
SOILS

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Liming Coastal Pastures

Soil acidity is a universal problem for crop production in humid or high rainfall environments. Agricultural production practices such as addition of ammonium-N fertilizer adds to soil acidity. Reduction of soil acidity is achieved with the application of lime, calcium carbonate. Cropping systems differ in the reason soil acidity limits growth, ability to apply lime in crop sequence, and economics or return from lime application. The need for lime and benefit from application has been measured in coastal pastures research plots for more than a half century. The research work demonstrated that lime applied to soil with pH of 5.5 or lower will increase forage yield and increase longevity of orchardgrass, perennial ryegrass and white clover in pastures.

The half century of research has not satisfied Coastal Oregon pasture managers. They continue to question the need to apply lime and the benefit from its application. The primary questions are economics and yield often expressed as “how much does liming cost?” and “what do I get from applying lime?” Coastal Oregon forage producers pay a relatively high price for lime that produces a modest yield increase. Lime costs more on the coast than in the Willamette Valley, typically 25 to 30 % more/ton. Forage grass yield increase from lime application varies, from 250 to 1750 lb/a.

This article explores lime needs and benefits from lime application on pastures using data from experiments in Curry, Clatsop and Tillamook counties from 1956 through 1996. Forage yield and quality data from two Tillamook County pasture sites that received lime in the fall of 2003 will be presented in the November edition of this newsletter.

Coastal pastures in Curry, Coos, Lincoln, Tillamook, Clatsop and portions of Douglas and Lane are usually situated in river or bay flood plains and terraces or rolling hills. The rolling hills are one to several hundred feet above sea level, one to several miles from the ocean, and the soil is formed from sedimentary rock. Two of the three examples used in this article are from pastures on river or bay alluvium. Pastures situated on flood plains would be more likely to be limed since many hill pastures are too steep for lime to be applied.

The soil series commonly found in coastal pastures are Coquille, Brallier, Brenner, Clatsop, Nehalem, Nestucca, Knappa, Hebo, Chitwood, and Walluski. These soils formed in recent alluvium at elevations of 0 to 550 feet. The climate is characterized by cool moist summers and cool wet winters. The average annual precipitation is 60 to 100 inches.

In Tillamook County alone, dairy cattle graze approximately 10,000 acres of pasture, producing over \$80 million dollars of milk annually. Soil pH in Tillamook County dairy pastures are commonly between 5.4 and 5.6. Some pastures have soil pH below 5.0.

The lack of predictable economic return from lime application is a concern. Increasing yield is not the only benefit from lime application. Producers also should consider longevity of pastures as an additional benefit. Liming prevents soil pH from declining to a point where the stand fails and \$300 to \$400/a are needed to re-establish a pasture. Lime application can increase protein harvested by increasing protein in forage or sustaining protein as yield increases.

If producers understand reasons that soil acidity limits forage production, hopefully they will then view lime application favorably. Soil acidity can decrease forage production or quality by limiting the availability of essential nutrients and increasing the availability of toxic elements (Barnes et al., 1995). As soil pH decreases, several situations can exist: 1) The concentration of soluble metals may become toxic, especially aluminum (Al) and manganese (Mn), 2) The microorganisms involved in transformations of nutrients like nitrogen, sulfur and phosphorus may become altered, 3) Calcium may become deficient as pH decreases, especially when cation exchange capacity is low, 4) Symbiotic nitrogen fixation is reduced or ceases, 5) availability of magnesium and molybdenum is reduced.

The first example of lime application on coastal pastures illustrates item 2, the influence of soil pH on nitrogen availability. Lime application significantly increased forage yield compared to no lime application in 1995, Table 1 (Rogers 1995).

Table 1. Topdress lime application influence on yield of orchardgrass grown in a Coquille silt loam in Tillamook County. The soil pH in the surface two inches before lime application in the fall of 1993 was 5.2.

Lime Rate	1994 Yield	1995	1995 soil pH
t/a	lb/a	lb/a	0 to 2 inch
0	5056	4203	5.3
1	5447	4722	6.3
2	5204	5147	6.8

The yield increase measured was associated with increased N availability. Average protein concentration did not significantly change with lime application, even when yield increased 1,000 lb/a, Table 2. To maintain protein at 20% and increase yield 1,000 lb/a, approximately 30 lb additional N/a are needed.

Table 2. Topdress lime application influence on average protein of orchardgrass grown in a Coquille silt loam in Tillamook County.

Lime Rate	1994 cutting			1995 cutting		
	1	2	3	1	2	3
t/a	----- % -----					
0	22	14	14	20	16	19
1	22	13	14	20	18	21
2	22	13	14	20	16	21

Incorporation of lime was not compared with topdressing at Tillamook in 1993. Topdressing lime is logically less efficient than incorporation since lime is not soluble or mobile and must be mixed with soil to raise the soil pH. When lime was incorporated before planting a legume-grass forage mix in Clatsop County, the yield increase was similar to the amount measured from topdressing lime in Tillamook in 1993, Table 3 (Jackson and Howell 1967). The yield increase in shown in Table 3 was also attributed to additional N availability.

Table 3. Preplant incorporated lime influence on forage yield on an Astoria silt loam. Initial soil pH 5.1 and extractable Ca 1.3 meq/100g soil. Irrigation was provided for the first two years, but not the third.

Lime Rate	1957	1958	1959	Sum 3 years	Soil pH
t/a	----- lb/a -----				
0	9330	7830	3120	20280	5.1
3	9820	9020	3590	22430	5.5
6	11050	9800	3510	24360	5.7
12	11360	9520	3610	24490	6.1
24	12000	9490	3450	24940	6.9

The Clatsop County site produced a high yield and inconsistent increases from lime application. As an example the 3 t/a lime rate produced 500, 1200, and 400 lb/a more forage than the treatment receiving no lime. The 6t/a lime application produced a greater initial forage yield increase compared to no lime application, 1700 in 1957 and 2000 lb/a in 1958. These large increases were followed by an increase of 400 lb/a than the no lime treatment in 1959.

The pattern of yield increase from lime application is similar at the Tillamook and Clatsop sites. A large yield increase compared to no lime application, 1,000 to 2,000 lb/a is usually measured in the second year after application and followed by a

modest increase of 400 to 500 lb/a in the third year. The one time large yield increase is attributed to increased N availability that is not sustained.

At the Clatsop site, the forage yield increase for both lime rates was statistically greater than forage produced when no lime was applied. The statistical test tells us the yield increase from lime application is not by chance. Even though forage yield increases, how economical is it?

A single lime application of 6 t/a is difficult to evenly incorporate and expensive. If lime costs \$60/t, a 6 t/a rate costs \$360/a. The three year total increase in forage production from 6 t/a lime compared to no lime application was 2 t/a. If similar quality forage such as alfalfa hay costs \$160/ton, then more than 3 years are required to recover the cost of the lime application.

Let's look at the economics of a 3 t/a lime application. A 3 t/a lime application costs \$180/a. The three year total yield increase from the 3 t/a application compared to no lime applied is approximately 2 t/a. The 2 t/a forage yield increase is worth \$320. Lime cost would be recovered by increased forage production in two years.

At the Tillamook site, both rates of lime increased the two year sum of forage production approximately 1,000 lb/a. Using the same lime and hay cost as in the calculations for the Clatsop site, between 2 and 3 years production are necessary to recover the expense of topdressing 1 t/a lime.

Lime increased forage yield at both the Tillamook and Clatsop sites. The yield increase was small, requiring several years to recover expenses when only yield and lime cost are considered. Two additional costs need to be considered, weed control and stand establishment or longevity. In the Clatsop County plots, lime markedly increased persistence of orchardgrass and perennial ryegrass and reduced the invasion of undesirable species, bentgrass and sweet vernal grass. White clover was also seeded in the plots at the Clatsop site and persisted when the soil pH was above 5.5.

Stand longevity and maintenance of desirable species are benefits from lime application that need to be considered when examining the economics of lime application.

The previous examples showed forage yield increase from lime application in grass pastures with a soil pH was between 5 and 5.5. At the same soil pH, lime application increases leguminous forage yield more than grass forages. For example, a 3,000 lb/a yield increase of orchardgrass and white clover was measured from a Willamette Valley site when 2 t/a lime was applied to a Chehalis soil with a 5.9 pH (Rogers 1995).

Additional examples of leguminous forage yield increase from lime application were measured in non-irrigated south coastal pastures, Table 4. The sites were established on a Knappa silt loam, a soil commonly found terraces of coast range in Oregon and Washington. Lime at 2.5 t/a was applied in October of 1970. The new seeding was a grass- subclover mix and the established pasture was white clover.

Table 4. Forage yield from lime and Mo application in Curry County in 1971.

Treatment	Site	
	New Seeding Yield	Established Pasture
	lb/a	
Control	560	1575
Mo	940	1954
2.5 t/a lime	960	2950
Mo + lime	940	4090
Initial soil pH	5.4	5.1
Initial soil Ca meq/100g	1.4	1.4

Addition of either lime or Mo increased forage yield at both locations, Table 4. Even though the yield increase was only 400 lb/a for the new seeding, lime or Mo almost doubled yield. The yield increase measured from lime and Mo application in the established pasture was more than 1 t/a and a doubling of yield.

Nine years after lime application, the Curry County plots could still be identified by preferential grazing. Forage yield was measured but showed no significant increase from lime application even though lime increased yield 400 to 500 lb/a for the new seeding. The soil pH at both sites was 5.4.

Molybdenum is necessary for N fixation. Molybdenum availability decreases as soil pH declines. Lime application increases soil pH and Mo availability.

Forage yield increase from lime application depends on species and limitation caused by low soil pH. When the soil pH is between 5.0 and 5.5 both grass and legume growth is limited by lack of nitrogen. Low soil pH reduces Mo availability and N fixation for legumes. For grass species, the low soil pH reduces bacterial conversion of N to plant available forms.

Recovery of the cost of lime application typically requires 2 to 3 years of increased forage production in grass pastures. Producers should also consider stand and species longevity as economics of lime application are considered.

At least one additional question about lime application on coastal pastures remains. Dairy producers wish to know if liming changes feed quality. Dairies need palatable high-energy-high protein feed. For the dairy industry, quality of feed produced is more important than the quantity of feed produced.

Dairy pastures receive N from manure. Data from the Tillamook and Clatsop sites in tables 1 and 3 illustrate the role of lime and soil pH in conversion of N to a plant available N form. Supplying the entire need of an intensively managed pasture from manure also supplies substantial amounts of potassium, some calcium, and magnesium. These elements assist or resist soil from acidifying.

The next article provides yield, protein, and digestibility data from a recent trial in Tillamook County where all N was supplied from manure.

References

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