THE UNIVERSITY OF ARIZONA
Cooperative Extension

az1833 July 2020

Improving Alfalfa Yield with Applications of Balanced Fertilizers

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Introduction

Alfalfa (*Medicago sativa L.*) has an annual economic value of $9 billion in the United States (USDA NASS, 2018). In Arizona, there are currently 260,000 acres of alfalfa producing 2.16 M tons of hay with a cash value of $451 million. Increasing the productivity and improving the profitability of alfalfa in the low desert southwest United States is of great importance for dairies and livestock. Growers intensively manage and frequently harvest alfalfa to achieve and sustain high yields with high nutritive value that dairies depend upon.

Among the potentials for enhancing production, profitability, and nutrition efficiencies is through effective use of fertilizers. For many soils in the low desert of Arizona, phosphorus (P) as a phosphate fertilizer is very commonly applied prior to planting alfalfa. Potassium (K) is assumed to be abundantly available in desert soils; therefore, not typically applied to crops. Nitrogen (N) fertilizer is generally not applied for alfalfa production since alfalfa can obtain its own N from N-fixing nodules. Specific information about the interactions and effects of P and K on alfalfa yield and quality for Arizona has not been developed. The University of Arizona Cooperative Extension Field Crop Program investigated and demonstrated the importance of balanced fertilizer applications to maximize alfalfa yield.

Rational for Research

Frequent alfalfa harvesting may lead to reduction in yield and stand persistence (Brink and Marten, 1989). To sustain yields and maintain stand persistence, alfalfa fertilization with P and K becomes increasingly important as management intensifies (Kafkafi *et al.,* 1977). Proper P nutrition is essential to maximize alfalfa stand development, productivity, and persistence (Berg *et al.,* 2007). Currently, Arizona alfalfa production systems are not fertilized with K due to the assumed high levels of total K in the low desert soils. Potassium is usually at high concentrations in the desert soils of California and Arizona; although K deficiency in alfalfa can occur on sandy soils and on soils with a history of crops that remove a large amount of K such as alfalfa and cotton (Clark *et al.,* 2017). The response of alfalfa to potassium (K) fertilizer often varies with soil type, the initial soil test P and K levels, irrigation and harvest management, and yield level (Abdel & Westfall, 2005). Alfalfa can remove large amounts of K (60 lb/ton) under intensive production systems (Robert, 2004) such as those in Arizona.

For decades, in many intensive agricultural systems, producers increased single, high nutrient P fertilization inputs in order to achieve higher yields, often leading to soil nutrient accumulation (Pizzeghello *et al.,* 2011). There has been research suggesting that a balanced application of P and K fertilizers is needed to achieve increased yield and extend stand longevity rather than single high nutrient applications (Berg *et al.,* 2007). Another study revealed that the imbalance of soil P and K may result in reduced crop yields and that balanced levels of P and K have a positive effect on yield in soils where K is not lacking (Lissbrant *et al.,* 2010).

Impact on Yield

A field trial was conducted during two growing seasons (2018 and 2019) on a sandy clay loam soil at The University of Arizona Maricopa Agricultural Center (MAC). The non-dormant (fall dormancy = 9.0) October planted alfalfa crop was used. A factorial combination of three fertilization rates of P and three of K were compared in a randomized complete block design with four replications of each plot 400 ft^2.

The results of two years study revealed that the 100 and 125 lb P_2O_5 acre^{-1} rates significantly ($P<0.05$) increased alfalfa yield compared to the unfertilized check. A slight trend of higher yield was observed due to application of K, but no significant difference was detected. However, the yield (14.9 T/A) obtained from P & K combination rate of 125 lb P_2O_5 acre^{-1} and 100 lb K_2O acre^{-1} was significantly higher than the unfertilized plot (12.9 T/A) or K fertilized plot alone (Table 1).

Application of P & K blends produced a greater yield than P & K individually. Percent yield increase (Figure 1) due to a combination of P & K fertilizers over the unfertilized control plot ranged from 7.0% to 14.7% in 2018 (eight cuttings) and 2.6 to 12.4 percent in 2019 (six cuttings).

In 2018, blends of 125 lb P_2O_5 acre^{-1} and 100 lb K_2O acre^{-1} increased hay yield by 2.6 T/A (14.7%) over the unfertilized control, 0.6 T/A (3.4%) over the P fertilized plot alone, and 1.5 T/A (8.3%) over the K fertilized plot alone or an average increase of 5.9% more than the average of when each was applied alone (Table 2). In 2019, P and K fertilizer blends increased hay yield by 1.5 T/A (12.4%) over the unfertilized control, 0.8 T/A (6.2%) over the P fertilized plot alone, and 1.0 T/A (8.4%) over the K fertilized plot alone or an average increase of 7.3% more than when each was applied alone. The results demonstrated that the 125 lb acre^{-1} P_2O_5 rate combined with 100 lb acre^{-1} K_2O appeared adequate to maximize yield as compared to higher P or K fertilizers alone. More research is needed to refine P and K fertilizer recommendations to evaluate the cost-benefit advantage for irrigated alfalfa hay production in the low deserts of Arizona.

Table 1. Alfalfa hay yield as affected by three P fertilization rates in combination with three K fertilization rates in 2018 & 2019 growing season at Maricopa Ag Center. Data are the means of four replicates.

P_2O_5	K_2O	2018	2019	Average
lb acre^{-1} yr^{-1}		Tons acre^{-1}		
0	0	14.99c	10.72c	12.86c
0	100	16.12bc	11.21bc	13.66bc
0	300	16.38abc	11.01bc	13.69bc
100	0	16.97ab	11.96ab	14.47ab
100	100	17.24ab	11.55abc	14.40ab
100	300	17.40ab	11.70ab	14.55ab
125	0	16.94ab	11.47abc	14.20ab
125	100	17.57a	12.24a	14.90a
125	300	17.20ab	11.95ab	14.57ab

† Within a column, values followed by the same letter are not significantly different at 0.05 level of probability (Student's t-test).

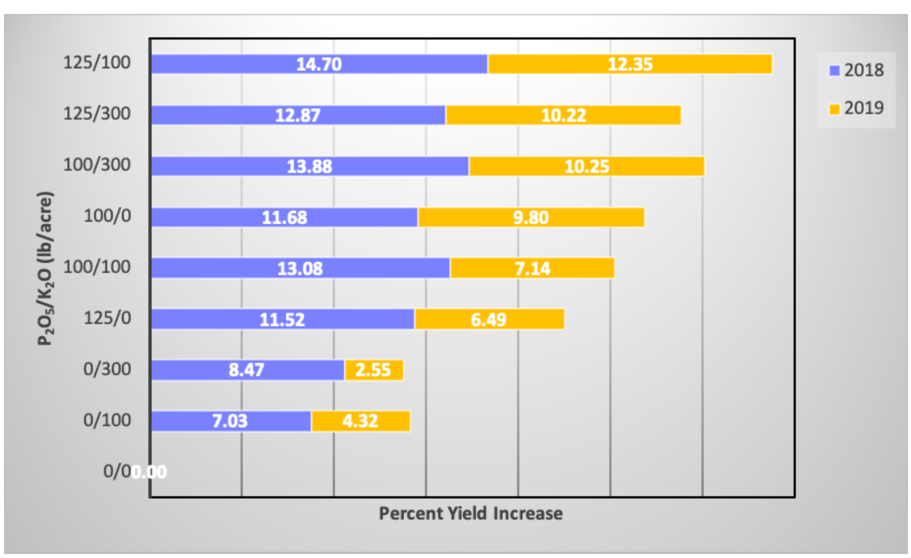

Fig. 1. Percent alfalfa yield increase due to P & K combination over untreated control.

Table 2. Balanced P and K Fertilizers effect on alfalfa yield at Maricopa Ag Center.

P_2O_5 (lb. acre^{-1})	K_2O (lb. acre^{-1})	Code	2018		2019	
			Yield (tons acre^{-1})	Response (tons acre^{-1})	Yield (tons acre^{-1})	Response (tons acre^{-1})
0	0	Unfertilized	15.0	-------	10.72	-----
0	100	K alone	16.1	1.13	11.20	0.48
125	0	P alone	17.0	1.95	11.47	0.75
125	100	PK	17.6	2.6	12.23	1.51
Ave (P + K)			16.5	1.54	11.34	0.62
PK-(Ave (P + K)			1.0	5.92%	0.89	7.28%
Yield advantage of PK over individual components						
PK over P alone			0.63 (3.59%)		0.76 (6.21%)	
PK over K alone			1.45 (8.25%)		1.03 (8.42%)	

Acknowledgement

This research has been supported by funding from the University of Arizona Extension Strategic Investment Program (ESIP), and Maricopa County Electric District #8. We would like to thank Kyle Harrington, Lauren Tomlin and Marisa Noble for their technical help.

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