ANNUAL RYEGRASS SEED PRODUCTION IN ACIDIC SOIL

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Introduction

Annual or Italian ryegrass (*Lolium multiflorum* Lam.) is grown on approximately 125,000 acres in the southern Willamette Valley, primarily on moderately and poorly drained acidic soils. The soil pH in fields typically is below 5.5 (2:1 soil water), the value at which lime is recommended. Annual ryegrass forage production studies in Texas, Louisiana, and Florida have shown an increase in production when lime was applied to fields with a soil pH below 5.0, especially on sandy loam soils (Haby 1995**.** Despite acidic soil in western Oregon, seed yields comparable to or greater than the industry average (2000 lb/a) are commonly obtained at strongly acidic pH levels (below 4.5) that would limit seed production of perennial ryegrass and other perennial seed crops in the area.

Among western Oregon grass seed crops, annual ryegrass has the lowest economic return. Seed producers are cautious about purchasing lime since it is expensive, usually more than $60/t. One strategy employed by growers of annual ryegrass seed is to band granular lime at planting on acidic soil, especially on leased ground where they are uncertain about sufficient time for a return on an investment in conventional agricultural lime. While granular lime is 3-4 times as expensive as agricultural lime, approximately $225/t, the product is used at a rate of 110-150 lb/a and therefore costs 10 to 15% of a conventional 2-3 t/a agricultural lime application. Granular lime is placed with the seed at planting, in theory to neutralize acidity in the zone of germination, improve seedling growth and establishment, and ultimately help maintain seed yields on low pH soils; however this benefit has never been documented in western Oregon seed fields.

While annual ryegrass is considered a widely adapted cool season grass, tolerant of both poor drainage and low soil pH, the excellent seed yields achieved under very low pH levels on some soils in the Willamette Valley are surprising. The reason for this is not well understood.

The purpose of this trial was to: (1) evaluate the changes in soil chemical properties and annual ryegrass seed yield from lime application on acidic soil and (2) compare seed yield when granular lime is banded at a low rate to traditional broadcast lime application.

Material and Methods

A field was selected for this study with an initial pH of 4.2 (2:1 soil water), yet had a history of 2,500 lb/a or greater annual ryegrass seed yield. This yield is above the industry average for Oregon. The soil type was typical for the region where annual ryegrass is grown as a seed crop in the southern Willamette Valley of western Oregon, silt loam surface texture with a subsurface clay accumulation that restricts water movement. The field had been in production of annual ryegrass for over 30 years, managed mostly under a conventional tillage system where the full straw load was flail chopped and worked back into the soil each year. The field had never been limed. Gulf annual ryegrass was the variety grown historically in this field, and is the most commonly grown diploid annual ryegrass cultivar in Oregon. We continued with this variety during the trial period.

In August of 2005, 2.5 and 5 t/a of by-product agricultural lime was applied to the field using commercial lime application equipment and preplant incorporated with a harrow to a depth of approximately 5 inches. Additional treatments were an untreated or "check" and 150 lb/a granular lime (trade name Cal-Pril) annually applied in a band using a standard grain drill equipped with a fertilizer box attachment. All lime treatments are expressed as 100 score material. Soil pH, ammonium acetate extractable Ca, and KCl extractable aluminum were measured during the experimental period.

The trial was arranged in a randomized complete block design with three replications. Individual plots were 60 ft wide by 410 ft long. The variety Gulf annual ryegrass was planted each year in September. Seed yield was measured for three years. The plot area was harvested with grower equipment by first making a 16 ft swath the length of center of each plot, allowing the grass to dry, and threshing with a combine. A weigh wagon was used to measure plot yields. Sub-samples of the harvested seed were collected to determine 1000 seed weight, percent cleanout, and calculate total clean seed weight.

Results and Discussion

Lime application produced a small but significant increase, 200-320 lb/a, in annual ryegrass seed yield (Table 1). In spite of a 4.2 soil pH in the treatment receiving no lime, seed production was 2515 lb/a, which is 25% above the regional average. The application of granular lime and 2.5 t/a by-product lime produced the same yield statistically. The greatest seed yield, 2837 lb/a, was obtained from the incorporation of 5 t/a of lime.

Soil pH and extractable Ca were increased by the conventionally incorporated lime treatments. The 5 t/a lime rate raised the soil pH from 4.2 to 6.0 in the first season following application.

Table 1. The changes in three year average seed yield, soil pH and extractable Ca from lime applications on annual ryegrass seed yields on a strongly acid soil in western Oregon, USA.

Lime rate	pH		Ca		Seed yield
	10/05	06/08	10/05	06/08	
(t/a)			---- (meq/100 g soil) ---		(lb/a)
0	4.2	4.4	2.1	2.2	2515
0.075	4.2	4.3	1.8	2.1	2740
2.5[1]	5.4	4.7	6.1	4.4	2723
5[1]	6.0	5.1	11.3	6.5	2837
P Value	0.0007	0.0122	0.0067	0.0035	0.0066
LSD (0.05)	0.24	0.16	1.86	0.77	138

[1] By-product, lime score of 72, applied 20 August, 2005 to provide an equivalent amount of 100 score lime.

The 5 t/a preplant lime treatment increased soil pH and Ca to levels considered adequate in the Oregon State University nutrient management guide for annual ryegrass seed production (Hart *et al.*, 2003). The conventional lime treatments maintained soil pH and Ca values above those from the untreated plots for the three-year period of this study. Soil pH and Ca levels from the conventional lime treatments decreased with time due to annual plowing and mixing of lime plus acidification associated with ammonium-N application. The band application of granular lime did not change soil pH or Ca. This outcome was expected as the application rate of granular lime was low.

Aluminum (Al) toxicity is considered a primary plant growth limiting factor for strongly acidic soils. As soil pH decreased, extractable Al increased exponentially (Figure 1), and grass seed yield decreased linearly (Figure 2).

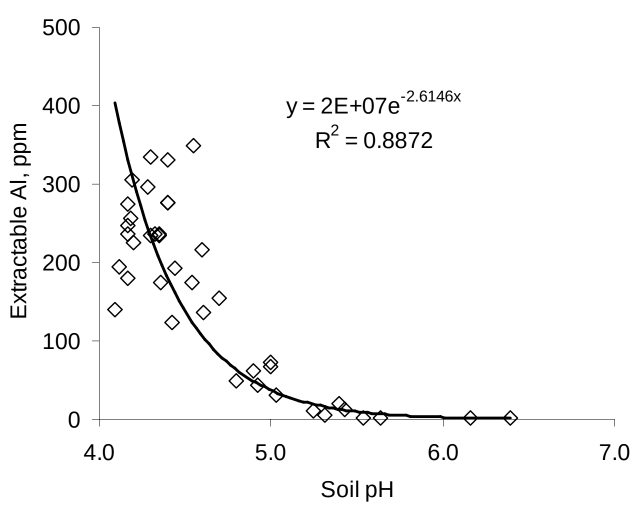

Figure 1. KCl extractable Al change with 2:1 soil:water pH

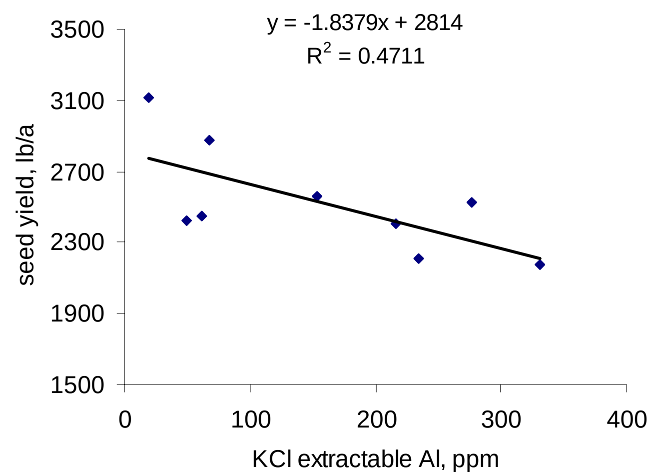

Figure 2. Annual ryegrass seed yield change with KCl extractable Al. Data from treatments receiving no lime and both rates of broadcast lime in 2008.

The soil pH at which Al becomes toxic to plants is dependent on the soil, plant species, and variety grown. In Willamette Valley soils, a pH of 4.7 has been considered a threshold level where Al concentration begins to increase exponentially and affect the growth of grass roots in forage and seed production systems. The increase in extractable Al measured in this trial also showed a sharp increase at approximately pH 4.7 (Figure 1). At soil pH 4.7, the extractable Al was approximately 100 ppm. Maximum annual ryegrass seed yield was measured when the extractable Al was below 100 ppm, supporting the choice of a soil pH 4.7 as threshold value for sufficient Al to limit root growth in this area.

Even when KCl extractable Al was three times the amount where toxicity was thought to affect root growth, 300 ppm, seed yields were above the industry average of 2000 lb/a. One possible reason that seed yield was maintained under these conditions was an Al-complex by organic acids, thus ameliorating the effect of Al toxicity on root growth. This explanation is possible since total soil C at the site was 2.5%. Another possibility is that the Gulf annual ryegrass cultivar grown in Oregon has developed tolerance to lower pH conditions. The seed stock of Gulf annual ryegrass used in this trial came from the same farm and from fields with similar low soil pH. These are plausible reasons for the annual ryegrass to grow well in acidic conditions.

Even though a reasonable relationship exists between KCl extractable Al and annual ryegrass seed yield, use of extractable Al to predict lime need is not recommended. The test is not universally available and critical Al levels are expected to vary with soil and crop. The strong relationship between KCl extractable Al and soil pH shown in Figure 1 shows that soil pH is an adequate indicator of the amount of Al in the soil and therefore, need for lime.

Data from the last two years of this project can be used to strengthen the idea that soil pH is an adequate indicator of lime need. A trend exists between soil pH and relative seed yield (Figure 3). The slope of the regression line differs from 0, but factors other than soil pH change yield. The relative seed yield and soil pH data was sorted into to groups, above 5.3 and below 5.3. The two groups of data plotted in Figure 4 support the OSU recommendation that lime is needed when the soil pH is below 5.5. Yield decreases as soil pH decreases when the pH is below 5.5 and yield does not change as the soil pH increases when the pH is above 5.5.

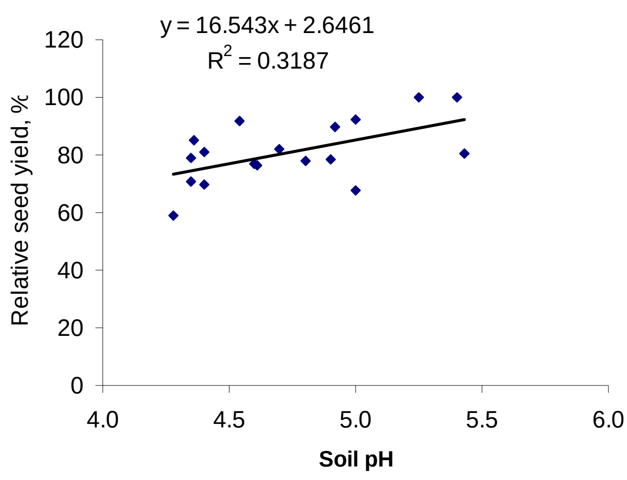

Figure 3. Annual ryegrass relative seed yield change with soil pH. Data from treatments receiving no lime and broadcast lime for 2007 and 2008.

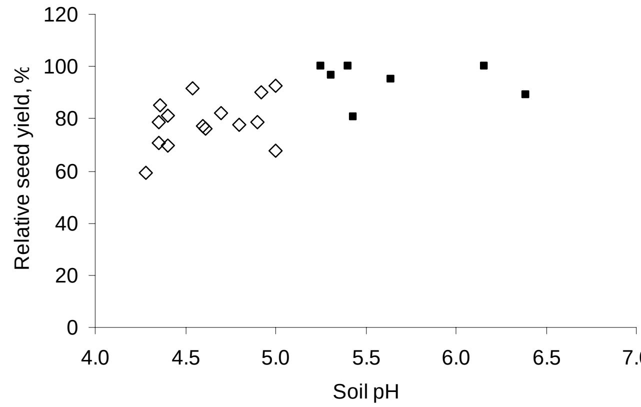

Figure 4. Annual ryegrass relative seed yield as changed by soil pH below 5.3, open diamonds, and above 5.3, solid squares.

The magnitude of yield reduction when soil pH decreases from soil pH 5.5 to 4.5 is 16% as shown by the equation of the regression line in Figure 3. The value of the seed yield decrease is approximately equal in value to one ton of lime. A 2.5 t/a application requires 3 years to recoup the cost of lime application, hence the reluctance of many producers to apply lime. A band application of 150 lb/a granular lime cost is approximately one-quarter to one-third the cost of a ton of agricultural or ground limestone. In addition, the seed yield increase from these two treatments is the same, which then produces a return on investment in one year from the granular lime application.

Annual ryegrass is considered to be a broadly adapted cool season grass, growing on poorly drained and acidic soils. These results confirm that annual ryegrass is tolerant of low soil pH on silt loam soils with relatively high organic matter concentration. However, even under these conditions, annual ryegrass seed yield will increase with lime applications on strongly acid soils. Use of granular lime is a very economical option for maintaining seed yield when the soil pH is below 5.5. The rate of lime used for a band application is insufficient increase soil pH, soil Ca or decrease extractable Al levels throughout the root zone. Conventionally incorporated lime applications, while more expensive, provide greater assurance of increasing soil pH, reducing extractable Al, and increasing seed yields on strongly acidic soils of the Willamette Valley, not only for annual ryegrass, but for other crops that may be grown in rotation.

References

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Acknowledgement

We appreciate the help and cooperation in this trial from JH Davidson Farms, Peter Kuenzi of Wilbur-Ellis Co., and Pat Boren of Crop Production Services.