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Annual Ryegrass Grown for Seed

(Western Oregon)

J.M. Hart, M.E. Mellbye, W.C. Young III, and T.B. Silberstein

Summary

Fall, before planting

Note: For fields established by volunteer seedlings, no fall nutrient applications are recommended.

Lime	Apply lime according to Table 6 when the soil pH is below 5.5. See pages 4–6.
Nitrogen (N)	Application of 20 lb N/a is common and optional. See page 3.
Phosphorus (P)	When soil test P is below 25 ppm, apply P according to Table 2. See pages 3–4.
Potassium (K)	When soil test K is below 150 ppm, apply K according to Table 4. See page 4.
Calcium (Ca)	When soil test Ca is below 5 meq/100 g of soil or 1,000 ppm, apply lime. See page 6.
Magnesium (Mg)	When soil test Mg is below 0.5 meq/100 g of soil or 60 ppm, use 1 t dolomite/a for 1 t lime/a of the lime requirement. See page 6.

Spring

Note: These spring nutrient applications apply to all fields, including those established by volunteer seedlings.

Nitrogen (N)	Apply 100 to 140 lb N/a between mid-March and mid-April. See pages 6–8.
Sulfur (S)	Apply 10 to 15 lb S/a in early spring with the first application of N. S can be applied every other year at 20 to 25 lb/a. See page 8.
Potassium (K)	K may be applied in the spring for maintenance purposes. If a soil test indicates the need for K, apply in the fall.
Chloride (Cl)	No application is recommended. See page 9.

Photo: Mark Mellbye

Annual ryegrass is grown for seed primarily on Dayton, Bashaw, and similar poorly drained soils in western Oregon. Dayton, called "white soil" by growers, is found on broad, flat areas of the southern Willamette Valley floor. Bashaw, a black, sticky clay sometimes called "gumbo soil" by growers, is formed on the low-lying and gently concave areas associated with narrow stream valleys and at the edges of some hill slopes. These soils are not well suited to perennial grass production because of poor drainage, which causes water to stand on the soil surface. Recommendations in this guide assume production in these settings and apply to commonly grown varieties of annual ryegrass.

Management practices, from seedbed preparation to harvest, must be performed in an appropriate and timely manner for optimum annual ryegrass seed yield. Fertilizer is not a substitute for failure to control insects, diseases, or weeds. Excessive stand density, low soil pH, and/or poor drainage can be significant limiting factors in obtaining high seed yields. Increasing fertilizer rates or adding nutrients already in adequate supply will not correct these limiting factors.

Nutrient management can be addressed by answering the following questions:

- How much fertilizer should be applied?
- When should the material be applied?
- How should the material be applied?
- What material should be used?

This guide primarily answers the first two questions.

John M. Hart, professor of crop and soil science, emeritus; Mark E. Mellbye, area Extension agronomist; William C. Young III, Extension seed production specialist; and Thomas B. Silberstein, area Extension agronomist; all of Oregon State University.

Oregon State University Extension Service

The average seed yield for annual ryegrass is approximately 2,000 lb/a. Higher yields do not require greater amounts of nutrients than recommended by this guide. These recommendations, especially those for nitrogen, are adequate for seed production of more than 3,000 lb/a on sites where soil pH and drainage do not limit yield. For information about adjustments needed based on the method of stand establishment, see the sidebar "Stand establishment method and nutrient management."

Recommendations in this guide are the result of 50 years of large- and small-plot research throughout the Willamette Valley (see page 10). Several research projects evaluated the impact of grazing on annual ryegrass seed yield. No reduction in seed yield was measured from grazing durations between late February and early to mid-April. However, late-spring grazing will remove the apical meristems (growing points) of primary tillers. Thus, to maintain seed yield under grazing management, sufficient nutrients and moisture for regrowth are necessary during the post-grazing period.

Soil sampling and analysis

Sample and analyze soil to estimate the need for lime, phosphorus, potassium, calcium, and magnesium. Sampling soil every second or third year is sufficient. A single sample should represent only 40 acres, a single soil type, or the same management practices in a field.

Crop growth and nitrogen uptake

Rate and timing recommendations for nitrogen (N) are based on plant demand. Annual ryegrass growth and N uptake patterns help determine application timing (Figure 1).

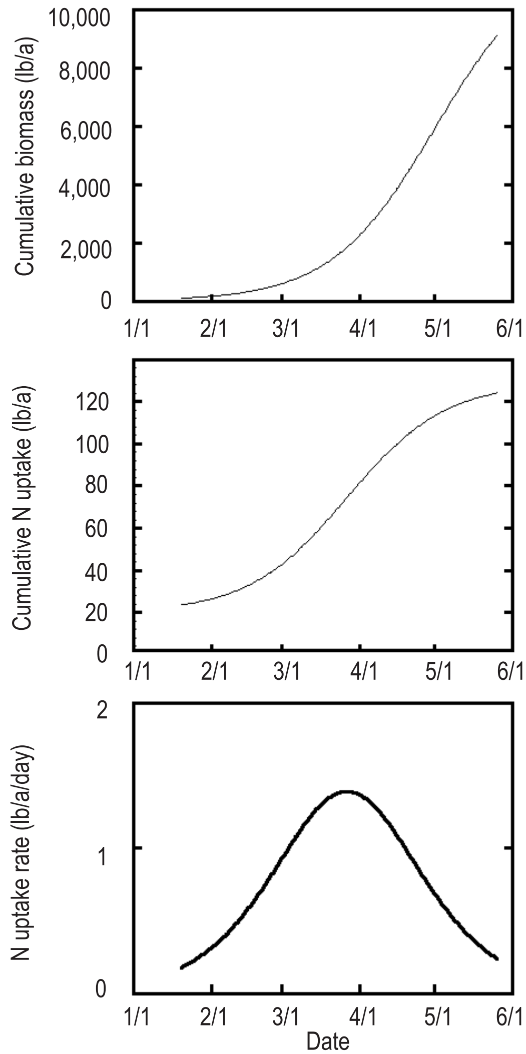

Figure 1.—Biomass accumulation and N uptake for high-yielding annual ryegrass grown in the southern Willamette Valley. Data are from 1991.

Stand establishment method and nutrient management

Before 1985, much of the annual ryegrass straw was burned, and subsequent plantings were no-till seeded. Current legislative statutes prohibit open field burning of residue in annual ryegrass seed production. Now, annual ryegrass is established (1) by planting in a conventionally prepared seedbed, (2) by direct seed or no-till planting, or (3) with volunteer seedlings from the previous year's crop.

Recommendations in this guide apply to all common methods of establishing a stand. Only minor adjustments are needed for each method. In general, if the seed is drilled, we recommend a fall application of nutrients (preplant or banded at planting), except nitrogen. Recommended rates are discussed on pages 3–6.

Using volunteer seedlings for stand establishment reduces tillage and planting cost. However, nutrients aren't incorporated at planting with this method. For these stands, only spring N and S will be applied.

For this reason, volunteer stand establishment should be used only when soil pH and nutrient levels are adequate. Volunteer stand establishment is recommended when soil pH is above 5.3, soil test phosphorus is above 25 ppm, soil test potassium is above 150 ppm, soil test calcium is above 5 meq/100 g soil (1,000 ppm), and soil test magnesium is above 0.5 meq/100 g soil (60 ppm). Do not use volunteer stand establishment where soil pH is below 4.8.

To take advantage of the cost saving from a volunteer stand without reducing yield, competition must be reduced. Banding herbicides to establish rows and heavy grazing with sheep are two common ways to reduce competition.

Growth is slow during fall and winter. Depending on the year and whether fields are grazed, between 500 and 1,000 lb dry matter/a is accumulated by mid-March. Growth is rapid and linear from early April to early June.

Approximately 100 to 125 lb N/a is taken into the aboveground portion of the crop when 90 to 135 lb N/a is applied in spring. The maximum N uptake rate is approximately 1.5 lb/a/day during late March and early April. Intensive grazing will delay biomass and N accumulation.

At physiological maturity, the total aboveground biomass of approximately 9,000 lb/a consists of 2,700 lb seed/a and 3 t straw/a. Straw N concentration is about 1 percent, and seed N concentration is about 2 percent. Slightly less than half of the N is removed in the seed.

Fall nutrient management

In general, if the seed is drilled, we recommend a fall application of nutrients (preplant or banded at planting), except nitrogen. Recommended rates are discussed in each of the sections below. For volunteer-established stands, no fall fertilizer is recommended.

Nitrogen (N)

Traditionally, a fall application of 20 lb N/acre was recommended, based on research with open field burning followed by no-till planting.

A seed yield increase from a fall application of N is not documented with current establishment methods. For example, little or no increase in seed yield was measured from a late-fall/early-winter N application when the annual ryegrass crop was established from a volunteer stand and rows were established with a winter herbicide application. A December application of 20 lb N/a as a liquid sprayed over rows provided an insufficient seed yield increase to recoup the cost of application (Figure 2). A seed yield increase of at least 80 lb/a is necessary to recover the cost of 40 lb N/a if N costs $0.50/lb (urea at $460/t) and the price for seed is $0.25/lb.

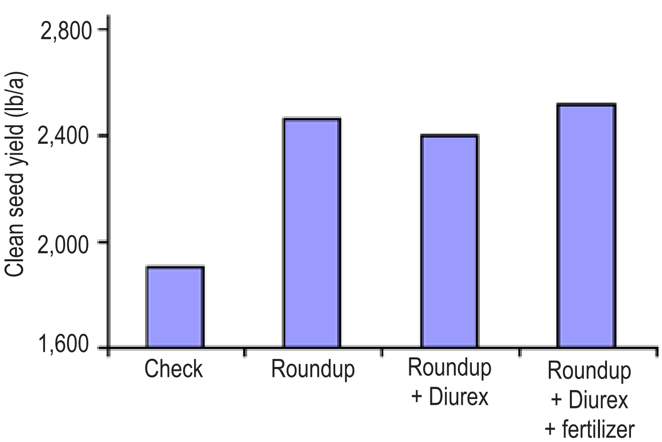

Figure 2.—Clean seed yield response to herbicide and fertilizer treatments for establishment of rows in a volunteer stand of annual ryegrass. The fertilizer was liquid 20-3-3-3 applied over the row at the rate of 10 gal/a (20 lb N/a) in December.

Field research has shown that fall N application is less important to seed production than is spring N application (Table 1). Seed was harvested from annual ryegrass receiving either 0 or 40 lb N/a as a preplant broadcast application. All treatments received 15 to 25 lb N/a in a band at planting. The crop residue was either burned or chopped and plowed into the seedbed.

Table 1.—Influence of residue management, fall nitrogen application, and spring nitrogen rate on annual ryegrass seed yield, cleaned.[a]

Residue management	Preplant broadcast fall N[b] (lb/a)	Spring N (lb/acre)	Seed yield (lb/a)
Burn	0	80	2,226
	0	120	2,481
	40	80	2,241
Chop/plow	0	80	2,182
	0	120	2,483
	40	80	2,120
LSD 0.05			~200[c]

[a]Data were collected from plots near Shedd, Oregon, from 1983 through 1985 and are treatment averages.
[b]All treatments received 15 to 25 lb N/a in a band at planting. The rate varied annually.
[c]A seed yield difference of less than 200 lb/a was not statistically significant in this trial.

Although fall applications of N have not produced documented increases in seed yield, use of fertilizer at planting can promote early growth, aid in establishment before winter, and provide additional forage for grazing.

If a fall N application is made, band a maximum of 20 lb N/acre. If desired, N can be applied to volunteer stands during a row spray operation. Ammonium phosphate, the most common phosphorus fertilizer, contains N. Thus, if 30 lb P_2O_5/a is banded at planting, 15 to 25 lb N/a typically is supplied.

Phosphorus (P)

Annual ryegrass has approximately the same need for P as do other grasses grown for seed in the Willamette Valley. Between 10 and 15 lb P/a is contained in a mature annual ryegrass crop that yields 2,000 lb seed/a. A small amount, between 1 and 2 lb P/a, is contained in the seed.

When P limits seed yield, the yield increase from P application is approximately 300 lb/a. In comparison, a seed yield increase of 500 to 1,000 lb/a is common from applications of N fertilizer.

Determine P need from a soil test and the application rate from Table 2 (page 4). When needed, band P near the seed at planting.

Table 2.—Phosphorus application rates based on soil test.

Soil test P[a] (ppm)	Apply this amount of P_2O_5 (lb/a)
0–15	40–60
16–25	30–40
Over 25	0

[a]Bray P1 soil test method.

Potassium (K)

Potassium concentration in the seed of cool-season grasses is constant, approximately 0.6 percent or 12 lb/t of seed. Thus, little K (only about 10 to 15 lb/a) is removed from an annual ryegrass field in seed. Considerably more—30 lb K/a or more—leaves the field in baled straw. Table 3 gives amounts of K in grass seed straw.

Table 3.—Potassium concentration and content in straw of grasses grown for seed.

	K in straw of a grass seed crop[a]		
	(%)	(lb/t)	(lb/a)
Annual ryegrass	0.75	15	30
Perennial ryegrass	1–2	20–40	50–100
Tall fescue	1–2	20–40	60–120

[a]Average straw produced: annual ryegrass = 2 t/a; perennial ryegrass = 2.5 t/a; tall fescue = 3 t/a.

Because most of the K in a grass seed crop is contained in the straw, K management depends on straw management. When annual ryegrass straw is chopped and plowed into the soil or chopped and left on the surface, little K leaves the field. Potassium in straw is very soluble and leaches from the straw into the soil with fall rains. It is readily available and can be used by seedlings.

With field burning restricted, many growers in the southern Willamette Valley are now baling annual ryegrass straw. Where straw is baled and removed, much more K leaves the field than where straw is retained, and soil test K levels decline more rapidly. Growers should pay careful attention to soil test K depletion and the economics of baling straw.

Determine K need from a soil test and the application rate from Table 4. Reduction of annual ryegrass yield from a K deficiency is not expected until soil test K is below 75 ppm. The recommended soil test level above which no K is recommended is 150 ppm.

Use the higher application rates in Table 4 on Dayton soils to compensate for declining soil K supply with depth (approximately 100 ppm in the first foot and 75 ppm in the second foot). In contrast, Bashaw soil usually has more than 200 ppm in the top 2 feet of the profile, so the lower rates are adequate.

When K is placed with the seed, rates should not exceed 30 to 40 lb K_2O/a.

Table 4.—Potassium application rates based on soil test and residue management.

Soil test K[a] (ppm)	Apply this amount of K_2O[b] (lb/a)	
	Bale	Chop
0–100	60–90	30–60
101–150	30–60	0–30
Over 150	0	0

[a]Ammonium acetate method.
[b]Use the higher rates on Dayton soils.

Sulfur (S)

Although S can be applied in the fall, spring application is preferable. See page 8 for rates and information.

Lime, calcium, magnesium, and pH

Annual ryegrass is a widely adapted cool-season grass, tolerant of both poor drainage and low soil pH. Even so, a lime application is suggested when the soil pH is less than 5.5. Although annual ryegrass can be produced at lower soil pH, the risk of stand failure and depressed yield increases rapidly as soil pH decreases.

In a 3-year trial conducted on Dayton soil near Halsey, Oregon, lime was applied to a field of Gulf annual ryegrass on a very acidic soil. Lime application produced a small but significant increase in seed yield (200 to 320 lb/a), as shown in Table 5.

Aluminum (Al) toxicity is considered a primary plant growth-limiting factor in strongly acidic soils. As soil pH decreases, extractable Al increases exponentially and grass seed yield decreases. The soil pH at which Al becomes toxic to plants depends on the soil, plant species,

Table 5.—Changes in 3-year average seed yield, soil pH, and extractable Ca from lime applications.

Lime rate (t/a)	pH		Ca (meq/100 g soil)		Seed yield (lb/a)
	Year 1	Year 3	Year 1	Year 3	3-year average
0	4.2	4.4	2.1	2.2	2,515
0.075[a]	4.2	4.3	1.8	2.1	2,740
2.5[b]	5.4	4.7	6.1	4.4	2,723
5[b]	6.0	5.1	11.3	6.5	2,837

[a]Granular lime banded at rate of 150 lb/a.
[b]By-product, lime score of 72, applied 20 August, 2005 to provide an equivalent amount of 100-score lime.

and variety grown. In Willamette Valley soils, a pH of 4.7 has been considered a level at which Al concentration begins to increase exponentially and affect the growth of grass roots in forage and seed production systems. (See the sidebar "Should soils be tested for aluminum?")

Seed yields were above the industry average of 2,000 lb/a even when extractable Al was three times the amount thought to affect root growth. One possible reason for this result is that soil organic matter can reduce the effect of Al toxicity on root growth. This explanation is possible since total soil carbon at the site was 2.5 percent. Another possible explanation is that the Gulf annual ryegrass cultivar grown in Oregon may have developed tolerance to lower soil pH. The seed stock of Gulf annual ryegrass used in this trial came from the same farm and from fields with similar low soil pH.

Regular soil sampling and testing to monitor soil pH changes is recommended. Seasonal fluctuation of soil pH makes year-to-year comparison difficult unless soil samples are collected at the same time each year, for example, in the summer before planting. Soil pH increases as soil is wetted with fall and winter rain. Soil pH is highest in the wettest time of the year, February or March.

Measured soil pH also depends on sampling procedure and can vary throughout a field. Our recommendation for lime application when soil pH is below 5.5 provides a margin of safety.

The amount of lime required to increase soil pH is based on the SMP lime requirement test, also known as a buffer test (Table 6). It is named after the three scientists who introduced the test, Shoemaker, McClean, and Pratt. The SMP buffer test is measured in the same units as soil pH, but it is a different test. Soil buffer or SMP pH usually is about 0.8 pH unit higher than soil pH.

Table 6.—SMP lime requirement when soil pH is below 5.5.

	Amount of 100-score lime needed to raise pH of surface 6 inches of soil to the following pH[a,b] (t/a)	
SMP buffer	**5.6**	**6.0**
4.8–5.0	6–5	8–7
5.1–5.3	5–4	7–6
5.4–5.6	4–3	6–4
5.7–5.9	3–2	4–3
6.0–6.2	2–1	3–2
6.3–6.5	0	2–1
6.6	0	1

[a]Rates are based on 100-score lime. The combination of calcium carbonate equivalent, moisture, and fineness determines lime score. Lime application rates are adjusted for score. Lime score is legally required for all materials marketed as "liming materials" in Oregon. For more information about lime score and liming materials, see FG 52, *Fertilizer and Lime Materials Fertilizer Guide*.

[b]Use the higher lime application rate for the lower buffer test value.

Should soils be tested for aluminum?

Lime was applied to an acidic annual ryegrass field near Halsey, Oregon. Annual ryegrass seed yield and soil chemical properties were measured for 3 years (Table 5, page 4). Maximum annual ryegrass seed yield was achieved when extractable aluminum (Al) was below 100 ppm. At soil pH of approximately 4.7, extractable Al increased sharply, reaching approximately 100 ppm (Figure 3). Thus, a soil pH of 4.7 is considered the threshold value at which Al begins to limit root growth in this area.

Although a reasonable relationship exists between extractable Al and annual ryegrass seed yield (Figure 4), use of extractable Al to predict lime need is not recommended. The test is not universally available, and critical Al levels vary with soil and crop. The strong relationship between extractable Al and soil pH in Figure 3 shows that soil pH is an adequate indicator of the amount of Al in the soil and the need for lime.

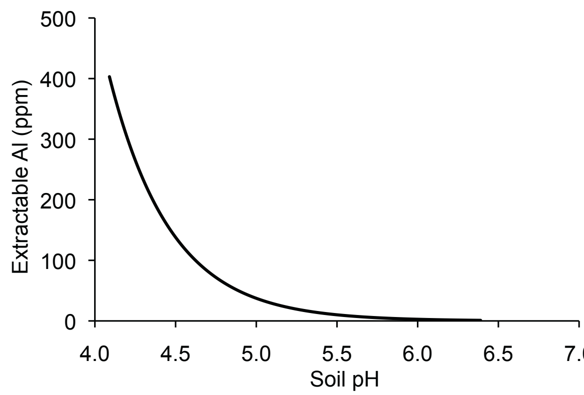

Figure 3.—pH change measured in extractable aluminum with 2:1 water:soil.

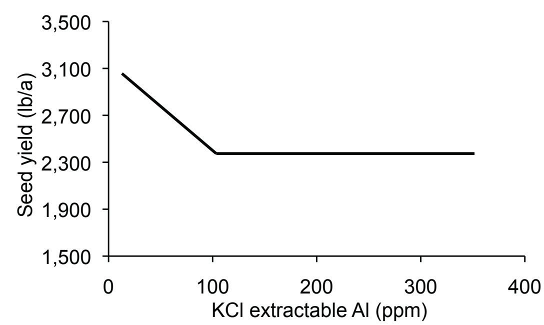

Figure 4.—Change in annual ryegrass seed yield with KCl-extractable Al.

Photo: Mark Mellbye

Figure 5.—Incorporate lime into the soil before planting.

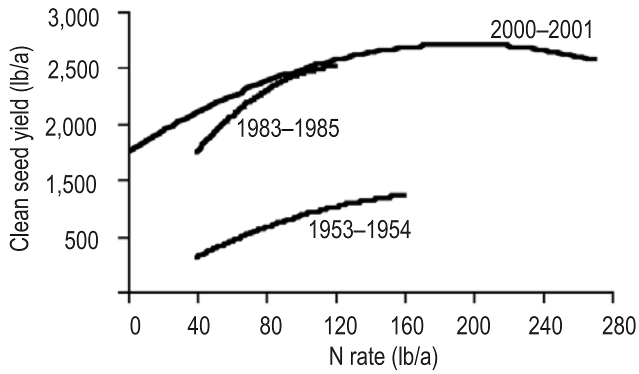

Figure 6.—Annual ryegrass seed yield change with rates of spring-applied N. Dates of field experiments are noted.

Some soil test results might have a high SMP buffer value (greater than 6.2) and soil pH below 5.3. This condition typically occurs when soil samples are taken in August or September. Spring fertilizer application and very dry summer conditions can combine to temporarily depress soil pH.

Work lime into the soil before planting (Figure 5). Lime applications of less than 4 t/a are effective for several years if thoroughly mixed with the soil. When the SMP test result is below 5.2, lime applications greater than 4 t/a are recommended (Table 6, page 5). Do not exceed 5 t/a in a single application, because mixing larger amounts with the soil is difficult. If the recommended amount of lime exceeds 5 t/a, split the application over 2 or 3 years or plow down half the lime and harrow in the remainder. When applying lime over a 2- or 3-year period, test soil pH and SMP buffer before the second application.

A low rate of granular lime (100 to 150 lb/a) banded during planting is an economical option for maintaining seed yield on fields with a low soil pH (see Table 5, page 4). Banding lime is recommended when the soil pH is between 5.0 and 5.5. However, the rate of lime used for a band application is insufficient to increase soil pH or soil Ca or to decrease extractable Al levels throughout the root zone. Therefore, it is recommended as a short-term management option, rather than as a replacement for broadcast lime application. Banding is recommended for only 2 or 3 years. Conventionally incorporated lime applications, while more expensive, provide greater assurance of increasing soil pH, reducing extractable Al, and increasing seed yields on strongly acidic Willamette Valley soils, not only for annual ryegrass, but for other crops that may be grown in rotation.

Calcium (Ca) and magnesium (Mg) are essential plant nutrients. Soil test Ca below 3 meq/100 g soil (600 ppm) is often associated with low soil pH and high extractable Al, conditions that limit annual ryegrass root growth.

When soil pH is above 5.5, soil test Ca usually is 10 to 15 meq/100 g soil (2,000 to 3,000 ppm) for Bashaw soil and 8 to 12 meq/100 g soil (1,600 to 2,400 ppm) for Dayton soil. At this soil pH, soil test Mg usually is 2 to 5 meq/100 g soil (240 to 600 ppm) for Bashaw soil and 1 to 3 meq/100 g soil (120 to 360 ppm) for Dayton soil. Calcium and magnesium usually are present in adequate quantities when the soil pH is above 5.0.

For situations where Ca is below 5 meq/100 g soil and soil pH is above 5.0, apply 1 t lime/a.

For soils with a pH below 5.5 and soil test Mg of less than 0.5 meq/100 g soil (60 ppm), use 1 t dolomite/a to supply 1 t/a of the lime requirement. Dolomite and limestone have approximately the same capability to neutralize soil acidity and increase soil pH, so dolomite can be substituted for lime. An alternative to dolomite is to broadcast 30 lb Mg/a annually. Compare material costs before choosing a magnesium source.

Spring nutrient management

Nitrogen

Nitrogen is supplied to annual ryegrass from a variety of sources, including crop residue, soil, and fertilizer. Soil can contribute 60 to 100 lb N/a, depending on soil drainage, soil organic matter content, and spring soil temperature.

Apply spring N to annual ryegrass at a rate of 100 to 140 lb N/a. Nitrogen rates higher than 150 lb/a have not been shown to increase seed yield enough to recover the cost of additional fertilizer. Excessive N rates also increase the need for lime. See the sidebar "Effects of N fertilizer on soil acidity" (page 7) for more information.

Figure 6 shows the relationship between annual ryegrass seed yield and spring N application from three research efforts spanning almost 50 years. Although a greater range of spring N application rates was explored in the 2000–2001 trials, the conclusions from all of the trials are similar. In each study, approximately 120 lb N/a was sufficient for optimal annual ryegrass seed yields.

Optimal rates vary due to differences in drainage, organic matter, and management. Soils with more than 5 percent organic matter produce less seed yield increase from N application than do other soils. Thus, an N application of 100 lb/a might be adequate for a Bashaw or Awbrig soil, while 140 lb/a might be needed on a soil with lower organic matter content.

Straw management has little effect on N needs. Residue removal, burning, and tillage have little short-term effect on N supply to the crop. Table 1 (page 3) presents seed yield data when residue is burned or chopped and plowed into the seedbed. When adequate spring N was applied (120 lb/a), yield was identical in fields where straw was burned and in those where straw was incorporated.

Timing

Timing of spring N applications requires consideration of both plant need and field condition. In nongrazed fields, the maximum daily rate of N uptake, 1.5 lb/a, occurs in late March or early April (Figure 1, page 2). On these fields, apply N in mid-March to mid-April unless wet conditions restrict access. In fields that are grazed, apply spring N as soon as sheep are removed from the field.

Nitrogen can be applied in a single or split application. Growers cite evenness of application as a reason for split applications of spring N. However, in Willamette Valley research, no increase in seed yield was obtained from a split application (Table 7). Annual ryegrass fields often remain wet late into the spring (Figure 7), so a single application after fields have dried is an option.

Table 7.—Annual ryegrass clean seed yield from single or split spring N application.

Nitrogen fertilizer application method	Seed yield (lb/a) Site 1	Site 2
Split[a]	2,550	2,385
Single[b]	2,620	2,500

[a]Site 1: Nitrogen application split as 35 lb/a in March and 93 lb/a in April. Site 2: Nitrogen application split as 68 lb/a in March and 63 lb/a in April.

[b]The mid-April single N application rate was 135 lb/a.

Figure 7.—If wet conditions limit field access, a single N application after fields have dried is an option.

Effects of N fertilizer on soil acidity

Use of most common N fertilizers increases soil acidity and lime need. Table 8 shows the effect of increasing N rate on soil pH in four southern Willamette Valley soils. Urea and other ammoniacal N sources acidify soil approximately 0.1 pH unit for each 100 lb N/a. For example, if urea is applied at the rate of 140 lb N/a, soil pH will decrease by approximately 0.14 pH unit. If 140 lb N/a is used for 3 years, soil pH will decline approximately 0.4 pH unit.

Thus, the use of N fertilizer beyond crop need has a double cost. The first cost—the N fertilizer itself—is not offset by increased seed yield or economic return. Second, the additional N acidifies soil, which then requires additional lime to raise the soil pH. Annual application of 50 lb N/a above crop need will require an additional 0.3 to 0.6 t lime/a in 3 years.

Urea, the most common N source for annual ryegrass seed production, is less acidifying than ammonium sulfate because the N in urea undergoes a different process to become plant-available. As urea initially reacts with enzymes in the soil, soil pH rises slightly; this change partially offsets acidification produced by subsequent reactions.

Table 8.—Soil pH from 0- to 2-inch depth, SMP values, and lime rates to raise the soil pH in grass seed fields after 3 years of nitrogen applications at three application rates.[a]

	Dayton silt loam			Concord silt loam			Bashaw silty clay loam				Amity silt loam		
N rate (lb/a)	Soil pH	SMP pH	Lime[b] (t/a)	Soil pH	SMP pH	Lime[b] (t/a)	Soil pH	SMP pH	Lime (t/a)		Soil pH	SMP pH	Lime[b] (t/a)
0	5.9	6.6	0	6.2	6.7	0	5.4	5.3	4.3[c]	6.0[b]	7.1	6.9	0
135	5.5	6.5	1	5.8	6.4	1.1	4.9	5.2	4.7	6.4	6.6	6.7	0
270	5.2	6.2	2	5.6	6.3	1.5	4.8	5.1	5.0	6.9	6.0	6.5	1

[a]Sampled November 2000.
[b]Lime to pH 6.0.
[c]Lime to pH 5.6

Spring fertilizer N economics

Annual ryegrass receiving a spring application of 100 to 140 lb N/a produces approximately 1,000 lb/a more seed than does unfertilized annual ryegrass (Figure 6, page 6). If seed sells for $0.25/lb, the increased yield is worth $250. If N fertilizer costs $0.50/lb, 120 lb N costs $60. Add $5 for application, and the total fertilizer cost is $65. An input cost of $65 produces a return of $250.

Growers sometimes wonder whether they should adjust spring N rates if the price of N fertilizer rises and/or the price for seed falls. The answer is simple: don't change the spring N rate as long as you are applying 100 to 140 lb N/a. Consider the data in Table 9. The table shows the maximum economic N rate when seed prices or fertilizer prices increase threefold. For example, the maximum economic N rate is 117 lb N/a when the seed price is $0.15/lb and the N fertilizer price is $0.20/lb. If the seed price doubles to $0.30/lb, the maximum economic N rate increases by only 5 lb/a to 122 lb/a. Since the price of seed is unlikely to double, the maximum economic N rate will change only slightly.

Table 9.—Maximum economic spring nitrogen rate with varying cost of nitrogen and price received for annual ryegrass seed.

Cost of N fertilizer ($/lb)	Price received for seed ($/lb): $0.15	$0.20	$0.25	$0.30
	Maximum economic N rate (lb/a)			
0.20	117	120	121	122
0.40	108	113	116	117
0.60	99	106	110	113

Conversely, when the fertilizer price triples but the seed price remains unchanged, the maximum economic N rate decreases. Again, the decrease is not large. For example, if seed sells for $0.20/lb and fertilizer N costs $0.20/lb, the maximum economic N rate is 120 lb/a. If the cost of fertilizer N increases to $0.60/lb, the maximum economic N rate is 106 lb/a, a decrease of only 14 lb/a.

In Table 9, the center represents a seed price of $0.20/lb and a fertilizer cost of $0.40/lb. Price changes in any direction will change the maximum economic N rate by less than 10 lb/a. Most fertilizer spreaders cannot be adjusted with this level of precision, nor can fertilizer be spread this evenly.

Growers often increase the N rate in an attempt to increase yield and profit. Figure 6 (page 6) shows the increase in annual ryegrass seed yield from N application. Compare the shape of the line for 2000 and 1954. In both cases, the point of maximum yield occurs at 120 to 160 lb N/a. Increasing the N rate produces a greener plant, but does not increase seed yield. Table 10 further illustrates this point. Increasing the fertilizer rate from 135 lb N/a to 180 lb N/a decreased the net return.

Table 10.—The economics of N fertilizer application on annual ryegrass.[a]

Fertilizer N rate (lb/a)	Clean seed yield (lb/a)	Net return above N cost ($/a)	"Incremental" net return per $ invested ($/a)
0	1,614	0	—
45	2,136	100	$6.65
90	2,428	149	$3.29
135	2,618	176	$1.78
180	2,645	167	$(-0.60)
225	2,645	152	$(-1.00)

[a]Data from OSU spring N fertilizer trials (2000–2001). Price of N = $0.33/lb; price for seed = $0.22/lb.

Potassium

If a soil test indicates a need for K, apply K in the fall. For maintenance purposes, K can be applied in the spring. Application of KCl is not needed in order to supply chloride. See the sidebar "Spring potassium and chloride application" (page 9) for more information.

Sulfur (S)

Annual ryegrass has approximately the same need for S as do other grasses grown for seed in the Willamette Valley. Between 15 and 25 lb S/a is contained in a mature annual ryegrass crop with a 2,000 lb/a seed yield.

Soil testing for S is not recommended. An annual application of 10 to 15 lb S/a is adequate for annual ryegrass production. Sulfur can be applied in the spring or fall, but spring application (with the first N application) is recommended. Sulfur application is not needed every year. Application of 20 to 25 lb S/a can be made every other year.

Plants use S from the soil in the form of sulfate, which is a common component of multinutrient fertilizers such as triple sixteen (16-16-16), 16-20-0-14, and urea-sul.

The use of S-containing materials often raises concern about possible soil acidification and a corresponding need for increased lime. Not all forms of S acidify soil. The application of S in the sulfate form does not increase soil acidity and the need for lime. Although ammonium sulfate acidifies soil, this effect is caused by the oxidation of ammonium to nitrate, not by the presence of sulfate.

Elemental S produces sulfuric acid and increases the long-term need for lime. Elemental S usually is not recommended for use as a fertilizer material in the Willamette Valley.

Spring potassium and chloride application

Potassium (K) application on grass grown for seed has traditionally been made in the fall. In the past decade, some growers began applying K in the spring and reported yield increases. Growers logically asked, "When should K be applied to grass for seed production?" and "Does the chloride (Cl) from a spring application of potassium chloride increase seed yield?"

To answer these questions, a K and Cl trial was established during the spring of 2003 and 2004 in a commercial field of continuous Gulf annual ryegrass near Junction City. The soil series was Bashaw, a typical soil for annual ryegrass production.

Flag leaf samples were collected as heading began to evaluate the influence of K and Cl application on tissue concentration. Both K and Cl tissue concentration increased when these nutrients were added (Tables 11 and 12). The 1,000-seed weight was not changed by Cl or K application.

Seed yield was not increased by K application and was not expected to do so, as soil test K was adequate (138 ppm K in the surface 6 inches). Table 4 (page 4) recommends 0 to 30 lb K_2O/a at this K soil test level. The lowest K application, 44 lb K_2O/a, increased flag leaf K concentration to a value no different than that measured when 88 lb K_2O/a was applied. These data and seed yield data in Tables 11 and 12 substantiate recommendations in Table 4.

When compared to treatments receiving no Cl application, treatments receiving Cl produced an increased seed yield in 2003 but not in 2004.

No explanation for the seed yield increase in 2003 was found, nor did we identify a way to predict a potential seed yield increase from Cl application. Soil test Cl did not predict whether a site would produce increased seed yield from an application of Cl. The Cl soil test from a 1-foot sample collection depth was 88 lb/a, almost triple the value used in North and South Dakota to predict Cl need for wheat production. Their recommendation is to apply Cl if soil test Cl in the top 2 feet of soil is less than 30 lb/a.

Flag leaf Cl concentration was not helpful for identifying an insufficient amount in the plant. In 2004, the flag leaf Cl concentration was 3,108 ppm with no chloride application, and seed yield did not increase with Cl application. In 2003, flag leaf Cl concentration was higher (3,535 ppm), but seed yield did increase with Cl application.

This research is part of a project conducted for 2 years in nine locations with three cool-season grass species grown for seed. Limited and unpredictable seed yield and seed weight increase were measured from Cl application. Annual ryegrass was the only species producing a yield increase from the application of Cl, and the flag leaf tissue Cl concentration from plots with no Cl applied was the highest of the three species.

Our conclusion is that spring application of KCl to supply Cl to annual ryegrass or other grass seed crops is not recommended, as no predictive measurement is available and the seed yield increase from Cl application is not economical when KCl is routinely applied.

Table 11.—Flag leaf tissue chloride, tissue potassium, 1,000-seed weight, and seed yield after spring application of potassium fertilizers, 2003.[a]

Treatment					
K_2O	**Cl**	**Tissue Cl**	**Tissue K**	**Seed wt**	**Seed yield**
(lb/a)		**(ppm)**	**(%)**	**(g/1,000)**	**(lb/a)**
0	0	3,535*a*	0.76*a*	2.55	1,499
88	0	3,675*a*	1.24*b*	2.58	1,461
44	35	5,934*b*	1.37*bc*	2.65	1,535
88	70	7,206*b*	1.56*cd*	2.68	1,525
176	140	11,567*c*	1.77*e*	2.63	1,515
				NS	NS

[a]Values followed by the same letter are statistically different.

Table 12.—Flag leaf tissue chloride, tissue potassium, 1,000-seed weight, and seed yield after spring application of potassium fertilizers, 2004.[a]

Treatment					
K_2O	**Cl**	**Tissue Cl**	**Tissue K**	**Seed wt**	**Seed yield**
(lb/a)		**(ppm)**	**(%)**	**(g/1,000)**	**(lb/a)**
0	0	3,108*a*	1.28*a*	2.90	2,630
88	0	3,154*a*	1.50*b*	2.85	2,758
44	35	4,503*b*	1.42*ab*	2.91	2,696
88	70	6,880*c*	1.54*b*	2.97	2,777
176	140	11,340*d*	1.77*c*	2.93	2,638
				NS	NS

[a]Values followed by the same letter are statistically different.

Micronutrients

No documented increase in growth or seed yield of annual ryegrass from the application of micronutrients has been measured in western Oregon.

Soil test boron (B) levels normally are very low in the Willamette Valley, and tissue and soil test B levels will increase with soil B applications. However, a seed yield increase from an application of B rarely is measured in grass seed crops. No seed yield increase from the application of 1.25 lb B/a was measured in field trials during 2000 (Table 13). Boron applied at 1 lb/a every 3 or 4 years may be used on a trial basis where soil test B is less than 0.3 ppm.

Soil test levels for zinc (Zn) usually are adequate (0.6 ppm). In addition to being plant nutrients, foliar Zn, copper (Cu), and manganese (Mn) have fungicidal properties. Distinguishing between fungicidal and nutritional responses with the use of foliar nutrients is difficult.

Table 13.—Influence of boron applications on annual ryegrass seed yield, flag leaf boron concentration, and boron soil test level.

Boron rate[a] (lb/a)	Soil	Soil test B[b] (ppm)	Flag leaf B[b] (ppm)	Seed yield (lb/a)
0	Dayton	0.2	10	2,143
1.25		0.5	39	2,123
0	Awbrig	0.1	9	2,098
1.25		1.4	42	1,999

[a]Boron applied in March 2000 as dry granular fertilizer mixed with urea.

[b]Soil and plant samples taken May 24, 2000.

For more information

Fertilizer and Lime Materials Fertilizer Guide, FG 52-E (revised 1990). http://extension.oregonstate.edu/catalog/pdf/fg/fg52-e.pdf

Research on which this publication is based

1953, 1954, and 1983–1985: Seed yield was measured on plots receiving a range of N rates. Data is presented in Figure 6 (page 6).

1995: Recycled paper residue at 35 t/a was applied to two farms near Harrisburg, Oregon in September. Soil pH and Ca increased with application of the paper waste, but yield was reduced an average of 270 lb/a. Lower rates than used here are suggested to provide desired soil pH increase and lessen yield reduction.

1996 and 1997: Volunteer seedlings were used to establish plots. Yield of a solid stand was lower than that of a stand treated with glyphosate to create rows. Highest yields were measured with 25 percent stand remaining.

1995–1997: Annual ryegrass was established by conventional tillage and drilling, no-till planting, and with volunteer seedlings where residue was removed by baling or not removed and flail chopped. The conventional plowing and drilling maintained a 3-year average 5 percent yield advantage over the no-till establishment and 16 percent over using volunteer seedlings to establish the crop.

2000 and 2001: Nitrogen was applied at rates of 0 to 270 lb/a at two sites. N rates between 90 and 135 lb/a produced the highest seed yield in three of the four sites.

2000: Treatments of 0 and 1.25 B/a were applied with spring N at two sites. Annual ryegrass seed yield did not increase with B application.

Photo: Mark Mellbye

Figure 8.—Weighing seed from plots in a grower's field.

2003–2004: K_2O rates from 0 to 176 lb/a and Cl from 0 to 140 lb/a were applied to Gulf annual ryegrass in the spring. Soil test K was adequate (138 ppm), and K did not increase seed yield. Chloride application increased seed yield one year. No method exists to predict Cl need, and routine application of KCl for Cl is not recommended. See "Spring potassium and chloride application" (page 9).

2005–2008: Preplant broadcast and incorporated lime was compared to 150 lb lime/a banded at planting, and yield was measured on Dayton soil near Halsey, Oregon. All lime treatments increased seed yield. The 3-year average seed yield for treatments receiving 150 lb/a lime banded at planting were statistically the same as 2.5 and 5 t/a lime incorporated at the beginning of the study.

References

Brown, W.G., T.L. Jackson, and H.W. Youngberg. 1975. Application of Nitrogen for Grass Seed Production—Does It Still Pay? Oregon State University Extension Service. Special Report 435.

Chapin, M.F. and J.H. Huddleston. 1992. Effects of annual ryegrass residue management on Dayton soil organic carbon distribution and related properties. In: W.C. Young III (ed.), 1991 Seed Production Research at Oregon State University, Department of Crop and Soil Science, Ext/CrS 89.

Fitzgerald, M.H., M.E. Mellbye, and D.M. Sullivan. 1998. Liming with recycled paper residue (RPR). In: W.C. Young III (ed.), 1997 Seed Production Research at Oregon State University, Department of Crop and Soil Science, Ext/CrS 111.

Griffith, S.M., S.C. Alderman, and D.J. Streeter. 1997. Italian ryegrass and nitrogen source fertilization in western Oregon in two contrasting climatic years. Growth and seed yield. J. Plant Nutrition 20(4&5):419–428.

Hart, J.M., M.E. Mellbye, G.A. Gingrich, W.C. Young III, T.B. Silberstein, and N.W. Christensen. Spring potassium and chloride application for grass seed production in the Willamette Valley. 2005. In: W.C. Young III (ed.), 2004 Seed Production Research at Oregon State University, Department of Crop and Soil Science, Ext/CrS 124.

Hart, J.M. and M.E. Mellbye. 2010. Annual ryegrass seed production in acidic soil. In: W.C. Young III (ed.), 2009 Seed Production Research at Oregon State University, Department of Crop and Soil Science, Ext/CrS 129.

Jackson, T.L. 1956. The effect of time and rate of nitrogen application on seed production of common ryegrass. In: Proc. 7th Annual Fertilizer Conference of the Pacific Northwest, June 28–30, Yakima, WA.

Jackson, T.L. 1984. Straw decomposition and disease suppression. Report to Field Burning Commission on Interagency Agreement, DEQ Contract No. 15-84, September 28.

Jackson, T.L. and N.W. Christensen. 1985. Nitrogen fertilizer effects on straw decomposition and old crown growth. Report to Field Burning Commission on Interagency Agreement, DEQ Contract No. 10-85, October.

Mellbye, M.E., W.C. Young III, T.G. Chastain, T.B. Silberstein, and C.J. Garbicek. 1998. The effect of straw removal and different establishment systems on soil fertility levels in annual ryegrass seed fields. In: W.C. Young III (ed.), 1997 Seed Production Research at Oregon State University, Department of Crop and Soil Science, Ext/CrS 111.

Mellbye, M.E. 1997. Effect of recycled paper residue soil amendment (RPR) on ryegrass seed yields. In: W.C. Young III (ed.), 1996 Seed Production Research at Oregon State University, Department of Crop and Soil Science, Ext/CrS 110.

Mellbye, M.E. and L. Gerig. 2002. Row Spraying Volunteer Ryegrass. Oregon State University Extension Service. FS 7.

Mellbye, M.E., G.A. Gingrich, and J.M. Hart. 2001. Do grass seed fields in the Willamette Valley need boron fertilizer? In: W.C. Young III (ed.), 2000 Seed Production Research at Oregon State University, Department of Crop and Soil Science, Ext/CrS 115.

Young III, W.C. 1981. Grazing duration effects on seed yield of annual ryegrass (*Lolium multiflorum* L.). M.S. thesis. Oregon State University.

Young III, W.C., T.G. Chastain, M.E. Mellbye, T.B. Silberstein, and C.J. Garbacik. 1997. Crop residue management and establishment systems for annual ryegrass seed production. In: W.C. Young III (ed.), 1996 Seed Production Research at Oregon State University, Department of Crop and Soil Science, Ext/CrS 110.

Young III, W.C., T.G. Chastain, M.E. Mellbye, T.B. Silberstein, and C.J. Garbacik. 1997. Establishment of rows in volunteer annual ryegrass seed crops using a shielded sprayer. In: W.C. Young III (ed.), 1996 Seed Production Research at Oregon State University, Department of Crop and Soil Science, Ext/CrS 110.

Young III, W.C., T.G. Chastain, M.E. Mellbye, T.B. Silberstein, and C.J. Garbacik. 1998. Crop residue management and establishment systems for annual ryegrass seed production. In: W.C. Young III (ed.), 1997 Seed Production Research at Oregon State University, Department of Crop and Soil Science, Ext/CrS 111.

Young III, W.C., D.O. Chilcote, and H.W. Youngberg. 1996. Annual ryegrass seed yield response to grazing during early stem elongation. Agronomy J. 88(2):211–215.

Young III, W.C., M.E. Mellbye, G.A. Gingrich, T.B. Silberstein, T.G. Chastain, and J.M. Hart. 2001. Defining optimum nitrogen fertilization practices for grass seed production systems in the Willamette Valley. In: W.C. Young III (ed.), 2000 Seed Production Research at Oregon State University, Department of Crop and Soil Science, Ext/CrS 115.

Young III, W.C., M.E. Mellbye, G.A. Gingrich, T.B. Silberstein, T.G. Chastain, and J.M. Hart. 2002. Defining optimum nitrogen fertilization practices for fine fescue and annual ryegrass seed production systems in the Willamette Valley. In: W.C. Young III (ed.), 2001 Seed Production Research at Oregon State University, Department of Crop and Soil Science, Ext/CrS 121.

Young III, W.C., B.M. Quebbeman, M.E. Mellbye, and C.J. Garbacik. 1995. Row spraying volunteer annual ryegrass seed crops. In: W.C. Young III (ed.), 1994 Seed Production Research at Oregon State University, Department of Crop and Soil Science, Ext/CrS 102.

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