# Annual ryegrass seed production in acidic soil

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## Abstract

A three-year study of lime application for annual ryegrass seed production in Oregon, USA was completed in 2008. Lime application significantly increased the three-year average seed yield ($p=0.05$) on a field with an initial pH of 4.2. The average seed yield with no lime application was 2815 kg ha$^{-1}$, compared to 3070 kg ha$^{-1}$ for annual banded lime application of 165 kg ha$^{-1}$, 3050 kg ha$^{-1}$ when 5,600 kg ha$^{-1}$ lime was applied preplant, and 3175 kg ha$^{-1}$ when 11,200 kg ha$^{-1}$ lime was applied preplant. KCl extractable aluminum (Al) increased exponentially as soil pH decreased and seed yield increased linearly as KCl extractable Al decreased.

## Introduction

Annual or Italian ryegrass (*Lolium multiflorum* Lam.) is grown on approximately 50,000 ha in the southern Willamette Valley of Oregon, 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 (2,240 kg ha$^{-1}$) are commonly obtained at strongly acidic pH levels (<4.5) that would limit seed production of perennial ryegrass and other perennial seed crops in the area.

Seed producers are cautious about purchasing lime since it is expensive. An alternative strategy is to band granular lime at planting. In theory, granular lime will neutralize acidity in the zone of germination, improve seedling growth and establishment, and ultimately maintain seed yields on low pH soils; however this benefit has never been documented in Western Oregon seed fields.

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 kg ha$^{-1}$ or greater annual ryegrass seed yield. This yield is above the industry average for

Oregon. The field had been in production of annual ryegrass (cv. Gulf) 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 was the most commonly grown diploid annual ryegrass cultivar in Oregon. We continued with this variety during the trial period.

In August of 2005, 5,600 and 11,200 kg $ha^{-1}$ of paper mill by-product lime were applied and preplant incorporated to a depth of 12 cm. At planting, treatments receiving no lime and 165 kg $ha^{-1}$ granular lime (trade name CalPril) annually applied in a band were established. All lime treatments are expressed as 100 score material. Soil pH, 1 N 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 18 m wide by 125 m long. The annual ryegrass cv. Gulf was planted in September. Seed yield was measured for three years. Grower equipment was used for harvest by first making a 5 m 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, 230-360 kg ha-1, in annual ryegrass seed yield, Table 1. In spite of a 4.2 soil pH in the treatment receiving no lime, seed production was 2820 kg ha-1, which is 25% above the regional average. The application of granular lime and 5,600 kg ha-1 by-product lime produced the same yield statistically. The greatest seed yield, 3180 kg ha-1, was obtained from the incorporation of 11,200 kg ha-1 of lime.

**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 | |
| kg ha-1 | | | --- cmol/kg --- | | kg ha-1 |
| 0 | 4.2 | 4.4 | 2.1 | 2.2 | 2815 |
| 165[2] | 4.2 | 4.3 | 1.8 | 2.1 | 3070 |
| 5,600[1] | 5.4 | 4.7 | 6.1 | 4.4 | 3050 |
| 11,200[1] | 6.0 | 5.1 | 11.3 | 6.5 | 3175 |
| P Value | 0.0007 | 0.0122 | 0.0067 | 0.0035 | 0.0066 |
| LSD (0.05) | 0.24 | 0.16 | 1.86 | 0.77 | 155 |

[1] By-product, lime score of 72, applied 20 August, 2005 to provide an equivalent amount of 100 score lime.
[2] Granular lime $250 USD tonne and byproduct lime $65 USD tonne

Soil pH and extractable Ca were increased by the conventionally applied lime treatments. The 11,600 kg ha-1 lime rate raised the soil pH from 4.2 to 6.0 in the first season following application. The 11,200 kg ha-1 preplant lime treatment increased soil pH and Ca to levels considered adequate in the Oregon State University nutrient 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 rate of application was low.

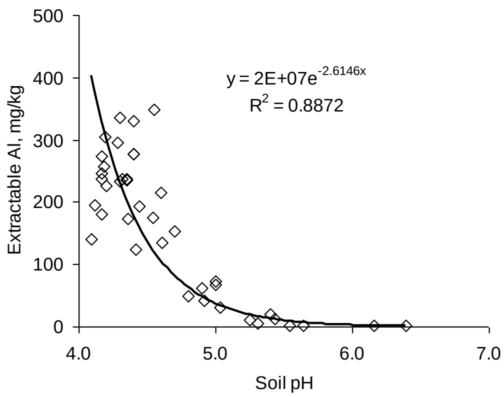


**Figure 1.** KCl extractable Al change with 2:1 soil:water pH

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.

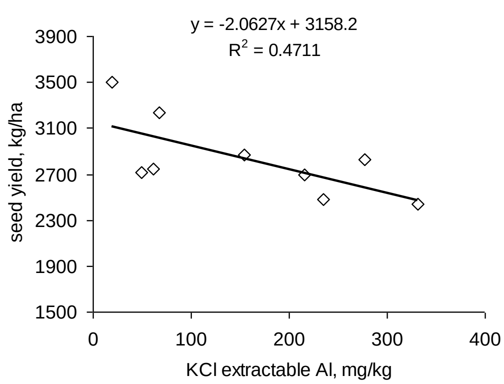


**Figure 2.** Annual ryegrass seed yield change with KCl extractable Al. Data from treatments receiving no lime and both rates of broadcast lime in 2008.

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, Fig. 1. At soil pH 4.7, the extractable Al was approximately 100 mg/kg. Maximum annual ryegrass seed yield was measured when the extractable Al was below 100 mg/kg, 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 mg/kg, seed yields were above the industry average of 2240 kg ha-1. 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 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 show that soil pH adequately indicates lime need. 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 3 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.

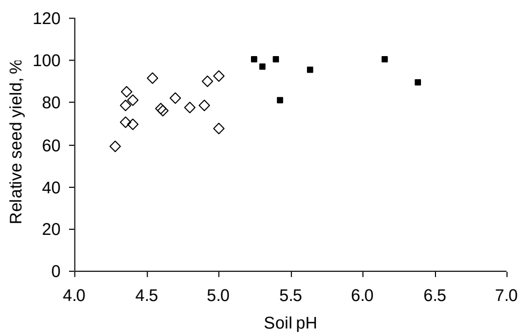


**Figure 3.** Annual ryegrass relative seed yield as changed by soil pH below 5.3, open diamonds, and above 5.3, solid squares.

Annual ryegrass seed yield increases with lime application on strongly acid soils. A low rate of granular lime is an economical option for maintaining seed yield when the soil pH is below 5.5. Conventionally incorporated lime applications, provide greater assurance of increasing soil pH, reducing extractable Al, and increasing seed yields on acidic soils of the Willamette Valley.

**References**

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