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Annual Ryegrass Yield Response and Returns to Phosphorus and Potassium Fertilization

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Ryegrass is primarily utilized by grazing throughout the growing season. Historically, grazing has frequently been discontinued on a portion of the acreage during April and early May when forage production is most abundant and ryegrass is harvested as hay. Dairymen have recently begun preserving the ryegrass as silage or haylage rather than as hay. This practice is expanding rapidly because ryegrass silage is high in protein and digestibility and is an excellent complement to corn silage. Milk production from ryegrass silage has been excellent, reflecting the very high forage quality.

Mechanically harvesting ryegrass for hay or silage greatly increases the quantity of nutrients removed by the crop compared to that removed during grazing. Therefore, soil fertility practices become more important for ryegrass production as mechanical harvesting of the crop increases.

Although several studies have shown the effects of nitrogen (N) fertilizer practices on ryegrass production, very little information is available to show the effects of phosphorus (P) and potassium (K) on ryegrass production in Louisiana. A four-year study was completed in 1995 to help determine the P and K requirements for sustained ryegrass production on a low fertility Tangi silt loam soil at the Idlewild Research Station near Clinton. The study was conducted on plots previously used to evaluate effects of P and K rates on white clover production. The rates were not changed when the crop was changed from white clover to ryegrass.

> Annual ryegrass is the most widely grown winter forage crop in Louisiana and throughout much of the southeastern U.S. If properly managed, it produces forage from early November until early May, although growth may stop or be very slow during the coldest period of January and February. It usually yields from 3 to 6 tons per acre and has the highest quality of any of the grasses grown in the region. Although it is normally planted every year, stand failures are rare and it commonly reseeds itself in many situations, making annual ryegrass a very dependable forage crop.

Phosphorus Effects on Ryegrass

The 4-year average results summarized in **Table 1** indicate that forage yield increased as P application increased to the highest level. However, a yield goal of near 90 percent of the maximum yield is generally recommended, and that yield level was obtained with 80 lb/A of P_2O_5. That P rate increased forage yield by 2 tons/A over the yield obtained with no added P, where only 48 percent of the maximum yield was obtained. The forage:P_2O_5 ratio indicates the pounds of forage produced for each pound of P_2O_5 applied. At 20 lb/A of P_2O_5, there was a yield increase of 119 lb of forage for each pound of applied P_2O_5, a very large return. The value decreased as the rate of applied P increased, as would be expected according to the law of diminishing returns. At 80 lb/A of P_2O_5, there was a return of 50 lb of forage per pound of P_2O_5, still a very favorable ratio.

Phosphorus concentration in the ryegrass and total P taken up by the crop increased as the rate of P application increased. Where no P was applied the ryegrass contained 0.13 percent P, and the crop removed 6 lb of P per acre from the soil. With 80 lb/A of applied P_2O_5, those values were 0.23 percent and 20 lb of P. The high P application rate of 320 lb/A of P_2O_5 increased P concentration in the ryegrass to 0.39 percent and P uptake to 38 lb/A, values well above the levels required for 90 percent of maximum yield.

Soil test P values were initially low and remained low at all P application rates of 80 lb/A of P_2O_5 or less, although values increased slightly even at low P application rates. At 160 and 320 lb/A of applied P_2O_5, soil tests reached medium and high levels, respectively. While the 80 lb/A rate of P_2O_5 produced nearly 90 percent of the maximum yield, it was insufficient to increase soil P levels appreciably while producing high yields of ryegrass during the four years of study.

Potassium Effects on Ryegrass

Potassium fertilizer effects on ryegrass are summarized in **Table 2** and indicate that forage yield increased as K application increased to the highest level. Again, as in the case of P application, 90 percent of the maximum yield was obtained well below the highest application rate, near 120 lb/A of K_2O. Furthermore, the yield increase due to applied K was much less than the increase due to applied P. Where no K was applied, the yield averaged 80 percent of the maximum yield. Application of 80 and 160 lb/A of K_2O increased the yield by only 0.4 and 0.6 ton/A, respectively, indicating about 0.5 ton/A yield increase at 120 lb/A of K_2O. The forage: K_2O ratios further reflect the low yield response to applied K. The highest ratio of 19 occurred at 20 lb/A and decreased to about 10 at 120 lb/A of K_2O, and to even smaller values at higher K rates.

Potassium concentration and total K uptake in the ryegrass increased with increasing K rates. Where no K was applied the crop contained 1.23 percent K and removed 102 lb of K per acre from the soil. Application of 80 lb/A of K_2O resulted in 1.56 percent K and 142 lb/A of K removal in the crop. Fertilizing with 120 lb/A of K_2O to produce 90 percent of the maximum yield would have caused the ryegrass to contain about 1.75 percent K and remove about 160 lb of K per acre.

TABLE 1. Phosphorus fertilizer influence on ryegrass yield, P removal, and soil test P levels of Tangi silt loam, 1992-1995.

P_2O_5 applied[1]	Yield of dry forage		Forage: P_2O_5 ratio	Forage P content		Soil test P, 1994
lb/A/yr.	tons/A	% of max.	lb/lb	%	lb/A	ppm
0	2.3	48	–	0.13	6	17
20	3.5	72	119	0.15	11	18
40	4.1	85	91	0.19	16	22
80	4.3	89	50	0.23	20	23
160	4.6	95	29	0.29	27	38
320	4.8	100	15	0.39	38	110

[1]Nitrogen was applied at planting and after each harvest at 50 lb/A.

The high K concentrations and total K removal in ryegrass at the 320 and 640 lb/A rates of K_2O show that the crop will absorb appreciably more K than it needs for maximum growth if the K is available in the soil. At the 640 lb/A K_2O rate, ryegrass contained over 3.5 percent K and removed over 360 lb of K per acre, more than twice the levels required to produce 90 percent of the maximum yield. These results are similar to the results obtained in the P study.

The two highest K rates depressed calcium (Ca) and magnesium (Mg) uptake by ryegrass. While Ca and Mg concentrations in the crop consistently declined with increasing K rates, the effect was most apparent at the two highest rates where K application exceeded the K requirement of ryegrass. The Ca and Mg concentrations at the highest K rate are low enough to cause deficiencies in ruminant animals, a fatal condition called grass tetany. Calculation of the grass tetany index, K/(Ca+Mg) equivalent ratio, at each K rate revealed that dangerously high indices consistently occurred at the highest rate of K_2O and occasionally at 320 lb/A of K_2O.

Soil test K values were initially low and remained low during this study at all rates of K application, although values were highest at the highest application rate. The low soil test values reflect the ability of ryegrass to absorb much larger quantities of K than it needs and further indicate that building up soil test K levels while harvesting high yields of ryegrass may not be practical or desirable. Basing K fertilization rates on the quantity of K removed in the crop would be more economical.

It appears that about 80 lb/A of P_2O_5 and 120 lb/A of K_2O are needed to sustain high yields of mechanically harvested ryegrass. Nutrient removal and fertilizer requirements would be much lower for ryegrass that is utilized by grazing.

Fertilization Costs and Returns

Costs and returns of ryegrass production are presented in **Table 3** from specific fertilizer combinations in which N was held constant at 200 lb/A while P and K rates were varied. Yields from **Table 1** and **2** were used to calculate returns per acre at forage values of $60 and $80 per ton. Returns above fertilizer costs were calculated to show the income available to pay all other production costs at the specific fertilizer rates.

It is apparent that total fertilizer costs did not increase greatly as P and K rates increased within the range where large yield responses occurred. Furthermore, increasing the forage value had a tremendous influence on returns above the fertilizer costs, emphasizing the importance of

TABLE 2. Potassium fertilizer influence on ryegrass yield, K removal, and soil test K levels of Tangi silt loam, 1992-1995.

K_2O_5 applied,[1] lb/A/yr	Yield of dry forage ton/A	Yield of dry forage % of max.	Forage: K_2O lb/lb	Forage mineral content K %	Forage mineral content K lb/A	Forage mineral content Mg %	Forage mineral content Ca %	Soil test K, ppm
0	4.1	60	–	1.23	102	0.31	0.67	49
20	4.3	64	19	1.25	110	0.31	0.69	35
40	4.4	86	15	1.33	116	0.30	0.66	30
80	4.5	88	11	1.56	142	0.28	0.64	31
160	4.7	93	8	1.97	188	0.27	0.61	34
320	4.9	96	5	2.84	258	0.23	0.56	23
640	5.1	100	3	3.50	362	0.18	0.46	76

[1]Nitrogen was applied at planting and after each harvest at 50 lb/A.

producing and marketing high quality forage through good management practices.

Returns above fertilizer costs increased as K_2O application rates increased to 60 and 120 lb/A, especially at the forage value of $80/ton. Returns to K application were less than returns to P application, reflecting the lower yield response to K than to P.

Summary

Annual ryegrass is utilized primarily by grazing beef and dairy animals but is also harvested as hay and silage. Mechanical harvesting of high-yielding ryegrass removes large quantities of P and K from the soil. A 4-year experiment with P and K fertilizer rates showed that high-yielding ryegrass required about 80 lb/A of P_2O_5 and 120 lb/A of K_2O to produce 90 percent of the maximum yield or about 4.5 tons/A when harvested mechanically. At that fertilization rate, the crop contained 0.23 percent P and 1.75 percent K, indicating that these levels were sufficient for the ryegrass but did not raise the low soil test P and K levels. Economic returns above fertilizer costs were maximized at or near the rates of 80 lb/A of P_2O_5 and 120 lb/A of K_2O in this study. BC

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TABLE 3. Costs and returns from fertilizing annual ryegrass for forage production in Louisiana.[1]

Fertilizers applied, lb/A $N-P_2O_5-K_2O$	Yield of dry forage, tons/A	$N-P_2O_5-K_2O$ Fertilizer $/A	Returns from forage $/A — Hay @ $80/ton Total	Hay @ $80/ton Above fert. cost	Hay @ $60/ton Total	Hay @ $60/ton Above fert. cost
200-0-120	2.3	78	185	107	139	61
200-40-120	4.4	86	330	242	247	159
200-80-120	4.3	98	344	246	258	180
200-160-120	4.6	118	370	252	277	169
200-320-120	4.8	158	387	229	290	132
200-80-0	4.1	80	329	249	247	167
200-80-60	4.4	89	358	269	268	179
200-80-120	4.6	98	371	273	278	180

[1]Fertilizer costs per acre were calculated by assuming N, P_2O_5 and K_2O costs to be 30, 25, and 15¢ per pound and the value of forage to be $80 and $60 per dry ton.

Cover Crops, Soil Quality, and Ecosystems Conference Set for March 12-14, 1997

The Soil and Water Conservation Society (SWCS) has scheduled a conference to look at the effects of cover crop management systems on soil quality in the context of soil pedons, watersheds and associated ecosystems. The program will be March 12-14, 1997 at Sacramento, California. PPI is a co-sponsor.

The conference will provide a forum for research scientists, farmers, agricultural advisers, product developers, and policy makers to discuss and identify possible enhancement of acceptability of such crop management systems. International community involvement is encouraged. More information is available from SWCS –

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