USING HAY TESTS SAMPLES TO MAXIMIZE ECONOMIC RETURNS FROM P AND K FERTILIZATION

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ABSTRACT

Developing critical plant nutrient levels in-season improves recommendations and applications, saving producers time, expense and effort since many growers take samples for hay quality. Three experiments were designed as follows: 1) Phosphorus (P) Rate study with differing rates of P_2O_5 using monoammonium phosphate (MAP); including: 0, 30, 60, 120, 240 lb P_2O_5 acre^{-1} on a low testing P soil <10 ppm (Olsen P method); 2) Potassium (K) Rate study with differing rates of K_2O using potassium sulfate: 0, 40, 80, 160, 240, 320 lb K_2O acre^{-1} on an <100 ppm K soil (ammonium acetate method). The following is summation of three field years of results for alfalfa harvested at mid-bud stage for all cuttings in the same field. Increasing P rate from 0 to 240 lb P_2O_5 acre^{-1} increased yield by 0.9, 1.5 and 1.6 tons acre^{-1} in 2018, 2019, and 2020, respectively. Averaged over years and assuming \$0.54 lb P_2O_5, the whole plant tissue level at the economic optimum was 0.36 and 0.37% at mid-bud stage for 150 and \$200 ton^{-1} of hay, respectively. If the price per lb P_2O_5 is increased by 40 or 60% then optimum economic fertilizer rate is decreased by 17% and 42%, respectively for \$150/ton hay and 12% and 27% respectively, when hay price is \$200/ ton. No potassium response was found in 2018 but yield increased 1.14- and 1.26-tons acre^{-1} in 2019 and 2020 respectively. About 80% of yield response occurred in the first and second cuttings indicating that P and K need to be applied in the fall or early spring to get the largest yield response. Potassium content in alfalfa varied widely between years optimum K content for the two years but the optimum for \$200 ton^{-1} hay, when the price lb of K_2O is was \$0.36, is 1.9 and 1.6% for 2019 and 2020, respectively. If the price per lb K_2O is increased by 40 or 60% then optimum economic fertilizer rate is decreased by 22% and 78%, respectively for \$150/ton hay and 14% and 42% respectively, when hay price is \$200/ ton.

Keywords: Alfalfa, Phosphorus, Potassium, Yield, Fertilizer Economics

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TRATIONAL AND OBJECTIVES

1) Develop and calibrate phosphorus (P_2O_5) & potassium (K_2O) nutrient recommendations for bud stage alfalfa using tissue testing for maximum profit, yield and direct comparison to current soil testing recommendations. 2) Compare efficacy of combinations of monoammonium phosphate (MAP) and struvite (magnesium ammonium phosphate, $MgNH_4PO_4 \cdot 6\ H2O$) for fertilization of alfalfa. 3) Evaluate quality of hay samples at different P_2O_5 and K_2O rates and tissue concentrations.

STUDY DESCRIPTION

Plot Layout: Three alfalfa research studies (P Study, K Study, and Struvite Study) were grown near Prosser, WA in South Central WA in a low P & K testing soil from 2018-2020.
P Study: Differing rates of P_2O_5 using MAP; including: 0, 30, 60, 120, 240 lbs./acre.
K Study: Differing rates of K_2O using potassium sulfate: 0, 40, 80, 160, 240, 320 lbs. K_2O/acre
Analysis: Dry matter analyzed for yield, P or K content (ICP method), hay quality (NIRS method).

RESULTS FOR PHOSPHORUS STUDY

Table 1. Hay phosphorus (P) content's impact on dollars lost by misapplying P and amount of P to adjust next years rate. The optimal P content was found to be 0.36 and 0.37 % P for $150 and $200 per ton hay, respectively. Optimum P content was based on mid-bud stage hay harvested and averaged over three years (1998-2000) under irrigation near Prosser, WA. The optimal P content should be applicable of a wide range of locations, however economics will vary based on productivity of the field. This field was harvested five times and yielded approximately 10 tons acre in years 2 and 3. Averaged over years and assuming $0.54 lb P_2O_5, the whole plant tissue level at the economic optimum was 0.36 and 0.37% at mid-bud stage for 150 and $200 ton^{-1} of hay, respectively. If the price per lb P_2O_5 is increased by 40 or 60% then optimum economic fertilizer rate is decreased by 17% and 42%, respectively for $150/ton hay and 12% and 27% respectively, when hay price is $200/ ton. Sixty-seven percent of the yield increase was in the first and second cuttings.

Table 1. Impact of applying suboptimal phosphorus fertilizer rates on a 3 year stand of alfalfa with low P soil test.

Hay Phosphorus (P) Content	**Amount to increase or decrease (P) rate next year based on $0.538/ lb of P_2O_5**		**Dollars lost by misapplying P over 3 years**	
%	($150 ton^{-1} hay)	@$200 ton^{-1} hay	@$150 ton^{-1} hay	@$200 ton^{-1} hay
0.24	150	160	330	522
0.26	130	140	250	406
0.28	110	120	175	294
0.30	80	100	108	193
0.32	60	70	52	104
0.34	30	40	12	35
0.36	-10	0	2	0
0.38	-80	-70	99	92

Table 2. Influence of price of phosphorus fertilizer price on optimal economic rate of P_2O_5 based on research at Prosser, WA from 2018-2020.

Fertilizer Price Of MAP (11-52-0)	**Hay Price $150 per Ton**	**Hay Price $200 per Ton**	**Hay Price $250 per Ton**
	Decrease in Optimum Fertilizer Rate lbs P_2O_5/acre / (% decrease)/ Optimal % P Conc.		
Base Price $ 560/Ton of MAP ($0.54 lb P_2O_5)	0/(0%)/0.36	0/(0%)/0.37	0/(0%)/0.38
40% increase in Fert. Price $784/Ton ($0.75 lb P_2O_5)	21/(17%)/0.35	19/(12%)/0.36	15/(9%)/0.37
80% Increase in Fert. Price $1008/Ton ($0.97 lb P_2O_5)	51/(42%)/0.33	39/(27%)/0.35	31/(19%)/0.36

RESULTS POTASSIUM STUDY

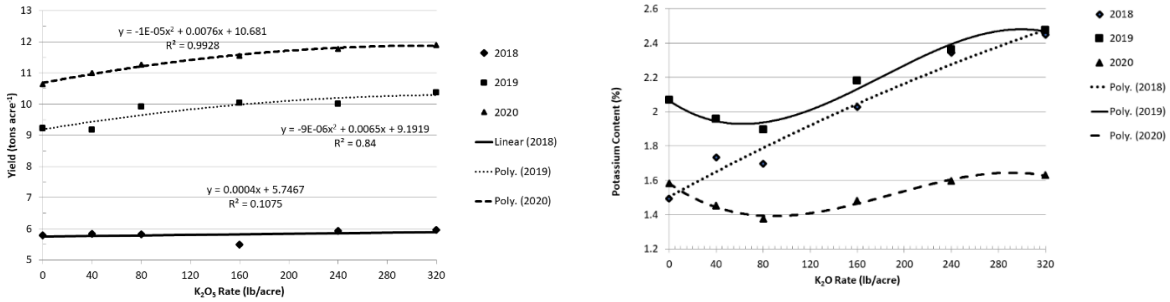

Figure 1a & 1B. Yield (1A left figure) and above ground biomass (1B right figure) of mid bloom alfalfa and as influenced by potassium rate (K_2O lb/acre) in each of the three years 2018-2020.

DISCUSSION OF FIGURES 1A and 1B

Left figure shows yield increases occurred with applications of potassium sulfate in 2019 and 2020. No yield response was found in the year of spring establishment 2018. Potassium contents of the forage is shown in the figure on the right. In 2020, the third year of the experiment, application of K_2O failed to match the K forage content in the hay in the previous two years as both K accumulated was less and increased yield diluted K content. Optimum potassium tissue concentration for $200/ton hay without quality consideration was 1.9 and 1.6% in 2019 and 2020 respectively. In 2019, RFQ was increased from 182 to 255 by increasing rate to 320 lb/K_2O per acre. During the three years the 320 lb/acre treatment soil available K decreased in the soil from 92.8 ppm in spring of 2018 to 62 ppm in the fall of 2020, a 33% reduction from beginning to end of the experiment. A total of 960 lb/a K_2O was applied in three years, however 1,166 lb/a K_2O was removed in the hay.

Table 3. Influence of potassium fertilizer price on optimal economic rate of K_2O based on research at Prosser, WA from 2018-2020.

Fertilizer Price Of KCl- (0-0-60)	**Hay Price $150 per Ton**	**Hay Price $200 per Ton**	**Hay Price $250 per Ton**
	Decrease in Optimum Fertilizer Rate (lbs K_2O/acre) / (% decrease)		
Base Price $ 432/Ton KCl^- Or $0.36 lb K_2O	0/(0%)	0/(0%)	0/(0%)
40% increase in Fert. Price $605/Ton KCl^-, $0.50 lb K_2O	46/(22%)	34/(14%)	28/(11%)
80% Increase in Fert. Price $950/Ton KCl^-, $0.79 lb K_2O	169/(78%)	102/(42%)	82/(31%)

MANAGEMENT RECOMMENDATIONS/CONCLUSIONS:

- To maximize economic return, phosphorus content of alfalfa hay should use your hay test sample to determine percent P and follow recommendations in Table 2 based on hay price and price per pound of P_2O_5 when harvested at mid-bud stage for hay. This is higher than published elsewhere.
- Price of fertilizer significantly influences the rate of fertilizer to put on and you can use the percentages above 2 and 3 to adjust rates.

- The optimum K concentration for the two years was 1.9 and 1.6% for 2019 and 2020, however, since there are significant differences between years continue to use soil tests for this nutrient.