Nutrient Management for Alfalfa Grown on Acid, Hilly Regions of Chongqing

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Researchers found that the optimal fertilizer treatment for alfalfa production in the hilly areas within Chongqing, China included not only N, P, and K, but also Mg — at a frequency of once every 2 or 3 years. While not impacting yield, inclusion of Mo in the balanced, optimal treatment may result in cases of higher crude protein and enhanced palatability of alfalfa forage.

Alfalfa is an important forage used for livestock and poultry feed in China. Recently, the area under alfalfa cultivation has been expanding rapidly within the "hilly regions" of Chongqing located in southwest China. However, little information is available on the best nutrient management practices for alfalfa and this is resulting in a continuation of low yields and farmer profitability.

A project was launched in 2007 to investigate the optimal fertilizer rates and combinations for high yielding, profitable alfalfa. The study was conducted on a slightly acid, purple soil in Gaojia village, Bishan county. Surface (0 to 15 cm) soil samples were collected from the field after harvesting the previous mustard (*Brassica juncea var. foliosa*) crop. These samples were then analyzed by the National Laboratory of Soil Testing with ASI method (Portch and Hunter, 2005) **(Table 1)**. The soil was determined to be high in P, K and Zn, medium in N, but deficient in Mg and B.

Table 1. Some selected properties of the experimental soil (ASI method).

OM, g/kg	pH	NH_4-N	P	K	B	Mg	Zn
		mg/L					
15.8	6.2	73	28	117	0.1	87	2.5

The experiment was set up in a randomized complete block design with three replications. An OPT NPK treatment was identified by soil test as 90-120-150 kg N-P_2O_5-K_2O/ha **(Table 2)**. The inclusion of N in the treatment set is based on prior field research with alfalfa (and peanut), which indicates that fertilizer N is required to maximize biomass production of legumes in Chongqing. Other treatments described here include the combination of 90 kg N/ha with three rates of P (0, 60, 120 kg P_2O_5/ha), three rates of K (0, 75, 150 kg K_2O/ha) and either Mg (15 kg Mg/ha), B (15 kg borax/ha), or Mo (5 g ammonium molybdate/kg seed). Other sources of fertilizers were urea for N, single superphosphate for P, potassium chloride for K, and magnesium sulfate for Mg. All the fertilizer P, Mg, and B were applied at seeding (a basal dose). Fertilizer N application was split between basal (60%) and topdress (20% each at the 2-leaf and shoot branching stages) applications. Fertilizer K was split between a basal dose (50%) and a topdressing (50%) at the shoot branching stage. Ammonium molybdate (Mo 54%) was applied as a seed treatment coating. The alfalfa was seeded at a rate of 22.5 kg/ha in March, 2007.

During the growing season the forage was weeded manually four times and harvested four times in early May, early June, mid-August and mid-October. Since fresh forage was used to feed animals, the alfalfa yield was recorded on a fresh weight basis. Plant samples were collected at early flowering to mid-bloom stages, oven dried, and analyzed for crude protein, crude fat, N-free extract, water, Ca, and P.

Forage Yield

Fertilizer treatment had a significant effect on fresh alfalfa yields, but the effect varied greatly between years **(Table 2)**. In 2007, the OPT+MgMoB produced significantly higher alfalfa yields than the OPT. Other treatments supplying at least 150 kg K_2O/ha were on par with the OPT. No significant yield response was observed for P, but yields did differ among K rates. The higher alfalfa yield generated from the OPT+MgMoB treatment could be attributed to the addition of Mg and/or a synergistic interaction of the three nutrients when applied together; however, since neither the OPT+Mo or OPT+B significantly increased alfalfa yield relative to the OPT. As was mentioned previously, soil testing did indicate a soil Mg deficiency.

In 2008, the effects of the fertilizer treatments differed somewhat as alfalfa significantly responded to both P and K

Common abbreviations and notes: B = boron; Ca = calcium; K = potassium; Mg = magnesium; Mo = molybdenum; N = nitrogen; P = phosphorus; S= sulfur; Zn = zinc; OPT = optimal (fertilizer) treatment; OM = organic matter.

Table 2. Fresh yields of alfalfa as affected by different fertilizer treatments, Chongqing, China.

Treatment	2007 Yield, kg/ha	2007 Relative yield, %	2008 Yield, kg/ha	2008 Relative yield, %	Average Yield kg/ha	Average Relative yield, %
90-120-150 (OPT)	37,589 b	100	45,107 a	100	41,348 a	100
90-60-150	38,833 b	103	40,996 b	91	39,914 b	96
90-0-150	37,166 b	99	38,941 c	86	38,054 c	92
90-120-75	35,777 c	95	38,885 c	86	37,331 c	90
90-120-0	35,222 c	94	37,496 d	83	36,359 c	88
90-120-150+MgMoB	41,277 a	110	43,662 a	97	42,470 a	103
90-120-150+B	37,722 b	100	41,551 b	92	39,637 b	96
90-120-150+Mo	36,944 b	98	41,496 b	92	39,220 b	95

Means in each column followed by the same letter are not significantly different at P = 0.05.

Table 3. Effects of fertilizer treatment on quality of alfalfa (Average of 2 years), Chongqing.

Treatment	Crude protein	N-free extract
	.... %	
90-120-150	17.8	36.1
90-60-150	15.8	37.6
90-0-150	15.1	36.7
90-120-75	16.8	33.9
90-120-0	15.7	39.7
90-120-150+MgBMo	16.7	38.4
90-120-150+B	16.9	41.3
90-120-150+Mo	18.2	39.9

fertilizer. A 14% yield increase was obtained between the OPT and OPT-P treatments; and a 17% yield increase was found between the OPT and OPT-K. Yield under the OPT and OPT+MgMoB treatments were equally superior to all other treatments.

As a result of higher yields across treatments in 2008, the 2-year average yields were considerably higher than initial yields obtained in 2007. The addition of B and Mo alone to the OPT treatment for two consecutive years resulted in lower relative yields compared to the OPT. This occurred in a field where B was considered deficient by soil test, and while soil Mo fertility was not tested, it is often considered deficient on these acid soils. From these results, it is concluded that alfalfa only responded positively to Mg when supplied within the OPT+MgMoB combination.

Effects of P and K on Alfalfa Yield

The alfalfa yield was obviously affected by P and K rates in the experiment. The lack of a response to added P in 2007 could be attributed to the high residual soil P carried over from the previous vegetable crop. This phenomenon was also observed for the alfalfa response to K fertilization. In 2007, increased K application resulted in a non-significant yield increase from 0 to 75 kg K_2O/ha, and a significant increase was observed from 75 to 150 kg K_2O/ha. In 2008, a significant yield increase occured with every increment of K. This result does highlight that residual P and K from the previously fertilized crops, though sufficiently high, could be significant for only one subsequent crop at the most.

Alfalfa Quality

Table 3 presents 2-year average indicators of alfalfa quality as affected by fertilizer treatment.

Among quality parameters, alfalfa crude protein and N-free extract are most important. The former governs feed value and the latter is proposed to influence feed palatability.

Data were insufficient for statistical analysis of alfalfa quality. However, the percentage of crude protein appeared to increase with P rate, while N-free extracts did not show an obvious P response. In response to K, percent crude protein also appeared to increase, while N-free extract seemed to decline under higher K rates. A K source comparison between potassium sulfate (K_2SO_4) and KCl was tested (data not shown), but produced equal results regarding alfalfa quality, although it should be noted that this site was not S deficient. Inclusion of Mo within the OPT, may be capable of producing higher crude protein in alfalfa, which is a result that is inferred from the nutrient's important role in N metabolism.

Summary

Alfalfa yield significantly responded to the rates of P and K in 2008, but not in 2007 due to residual effects carried over from the site's previous cropping history of significant fertilization of mustard grown prior to alfalfa establishment. This study stresses the importance of applying appropriate amounts of P and K under such conditions in order to sustain higher crop yields after short-term effects of residual soil fertility. Magnesium appears to have a role to play in alfalfa grown in the hilly region of Chongqing based on the yield advantages gained with its inclusion within an adequate NPK recommendation. It may be good practice to apply Mg once every 2 or 3 years when a soil deficiency is determined.

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