy farmers.

Mineral needs

Maintaining adequate levels of minerals in the cow is clearly critically important; however it is also important to avoid over-supply. Not only is excessive supply expensive but there are real risks of poisoning, notably of copper, selenium and iodine; there are risks of excessive levels in the milk affecting human health and high excretion affecting other livestock, such as copper affecting sheep and environmental pollution, such as phosphorus. Vitamins are often interrelated with trace mineral functioning, e.g. vitamin E with selenium, both of which are critically important for the immune system and mastitis. The principal minerals that are needed for optimum health and production of the cow are summarised in Table 1 along with the main role for each mineral.

Table 1. Principal minerals for cow health and productivity

Mineral	Key roles	Normally tested in:	Dietary recommendations[1]
Macro minerals			(g/kg/DM)
Sodium (Na)	Rumen function		1.2
Potassium (K)	Production, reproduction and immune system	Soil. Forage/feed	4.6
Calcium (Ca)	Skeletal growth. Fertility	Soil. Forage/feed	4.3
Magnesium (Mg)	Grass staggers	Soil. Forage/feed	2.0
Phosphorus (P)	Skeletal growth. fertility	Soil. Forage/feed	4.6
Micro minerals			(mg/kg DM)
Copper (Cu)	Immunity. Mastitis. Growth. Reproduction. Hormones. Feet. Scours and pale hair. Excess causes poisoning.	Soil. Forage/feed, Blood. Biopsy. Milk	10
Cobalt (Co)	Growth. Feed efficiency	Soil. Blood	-
Zinc (Zn)	Mastitis,Immunity. Growth. Production. Reproduction. Hormones. Feet	Milk. Forage/feed	50
Iron (Fe)	Immunity. Hormones. Excess reduces copper availability	Water. Soil	-
Manganese (Mn)	Immunity. Growth. Reproduction	Milk. Forage/feed. Soil	20-25
Selenium (Se)	Immunity. Mastitis. Feet. Reproduction. Toxicity risk	Soil. Blood. Biopsy. Milk. Forage/feed	-
Iodine (I)	Thyroid hormones. Calf vigour	Milk. Urine, Forage/feed	-
Sulphur (S)	Growth. Excess reduces copper availability	Forage/feed	-
Molybdenum (Mo)	Excess reduces copper availability	Soil, Milk	-

[1] AFRC/ARC Values represent the contribution from the diet, water and supplementary sources and are expressed on a g or mg/kg dry matter intake basis.

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Monitoring your minerals

Monitoring is essential to ensuring that optimum minerals are available. Table 1 identifies the role, the appropriate means of monitoring, which varies according to the mineral and the recommended levels in the diet.

The need for monitoring will depend on whether there are indications of a farm deficiency, e.g. poor animal performance, known deficiencies in the region or indications from the farm's milk buyer. Monitoring is essential before any supplementation, normally starting with soil and forage analysis. Subsequently and dependent on those results it may be necessary to monitor drinking water, blood, animal tissue (liver biopsy or of dead animals) and/or urine.

The difficulty of monitoring is complicated by the need to recognise that some minerals act as antagonists, restricting the cows' ability to absorb other minerals; the effect of high soil molybdenum on the availability of copper to the animal is well known, but iron (from water or soil contamination) and sulphur also affect copper absorption. Levels are also influenced by a number of factors such as stage of lactation and age.

Excessive supply of minerals has been reported in the past in conventional herds and recently shown to be a current problem (see box). The results demonstrate that while there is a considerable range in macro and trace minerals supplied, most farms were feeding in excess of recommended dietary concentrations. Even organic herds, with their higher requirements for inspection and regulation, are being over-supplied with minerals in early lactation and the dry period, while other individual herds are being under-supplied and are at deficient levels.

Mineral and trace element requirements of dairy cows *(Sinclair & Atkins 2011)*

A survey of mineral concentrations in the diet of 50 diary farms in England, including 10 organic farms found:

- There was a considerable range in the dietary concentration of macro-minerals, with on average a 67% excess of Ca and 28% excess of P, with one farm feeding 192% excess Ca and 66% excess P. In contrast, some farms were supplying only 82% of Ca and 80% of P requirements.
- There was a considerable range in micro-mineral dietary concentration, with many farms supplying substantially above but some below requirements.
- When accounting for all sources of Cu, 4 farms were supplying above 40 mg/kg DM with a further 10 above 30 mg/kg DM. These levels if fed long term are likely to lead to Cu toxicity. A total of 31 out of 50 were feeding above the recommended Cu allowance of 20 mg/kg DM.
- Based on the dietary Mo concentrations, for the vast majority of farms there was no justification for high dietary Cu concentrations to be fed.

Although the number of organic herds was small, they tended to feed above average levels of Ca and K, similar amounts of Mg and P and lower amounts of Cu and Zn than conventional herds.

Iodine concentrations in forage and milk in organic farms

Although concentrations of iodine in organic milk are well within the optimal levels (i.e. 60 to 300 µg/L), it normally contains less iodine than conventional milk. Research undertaken in the SOLID project investigated the relationship between iodine concentrations in bulk milk samples and in forage. The data show that iodine in urine does reflect cow dietary iodine and that there is wide variation in milk iodine levels between farms. Milk iodine concentrations were 2.3 times higher in the farms that use iodised post-dip teat disinfectants (mean 195 ± 13 µg/L) compared with the farms that don't (mean 85 ± 8.9). This indicates that the use of iodised post-dip teat disinfectant is the most important influencing factor for the iodine concentration in milk. Assessing iodine levels in milk is not an accurate means of identifying shortfalls in dietary iodine intake. Where doubts about the dietary iodine supply to animals exist, urine samples can be used to monitor the cow's iodine status. While average iodine levels in organic milk in the UK and elsewhere are demonstrably within the optimum range for human health, the results do point to the importance of each herd monitoring urine and milk iodine and ensuring that there is neither under nor over supply to the cow, nor excess levels in the milk. Where urine iodine levels are deficient then supplementation through feed, bolus, paint or water is effective.

Soil and water

The role of soil in the supply of minerals is crucial. Certain soil types are well known for causing micro mineral deficiency in livestock; this may be due to inherently low levels of one or more minerals. Soil management is the first step in ensuring mineral supply to the plant and animal. Ensuring good soil structure is likely to enhance rooting and availability of minerals, and maintaining pH between 6 and 7 is essential in order to optimise the availability of most minerals. The use of rock minerals to supply macro elements including phosphate, potassium and magnesium is standard practice, but there is also opportunity to rectify some trace minerals, notably cobalt, by soil application. The application of other trace minerals such as selenium is not common practice in the UK because of potential toxicity risks.

Farms using their own water supply should test for any antagonists to mineral absorption by the cow, such as high iron.

Forage

Organic and low-input farms will, by their nature, include a high proportion of legumes in their sown forage crops. The levels of most trace minerals including cobalt, copper, iron, and zinc are higher in legumes than grasses, but similar for manganese and molybdenum. Red clover is reported to be high; however the presence of cyanogenic glycosides in some white clover varieties may reduce selenium absorption in the rumen. White clover is higher than grass except for sodium, potassium, phosphorus, iron, cobalt and molybdenum. Inclusion of herbs such as chicory and plantain in the forage mix can potentially increase mineral intake (Van Eekeren *et al.*, 2006). In general there is a

Table 2. Mineral composition (per kg DM) of different species

		n	Na	K	Mg	Ca	P	Mn	Zn	Fe	Cu	Co	Se	S	Mo
			g	g	g	g	g	mg	mg	mg	mg	µg	µg	g	mg
	grass	24	1.6	35	2.3	6	4.9	58	40	251	8.9	105	97	3.7	4.0
Trifolium repens	white clover	22	1.4	32	3.4	13	3.7	45	39	156	10.2	97	98	2.5	3.4
Cichorum intibus	chicory	28	3.0	48	3.1	14	5.2	50	97	173	17.0	119	182	4.4	2.4
Plantago lanceolatus	plantain	22	1.3	39	2.8	15	4.7	39	61	137	11.4	110	120	4.0	1.8
Achillea millefolium	yarrow	20	0.5	51	2.8	11	5.5	57	45	289	15.2	146	106	2.5	2.4
Taraxacum officinalis	dandelion	8	1.3	53	2.9	11	5.1	34	53	596	12.8	239	248	4.5	2.7
Daucus carota	wild carrot	2	0.6	46	2.8	13	5.6	103	77	189	9.7	73	67	3.4	3.8

Data from report of the European Advisers Training meeting, May 2014 Belgium, pooling data from Van Eekeren et al., 2006 and http://www.wimgovaertsenco.be/

decline in mineral concentration with the age of the sward and some species (e.g. timothy, whole crop silage and kale) have lower levels of mineral concentration. Chicory stands out as having higher levels of most trace minerals except iron and molybdenum, both antagonists.

Supplementation

The need for further supplementation will depend entirely on the individual farm; some long established herds on fertile soils with cattle bred to suit the conditions are known to be getting sufficient minerals without additional supplementation. Organic farms aim for self-sufficiency in feed, consequently any specific farm deficiencies may be accentuated compared to a farm buying in feed which is likely to originate from a farm with a different soil type and different mineral profile in the feed. Analysis and monitoring is essential and if supplementation is required organic farmers may need to get permission from their control body to do so. The majority of minerals can be supplemented in various ways: in-feed, in-water, free access, bolus, body paint, soil application and injection.

In-feed supplementation

Supplementation in concentrates is routine in conventional farming while in organic farming in the UK it has depended on the compounder. In the past most have not included minerals, but in 2014 there was a change towards all compounders including minerals unless the individual farmer requested that they are excluded. The lack of certainty about the inclusion of minerals in concentrate feeds in the past may be one reason why there has have been both over and under supply of minerals to cows. While this is a reliable means of getting known quantities of a general purpose mineral into the cow the problem is that there is limited scope to tailor the minerals to the particular needs of the farm and the quantity supplied will depend on the quantity of concentrates fed; early lactation cows will be over supplied compared with later lactation cows. It should not form the only means of supplementation. Bespoke minerals meeting the herds individual needs are much more satisfactory, particularly where they are fed in a Total Mixed Ration system as this ensure that each cow gets the correct amount.

Chicory

In-water supplementation

Drinking water can act as a useful carrier for minerals, allowing reasonably accurate allocation to all cows but again there is a risk that high yielding cows will get more than they need. Systems are relatively cheap to operate and include water trough floating dispensers and pumps feeding the main farm water supply.

Table 3: Options for supplementation

		Supplementation options						
Mineral		In-feed	In-water	Free access	Bolus	Body paint	Soil apply	Inject
Macro								
Sodium (Na)		✓		✓			✓	
Potassium (K)		✓		✓			✓	
Calcium (Ca)		✓		✓			✓	
Magnesium (Mg)		✓	✓	✓			✓	
Phosphorus (P)		✓		✓			✓	
Micro minerals								
Copper (Cu)	Toxicity risk	✓	✓	✓	✓		X	✓
Cobalt (Co)		✓	✓	✓	✓		✓	
Zinc (Zn)		✓	✓	✓	✓			
Iron (Fe)		✓		✓			?	
Manganese (Mn)		✓	✓	✓	✓		✓	
Selenium (Se)	Toxicity risk	✓	✓	✓	✓			
Iodine (I)	Toxicity risk	✓	✓	✓	✓	✓	X	
Sulphur (S)		✓						
Molybdenum (Mo)		✓						

Free access

Free access mineral blocks or powder usually control intake by incorporating salt. While they may be tailored to a farm's needs and they are convenient, particularly for young stock, they are imprecise; intake is related to the cow's appetite for salt, not the need for the mineral.

Free access natural rock salt ensures that sufficient sodium is provided, and to a lesser extent potassium, calcium and magnesium, as well as other benefits, including reduction of bloat and encouraging saliva production enhancing digestion. It is a useful supplement which may, however affect the intake of free access general-purpose minerals.

Free access or in-feed seaweed meal offers potential for mineral supplementation and is quite widely used by organic farmers. However the quantities of minerals provided are relatively small.

Mineral bolus

Rumen boluses tailored to meet the farm's needs are a reasonably reliable method of getting the correct trace mineral into the cow. Again it is difficult to ensure the correct level of supply and they are relatively expensive.

Injection

Injection of trace minerals may be necessary in an emergency or if there is a major problem with antagonists, such as the effect of molybdenum on copper availability. The disadvantage is that the rumen is bypassed thereby denying the rumen bacteria potentially important trace minerals.

Form of supplementation

There is some evidence that the form in which minerals are supplied may affect the availability and utilisation by the cow. Selenium supplied as selenate was found to be more effective than selenite and selenium yeast product was more effective than either. There may be benefits from feeding organically bound minerals, such as that found following soil application and plant uptake.

Conclusions

It needs to be recognised that a whole farm systems approach is needed, one that recognises the characteristics of the farm – soil, water, breed of cow etc., ensures that soil, feed and forage is regularly monitored and that any deficiency is remedied, selecting the most appropriate form of mineral supplementation.

Farms should not necessarily be trying to replace all the minerals that go off the farm; many soils are capable of long-term supply, though in some cases our aim should be to improve the availability and utilisation of soil minerals.

Ongoing and regular monitoring is essential to ensure that adequate but not excessive minerals are being accessed by the cow.

It is strongly recommended that there is one specific person on the farm responsible for managing animal minerals and trace elements.

References

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THE ORGANIC RESEARCH CENTRE ELM FARM

Sustainable Organic and Low-Input Dairying

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