How Do New Alfalfa Varieties Respond to K Fertilization?

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Potassium (K), an essential plant nutrient, has been recognized as an important nutrient for alfalfa yield and persistence because of its role in enzyme activity in plant processes (i.e., photosynthesis, biological nitrogen fixation). Previous studies have shown K fertilization was associated with higher yields, increased winter hardiness, and improved disease resistance. However, much of this work was conducted with older alfalfa varieties with less disease resistance and winter hardiness than modern varieties and was conducted on soils with low soil test potassium (STK) levels where a fertilization response was expected to be dramatic. While we did not doubt the importance of K fertilization for improving yield, we wanted to evaluate its impact on newer, modern varieties subject to intense cutting management.

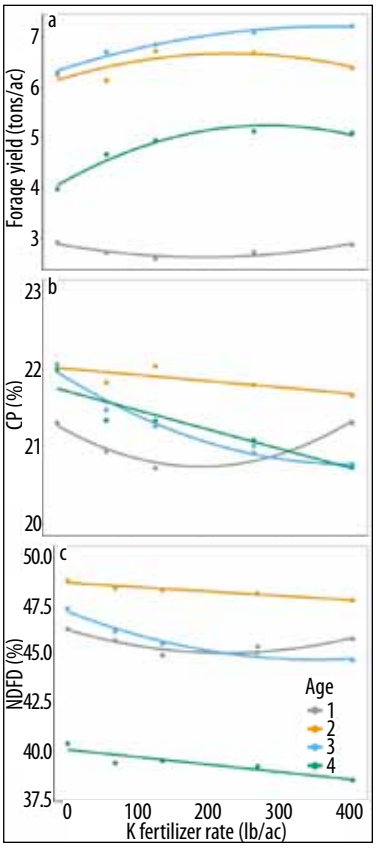
Six widely grown commercial varieties with fall dormancy (FD) 4 and 5 and two new USDA experimental entries with FD 3 also selected for levels of fibrous roots, were grown at three locations and annually fertilized with 5 rates of K fertilizer (as potassium sulfate) ranging 0-360 lbs/ac. Initial STK at the three locations represented low, moderate, and high levels of STK (Figure 2). To maximize forage yield and forage quality potential, we harvested 4-5 times per year at bud stage from seeding year to third year after seeding.

Table 1. Average forage yield, stem density, crude protein (CP), neutral detergent fiber (NDF), and neutral detergent fiber digestibility (NDFD) of modern commercial and experimental alfalfa cultivars. Forage yield and quality values are averaged for three production years. Stem density was measured in the third year of production.

Cultivar	Yield	Stem Density	CP	NDF	NDFD
	Tons/ac	Stems/ft²	---------- % ----------		
UMN3979	5.0 ab	39 ab	20.7 b	40.2 d	45.0 ab
UMN3980	4.8 b	36 b	20.7 b	39.8 cd	44.4 a
54V46	5.2 ab	40 ab	21.1 a	39.0 ab	46.6 c
55V48	5.2 ab	41 a	20.9 ab	39.3 bd	45.2 ab
ForageGold	5.2 ab	39 ab	21.2 a	38.3 a	46.2 bc
HybriForce 2400	5.3 a	40 ab	20.9 ab	38.8 ab	45.3 ab
Magna 551	5.4 a	37 ab	21.0 ab	38.8 ab	45.6 abc
PGI 557	5.3 a	39 ab	21.2 a	38.2 a	46.0 bc

Did alfalfa varieties differ in response to fertilizer K application? They had a similar response to K fertilizer application, and K fertilization was not preferentially beneficial to yield and persistence of any specific variety. Averaged over K fertilization treatment, we found commercial alfalfa varieties had very similar yield, forage quality, and stem density (a measure of persistence), while the experimental variety UMN3980 had lower yields. Both experimentals lacked overall disease resistance (Table 1). Results support the use of FD 4 and 5 alfalfas with excellent regrowth and winter hardiness potential for production of high-quality forage.

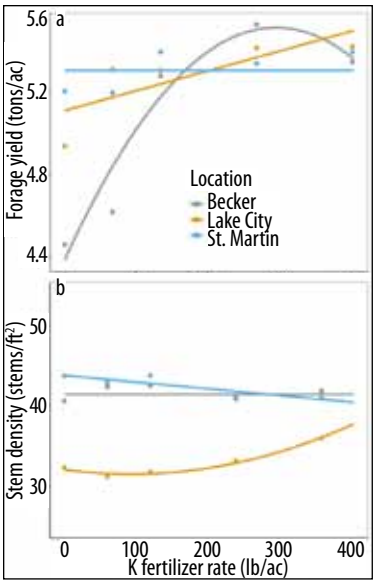
Figure 1. Effect of K fertilization rates on forage yield, and forage CP, and forage NDFD of alfalfa at several stand ages. The establishment year is designated as year 1.



Did potassium fertilization affect alfalfa forage yield, forage quality, and stand persistence? Effect of K fertilization on forage yield and stand persistence varied by locations that differed in initial STK level and stand age (Figure 1). Predictably, based on current Minnesota soil test recommendations, the greatest response occurred in Becker with initial STK of 35 ppm (Figure 2). There was no response in St. Martin where the initial soil test was 160 ppm. Yield responses to fertilization at all locations were limited in the establishment year when yields were low. Forage yields were greatest for 2- and 3-year-old stands and decreased dramatically in 4-year-old stands that had reduced populations.

Higher levels of K fertilization slightly reduced forage CP and NDFD. Changes are related to decreased leafiness and decreased maturity as forage yield increased. However, application of high rates of K fertilizer to achieve maximum yields resulted in luxury K consumption and its accumulation in herbage and roots. If forage K concentration of >2% is considered to be the upper limit to reduce risk of parturient hypocalcemia, or "milk fever," in cows, the forage produced at K rates for yield plateau in our experiment would need to be limited in the ration. Therefore, excess K should be considered an anti-quality factor in forage and K fertilization limited to levels needed

Figure 2. Effect of K fertilizer on yield and stem density. The initial STK at Becker, Lake City, and St. Martin, MN, respectively was ~35, 100, and 160 ppm representing low, moderate, and high levels of STK. Stem density measurements were taken in the fourth year of production.



to reach yield goals. Testing of forage for K concentration would allow adjustment of rations to avoid milk-fever issues.

Potassium fertilization has often been related to improved stand persistence. However, very high levels of K fertilization did not meaningfully prolong stand life as they aged beyond the third production year. Using a stem count of 50 stems/ft^2 as a standard for productive alfalfa stands, at all sites stands were marginal with K fertilization, providing an advantage only at Lake City. We observed no effect on root diameter or crown rot score. The 35% decline in forage yield in the fourth year compared to the second and third year was related to decline in stem numbers. Diminishing economic returns on K fertilizer investment are likely if K fertilizer is applied at high rates above recommended levels with a goal of increasing STK. Despite an increase in K uptake with fertilization, a net increase in STK was observed after accounting for K removal during harvest, which may be related to the release of K from soil minerals. At Becker, Lake City, and St. Martin, 148, 201, and 238 lbs/ac respectively of K could be removed and the soil test would still be maintained. Farmers are urged to monitor test results and consider potential annual K removal (determined by multiplying yield by the K% in forage).

Summary. Potassium fertilization is important for high forage yields when applied at recommended levels based on soil testing and University of Minnesota (UM) guidelines. However, it will not prolong stand life or sustain forage productivity of modern alfalfa varieties as stands age beyond the third production year. There is no economic or biological advantage for applying fertilizer at rates above UM guideline recommendations to achieve high yields. Potassium fertilizers should not be applied at levels above those recommended for production with a goal of accumulating K in the soil. In other words, due to costs, fertilization to achieve a STK of 150 or 200 ppm is not recommended. Alfalfa varieties with FD 4 and 5 have high yield potential but all have a similar response to K fertilization.

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