ECONOMICS OF ALFALFA FERTILIZATION UNDER INFLATED HAY AND FERTILIZER PRICES

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ABSTRACT

Knowing critical alfalfa nutrient levels in-season improves recommendations and applications, while at the same time saves producers time, expense and effort since many growers take samples for hay quality. Inflation has doubled hay and fertilizer prices which brings into question how current fertility decisions are made. From 2019-2020 detail information on phosphorus and potassium response was conducted. Two 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 second and third years of production (2019-2020) were used for determining P and K rates and yields. Alfalfa was harvested at mid-bud stage for all cuttings. Fall phosphorus soil tests levels were 6.7 and 5.7 ppm at the beginning of 2019 and 2020, respectively. Spring soil test levels for potassium study were 86 and 79 ppm at the beginning of 2019 and 2020, respectively. Failing to apply fertilizer in this experiment reduced yields by 15% for phosphorus and 11% for potassium. The lb P_2O_5 acre^{-1} that maximized gross income after fertilizer costs varied from 166 to 69 lb P_2O_5 acre^{-1} and from 307 to 0 lb K_2O acre^{-1} depending on price of hay and fertilizer. The optimum P level in the harvested hay was 0.41% prior to 2020. Potassium tissue levels were not found to be helpful recommending K rates as dilution of the nutrient occurred as yields increased. Optimized fertilizer rates guidance must consider both hay value and nutrient costs and adjustment values are provided for inflation.

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

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OBJECTIVE

To develop and calibrate phosphorus (P_2O_5) & potassium (K_2O) nutrient recommendations for irrigated bud stage alfalfa in the PNW using tissue testing for maximum profit and yield influenced by prices of fertilizer and hay.

STUDY DESCRIPTION

Plot Layout: Two alfalfa research studies (P Study, K Study) were grown near Prosser, WA in South Central WA in initial low P (add test and P ppm) & K (add test and K ppm) testing soil from 2019-2020.
P Study: Differing rates of P_2O_5 using MAP; including: 0, 30, 60, 120, 240 lb. acre^{-1}.
K Study: Differing rates of K_2O using potassium sulfate: 0, 40, 80, 160, 240, 320 lb. K_2O/acre
Analysis: Dry matter analyzed for yield, P or K content (ICP method).
Funded: Three years of funding was received from National Alfalfa and Forage Alliance and one year of funding from Washington State Hay Growers Association.

RESULTS FOR PHOSPHORUS AND POTASSIUM STUDIES

Fall phosphorus soil tests levels were 6.7 and 5.7 ppm at the beginning of 2019 and 2020, respectively (Figure 1a and 1b). Spring soil test levels for potassium study were 86 and 79 ppm at the beginning of 2018 and 2019, respectively. Failing to apply fertilizer in this experiment reduced yields by 15% for phosphorus and 11% for potassium (Figure 1a & 1b). Results were similar for both years, so they were combined over years for each nutrient.

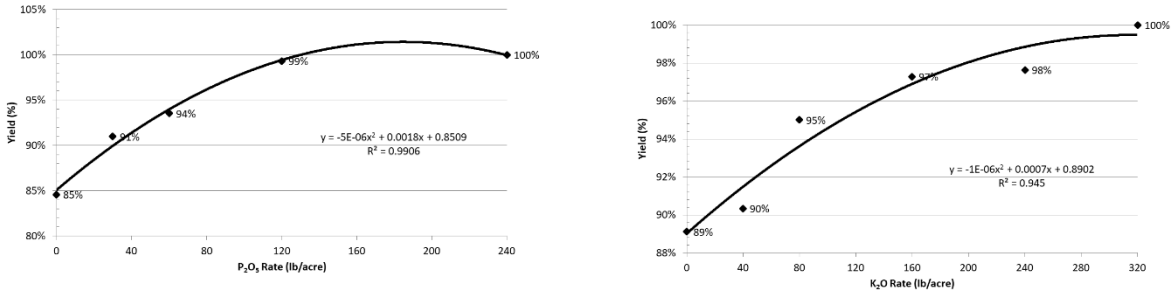

Figure 1a and 1b. The influence of P_2O_5 (Fig 1a) and K_2O (Fig 1b.) on yield of alfalfa averaged over the 2nd and 3rd years (2019 & 2020) of production at the Irrigated Research and Extension Center located near Prosser, WA.

The lb P_2O_5 acre^{-1} that maximized gross income after fertilizer costs varied from166 when P_2O_5 acre^{-1}when hay prices were \$300 ton^{-1} and fertilizer was \$0.54 lb P_2O_5 to as low as 69 lb P_2O_5 acre^{-1} when alfalfa hay was \$150 ton^{-1} and fertilizer was \$1.56 lb P_2O_5 (Table 1). This shows that in the new world of inflation prices for both hay and fertilizer need to be put into fertilizer recommendations.

The increased price of fertilizer can be so high when hay prices low that no amount of potassium would pay for itself, even in this responsive soil, which is the situation is when alfalfa

Table 1. Influence of price of phosphorus fertilizer price on optimal economic rate (P_2O_5) and optimal phosphorus concentration of second cut harvested alfalfa forage at Prosser, WA from 2019-2020.

Fertilizer Price Of MAP (11-52-0)	**Hay Price $150 per Ton**	**Hay Price $225 per Ton**	**Hay Price $300 per Ton**
	Opt. Fert. Rate (lb P_2O_5/acre) / % of Base Price / Opt. % P Conc.		
Base Price $ 560/Ton of MAP ($0.54 lb P_2O_5)	146/(100%)/0.41	159/(100%)/0.42	166/(100%)/0.43
95% increase in Fert. Price $1090/Ton ($1.04 lb P_2O_5)	107/(73%)/0.38	134/(84%)/0.40	147/(89%)/0.41
189% Increase in Fert. Price $1620/Ton ($1.56 lb P_2O_5)	69/(47%)/0.34	109/(69%)/0.38	129/(78%)/0.40

Table 2. Influence of potassium fertilizer price on optimal economic rate of K_2O based on research at Prosser, WA from 2019-2020.

Fertilizer Price Of KCl- (0-0-60)	**Hay Price $150 per Ton**	**Hay Price $225 per Ton**	**Hay Price $300 per Ton**
	Optimum Fertilizer Rate (lb K_2O/acre) / (% of base price rate)		
Base Price $ 446/Ton KCl^- 0-0-60 Or $0.37 lb K_2O	204/(100%)	246/(100%)	265/(100%)
122% increase in Fert. Price $990/Ton KCl^-, $0.83 lb K_2O	44/(22%)	144/(59%)	191/(72%)
244% Increase in Fert. Price $1534/Ton KCl^-, $1.28 lb K_2O	0/(0%)	43/(17%)	116/(44%)

hay is $150 ton^{-1} and the price of potassium is $1.28 lb K_2O (Table 2). Return on fertilizer is even more difficult if your goal is to maximize yield or replace nutrients removed (Table 3). When 0-0-60 price is increased from $0.37/lb of K_2O to $1.27/lb of K_2O the increased cost of the application over the optimum return on fertilizer went from $34 to $307 $acre^{-1}$. Farmers are already struggling so this increased cost may make it economically unsustainable for fertility to replace all the nutrients harvested and hauled off the field. Only the 120 and 240 lb P_2O_5 $acre^{-1}$ treatments maintain or increased P fertility and only the 320 lb K $acre^{-1}$ rate maintained the K soil fertility (data not shown).

Of the yearly increase in yield by fertilizer by type, the percent of the yield increase for the year by applying the fertilizer primarily occurred in the first two cuttings with it accounting for 79% P yield increase and 80% K yield increase, with first cutting providing 55% P and 54% K of the yield increases (data not shown).

Table 3. Impact of fertilizer price on optimum potassium fertilizer rate and cost per acre depending on the agronomic goal.

Goal	**Optimum Fertilizer Rate with Fertilizer Price (0-0-60)**		
	\$446/ton of Fert. (\$0.37/lb of P_2O_5)	\$990/ton of Fert. (\$0.83/lb of P_2O_5)	\$1,534/ton of Fert. (\$1.27/lb of P_2O_5)
Optimizing Annual Profit	265 lb acre^{-1}	191 lb acre^{-1}	116 lb acre^{-1}
Total K Replacement Rate or Maximizing Yield	356 lb acre^{-1}	356 lb acre^{-1}	356 lb acre^{-1}
Increased Fert. Cost \$/acre	\$34 acre^{-1}	\$137 acre^{-1}	\$307 acre^{-1}

Table 4. Impact of misapplying phosphorus to alfalfa at two scenarios, before inflation and after inflation. Different levels of second cut alfalfa tissue phosphorus concentration with 0.41% being optimum.

2nd Cut Harvest P Conc. (%)	Lbs of P_2O_5 to reach this from previous 0.01 %	Amount of P_2O_5 required to reach Optimum %	Dollars lost acre^{-1} year^{-1} for misapplying P when P is \$0.54 lb of P_2O_5 and Alfalfa is \$150 ton^{-1}	Dollars lost acre^{-1} year^{-1} for misapplying P when P is \$1.04 lb of P_2O_5 and Alfalfa is \$300 ton^{-1}
0.27	8	133	119	251
0.29	8	118	94	199
0.31	8	102	71	149
0.33	8	85	49	105
0.35	9	67	31	66
0.37	10	47	15	33
0.39	11	25	4	10
0.41	13	0	0	0
0.43	16	-29	5	10
0.45	20	-65	27	54

Recent global inflation has more than doubled the cost of misapplying phosphorus from both under and over applying fertilizer (Table 4). Interestingly, since both hay price and fertilizer price has increased the optimum of 0.41% P concentration in the harvested hay at second cut mid bud stage remains the same. Second cutting was used as the data was less variable in the samples taken. Table 4 also shows the amount of P_2O_5 needed to increase forage content by 0.01%. This amount will likely vary based on yield potential in other fields. Potassium tissue levels were not found to be helpful recommending K rates. This may have occurred as dilution of the nutrient occurred as yields increased. In the new inflationary times, we must adjust fertilizer rates to consider both hay and nutrient costs.

MANAGEMENT RECOMMENDATIONS FOR ADJUSTING FERTILZER RATES:

Phosphorus

- First, gather any hay tests that you have taken for second cut hay that has a % P of the hay. If you have no P contents from hay tests, use adjustment factor in Table 5 and multiply this number to your soil test number to get an adjusted soil test for inflation.
- Second, do your best to estimate the cost of P fertilizer and value of alfalfa hay and determine the box in table 1 that best matches your condition.
- Third, determine if your hay tests % P are similar to the suggested P concentration and determine the difference.
- Fourth, use table 4, second column, to add or subtract lb. P_2O_5 to get to the desired P concentration in the hay in table 1. Remember the number in each row is for a 0.1% increase or decrease for that tissue content. For instance, to get from 0.35 to 0.41% P. The difference is 0.6 increase needed. On average it takes about 11 lb per 0.1% increase (Avg of 10,11,13). So 6 times 11 would be an increase of 66 lb. **Add or subtract this amount to last years application amount.**

Potassium

- Do your best to estimate the cost of K fertilizer and value of alfalfa hay and determine the box in table 2 that best matches your condition and use the rate in the box in Table 6. For instance, you think at your next application you will have fertilizer price at \$990 Ton^{-1} KCl^- (0-0-60) which is \$0.83 lb K_2O and alfalfa hay will be \$300 ton^{-1}. That box has 0.94 in it.
- Take your recommended soil test rate from your soil sample and multiply it by 0.94 and this is your new adjusted rate for inflation.

Alternative - Request an excel spreadsheet that you can put the numbers into and get a recommendation based on our results. Contact Steve Norberg at s.norberg@wsu.edu .

Table 5. Adjustment factors for phosphorus fertilizer rates for different hay and phosphorus prices.

Fertilizer Price Of MAP (11-52-0)	**Hay Price $150 per Ton**	**Hay Price $225 per Ton**	**Hay Price $300 per Ton**
	Opt. Fert. Rate (lb P_2O_5/acre) / % of Base Price / Opt. % P Conc.		
Base Price $ 560/Ton of MAP ($0.54 lb P_2O_5)	1.00	1.09	1.14
95% increase in Fert. Price $1090/Ton ($1.04 lb P_2O_5)	0.73	0.92	1.01
189% Increase in Fert. Price $1620/Ton ($1.56 lb P_2O_5)	0.47	0.75	0.88

Table 6. Adjustment factors for potassium fertilizer rates for different hay and phosphorus prices.

Fertilizer Price Of KCl^- (0-0-60)	**Hay Price $150 per Ton**	**Hay Price $225 per Ton**	**Hay Price $300 per Ton**
	Optimum Fertilizer Rate (lb K_2O/acre) / (% of base price rate)		
Base Price $ 446/Ton KCl^- 0-0-60 Or $0.37 lb K_2O	1.00	1.21	1.30
122% increase in Fert. Price $990/Ton KCl^-, $0.83 lb K_2O	0.22	0.71	0.94
244% Increase in Fert. Price $1534/Ton KCl^-, $1.28 lb K_2O	0.00	0.21	0.57