

High Rates of Selenium Supplementation for Sheep to Determine Selenium Retention via Forage Fertilization

**Final Report to the Oregon Sheep Commission
June 20, 2008**

Gene Pirelli, Professor, Department of Animal Sciences, Polk County Extension, P. O. Box 640, Dallas, OR 97338. 503-623-8395.

Tom Nichols, Sheep Center Manager, OSU Department of Animal Sciences, Corvallis, OR, 97331. 541-737-2903.

Jean Hall, Department of Biomedical Sciences, College of Veterinary Medicine, Oregon State University, Corvallis, OR 97331.

Introduction

Many parts of the world are known to have soils deficient in the essential micronutrient selenium (Se), potentially leading to clinical signs of Se deficiency in livestock grazing or fed crops raised on them. Severe Se deficiency results in nutritional myopathy or "white muscle disease", whereas subclinical Se deficiency causes muscular weakness of the newborn, immunosuppression, unthriftiness, reduced weight gain, scours, infertility, abortion, and retained placenta.

Several means of administering Se to deficient ruminants have been developed with nearly a half-century of experience with Se supplementation. For example, there are several injectable preparations available, which often include vitamin E. Selenium can be added to feed, mineral, and protein supplements. Sustained-release boluses with a life of several months may be used. Because of their weight, these boluses stay in the rumen whereby they gradually release Se.

Selenium supplemented by these methods is usually inorganic sodium selenite or selenate. One limitation of supplementing with inorganic Se in salt or feed is the apparent short duration of Se storage in the animal. If Se is removed from the diet, blood Se concentrations may become deficient if they were initially in the lower part of the normal reference interval. Seasonal grazing practices may result in limited access to Se-containing salt-mineral mixes for extended periods of time, and therefore sheep may be Se deficient by the end of the grazing season.

Agronomic biofortification is defined as increasing the bioavailable concentrations of essential elements in edible portions of crop plants through the use of

fertilizers. The potential for using Se-containing fertilizers to increase crop Se concentrations and, thus, dietary Se intakes has been demonstrated in Finland, New Zealand, and Australia where it has proven to be both effective and safe.

A pilot study conducted at the Oregon State University sheep center from 2005-2006 for the Oregon Department of Agriculture (Pirelli, unpublished data) showed that high levels of Se applied to pasture (9.1 kg of Selcote Ultra® containing 225 g Se per hectare) resulted in Se concentrations (dry matter basis) of approximately 7 ppm in green forage and approximately 3 ppm in hay made from the pasture. This hay was fed to a small group of pregnant ewes for 100 days, at which time lambs were delivered by caesarian section. Blood tests showed Se concentrations of ewes (median 262; range 161 to 330 ng/mL) and lambs (median 282; range 212-311 ng/mL) were all within the normal reference interval (150-500 ng/mL). No toxic effects were observed clinically.

The purpose of this study was to evaluate Se status in sheep across time after short term exposure to high-Se-fertilized forage compared to a mineral supplement containing inorganic sodium selenite.

Materials and Methods

Three pounds of Selcote (Selcote Ultra®; 10 g Se/kg as sodium selenate) was applied to 15 acres of pasture on February 1, 2007. The selcote was mixed with nitrogen fertilizer in the form of urea. A rate of 60 pounds per acre of nitrogen was used as the application rate.

Pasture forage samples were obtained using a grid pattern with one sample generated from 25 subsamples. The pasture forage was sampled at three times (on days 1, 10, and 40 relative to the grazing period) to obtain samples for Se analysis. Forage samples were submitted to the University of California, Davis, (Davis, CA) for forage Se analysis.

On March 27, thirty ewes were sorted randomly into two groups. Ear tags and paint brands were used to identify the ewes. Blood samples were taken from all sheep. One group of 15 ewes was moved to the selenium fertilized pasture on March 30. This group had no mineral supplementation. The second group was also moved to pasture (non-fertilized) with a 200 ppm selenium sheep mineral mix. The average intake of mineral supplement was 7.1 g per day per ewe. The supplement also contained 95.0 g/kg calcium, 60.0 g/kg phosphorus, 375.0 g/kg salt (NaCl), 27.0 g/kg magnesium, 60 ppm cobalt, 1,700 ppm manganese, 210 ppm iodine, 1,350 ppm iron, 7,700 ppm zinc, 564,400 I.U./kg vitamin A, 70,550 I.U./kg vitamin D, and 123.5 I.U./kg vitamin E.

The two groups of ewes grazed for approximately 40 days on the pastures. Post-treatment blood tests were taken on May 9. The two groups of ewes were

combined and treated as a single grazing group with no mineral supplementation.

Sheep were then bled every 3-4 weeks for approximately 9 months to collect whole blood for Se analysis. Blood was collected into EDTA tubes and shipped on ice to a commercial laboratory (Center for Nutrition, Diagnostic Center for Population and Animal Health, Michigan State University, E. Lansing, Michigan).

Results and Discussion

Each pasture sample was a composite of 25 subsamples. Forage Se concentration (on a dry matter basis), on samples collected the day the sheep began grazing the pasture (58 days following fertilization), was 1.46 ppm, and on day 40, the day the sheep were removed from the pasture, it was 2.02 ppm. On grazing day 10, pasture Se content was 0.712 ppm. Variation in the measured pasture Se content could be attributed to laboratory error, sampling technique, or errors in dry matter determination.

In this study, whole blood Se concentration was influenced by treatment (sheep grazing Se-fertilized forage 319 ng/ml vs sheep consuming mineral supplement 172 ng/ml, $P < 0.0001$), collection date ($P < 0.0001$) and their interaction ($P < 0.0001$).

Sheep grazing Se-fertilized forage received 52.4 μg organic Se/kg BW/day. Sheep consuming the mineral supplement received 19.5 μg inorganic Se/kg BW/day. Whole-blood Se concentrations were higher ($P < 0.0001$) immediately post treatment in sheep grazing Se-fertilized forage (573 ± 20 ng/mL) compared with sheep consuming the mineral supplement containing Se (286 ± 20 ng/mL), and remained higher for approximately 9 months (97 ± 7 vs. 61 ± 7 ng/mL, respectively). (**See figure one**).

Whole blood Se concentrations were within the normal reference interval for a longer ($P < 0.0001$) period of time in sheep grazing Se-fertilized forage (243 ± 44 d) compared with sheep that received the mineral supplement containing Se (163 ± 55 d).

The maximum tolerable level for dietary Se in nonruminant (such as swine) diets is considered 2 ppm. In accounting for lower Se bioavailability in ruminants (sheep, etc) compared to nonruminants, the maximum tolerable level is defined as 5 ppm (NRC, 2005). However, some studies indicate that higher dietary Se concentrations can be fed without toxic effects.

Based on the amount of Se safely consumed in these toxicology studies, there appears to be a wide margin of safety between the concentrations of Se applied as fertilizers and subsequently consumed by ruminants in fertilized forage in our

study, and the maximum tolerable Se intake for ruminants. In our study, sheep feet were monitored during periodic hoof trimming sessions. There were no obvious clinical signs of selenium toxicity, such as lameness or cracked hooves, indicating that the Se-fertilized forage was non toxic for short- term exposure. Additionally, ewes were evaluated during blood sampling for other signs of selenium toxicity and no symptoms were observed.

Conclusion

Short-term exposure of sheep to Se-fertilized forage results in increased whole blood Se concentrations sufficient to maintain adequate concentrations throughout grazing periods when there is limited access to Se supplements. Targeted grazing of Se-fertilized forage provides another tool for sheep producers to maintain and improve the health and productivity of their flocks, particularly when seasonal grazing practices result in limited access to Se-containing salt-mineral mixes for extended periods of time.

Acknowledgements

John P. Maas, University of California, Davis, CA for forage Se analyses.

Sheep Center student workers

Wayne Mosher, Jim Oldfield and Phil Whanger, OSU Emeritus faculty

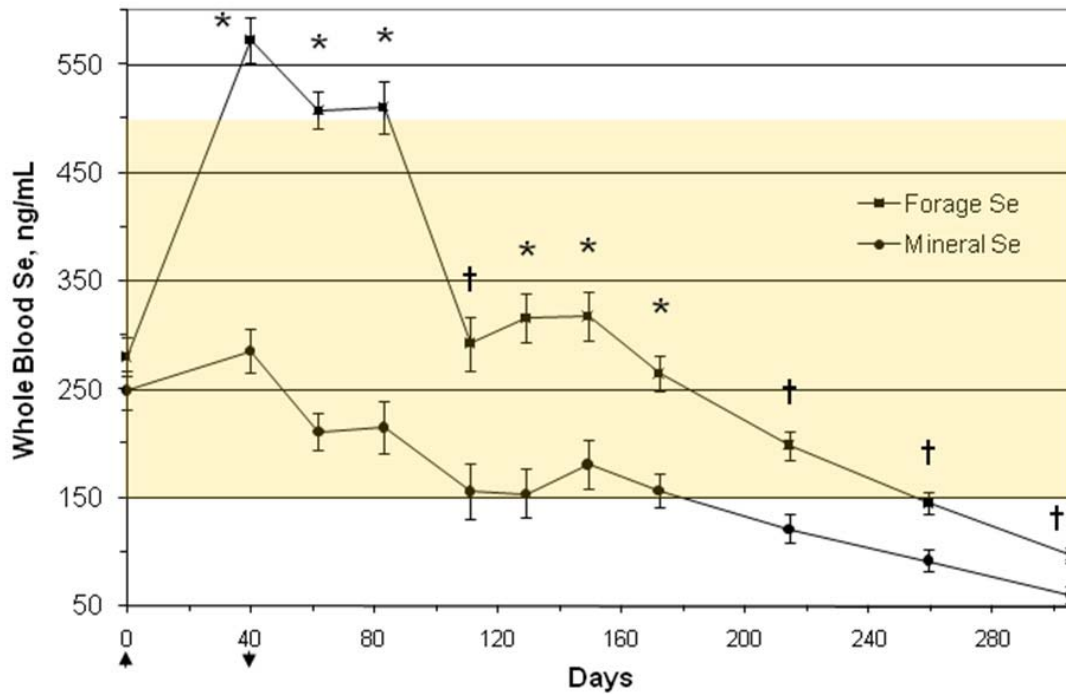


FIGURE 1

Comparison of least squared mean (\pm SEM) whole-blood selenium (Se) concentrations in sheep consuming either Se-fertilized pasture with no mineral supplement (n=15) or non-Se-fertilized pasture, with Se-containing (200 ppm) mineral supplement (n=15).

Treatment periods were for 40 days (arrows). Reference range for adult sheep whole-blood Se concentrations shown as shaded area. (Treatment differences within month: *P<0.0001, †P=0.001).