Estimation of Potassium Availability by Incremental Additions of K to K-Fixing Soils

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INTRODUCTION

Soil tests commonly used to develop K fertilizer recommendations, such as extraction by 1 M NH_4OAc at pH 7, measure both soluble and exchangeable K. This method and others like it are inadequate for soils that have a significant amount of fixed (non-exchangeable) K, a portion of which may be available to plants, and for soils having a high, unmet capacity to fix K.

We are investigating the use of alternative soil test procedures that can assist farmers in predicting the availability of fertilizer K applied to strongly K-fixing soils in California. These soils, formed in granitic alluvium from the Sierra Nevada, are found on the east side of the San Joaquin Valley. They contain vermiculite in the fine sand and silt size fractions. We have found extensive areas of such soils in cotton fields and wine grape vineyards.

We summarize here research on application of two laboratory analytical methods suited to K-fixing soils: (1) A 1-hr procedure for K fixation potential developed in our laboratory (Murashkina et al., 2007); (2) A simplified version (Cox et al., 1999) of the sodium tetraphenyl boron (TPB) procedure. The TPB procedure has been shown in some studies to provide a better measure of plant-available, non-exchangeable K. Cox et al. (1999) reported that it extracted 1.5 to 6 times more K than NH_4OAc extraction.

For our study, six soil profiles, representing a range of K-fixation potential (Kfix), were chosen. KCl in solution was added in increments equal to twice the Kfix of each sample. Samples were incubated moist for 1 day, and then air dried analyzed using the Kfix, NH_4OAc and TPB methods. Additionally, K equal to the CEC was added to samples, followed by a 16 day moist incubation, air drying, and analysis. Results were used to estimate the K fixation potential of the soil samples. The results of this work and subsequent studies will ultimately be useful for determining K fertilizer application requirements for K-fixing soils.

Table 1. Soil properties

Code/soil/classification	Depth cm	CEC cmol (+)kg⁻¹	NH_4OAc-K initial mg kg⁻¹	TPB-K initial mg kg⁻¹	Kfix initial mg kg⁻¹
DONA	9-28	28.8	113	265	19
Archerdale clay loam	28-46	28.4	123	267	42
Pachic Haploxeroll	110-135	26.1	119	234	289
VSSA	0-12	11.8	65	261	235
Bruella sandy loam	12 30	11.0	45	133	377
Ultic Palexeralf	30-44	9.2	32	153	259
	60-79	21.2	67	138	208
	79-100	23.2	53	113	231
KTRA	7-41	16.5	67	376	243
Columbia sandy loam	41-61	18.7	49	386	348
Aquic Xerofluvent	61-96	10.8	45	266	248
	96-135	13.0	36	263	318
DH2	20-40	14.5	63	203	422
Guard clay loam	40-60	16.2	79	215	500
Duric Haplaquoll	80-100	16.4	52	204	404
	100-120	21.5	50	188	503
	120-140	16.3	34	169	450
224	0-10	22.2	59	240	384
Armona loam	10-50	19.7	78	173	564
Fluventic Endoaquoll	50-100	13.9	48	88	740
	100-120	29.9	92	186	475
225	0-12	30.8	169	464	63
Gepford clay	12-56	30.4	102	296	267
Typic Natraquert	56-95	28.1	104	306	111

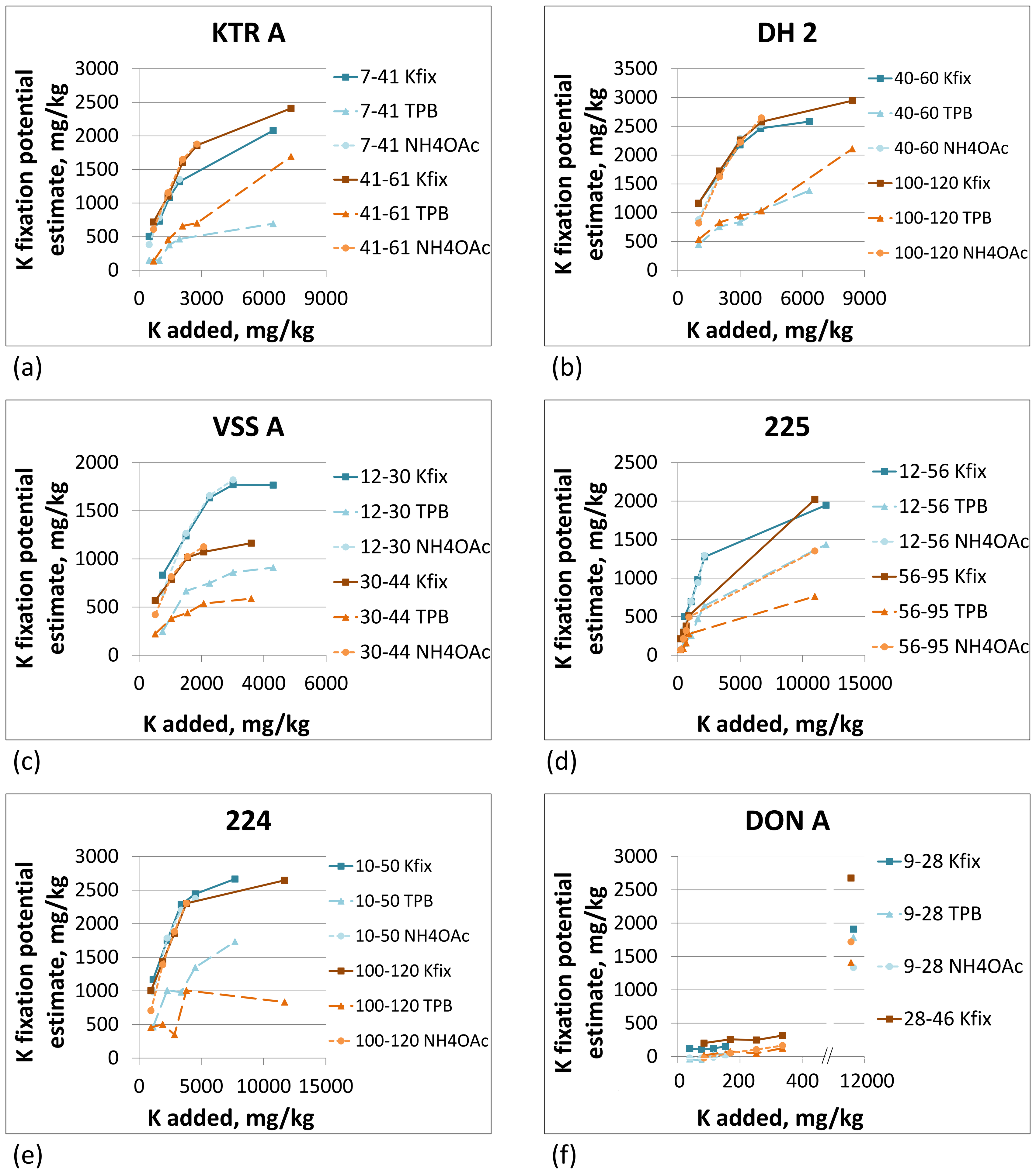

Fig. 1 (a-f). Estimated K fixation potential at increasing rates of applied K for selected depths for each soil. Note the broken x-axis in 1(f).

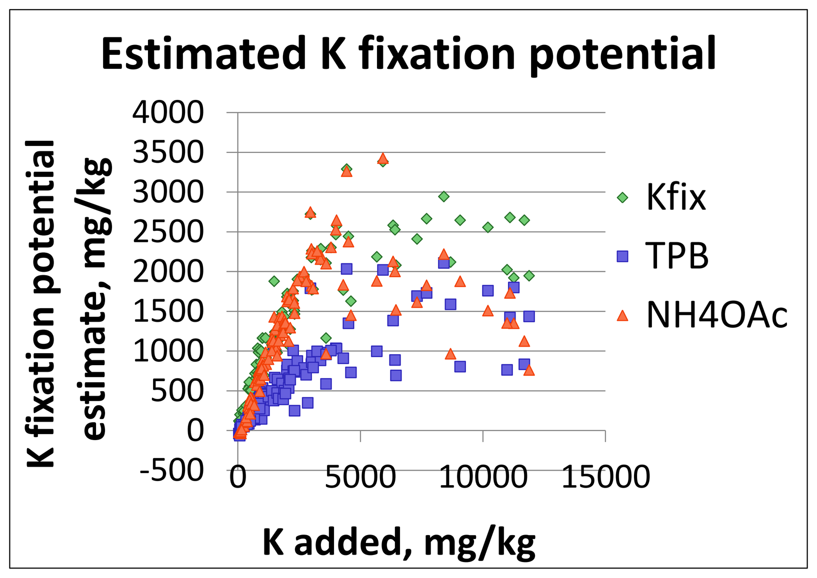

Fig. 2. Methods to estimate K fixation potential become less sensitive at high concentrations of added K

Adjusting to a percentage of added K fixed (Fig. 3) helps adjust for the reduced sensitivity

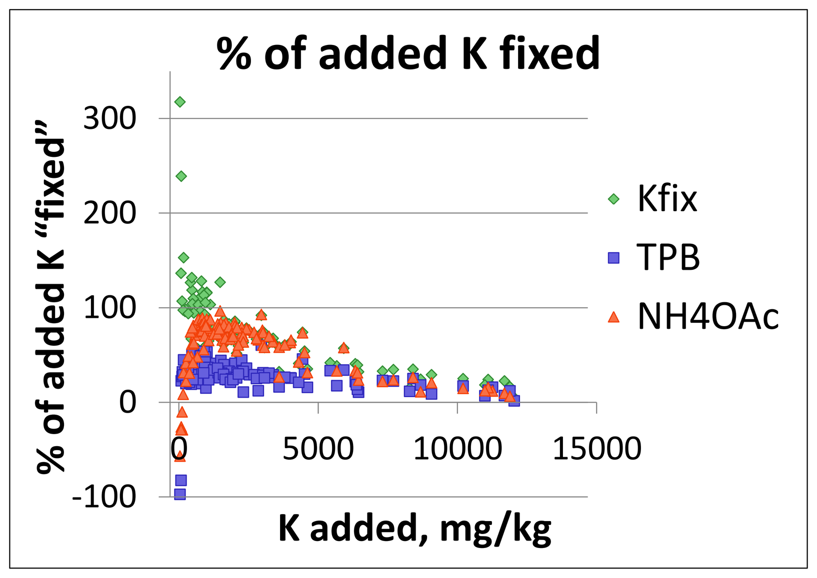

Fig. 3. Estimated K fixation potential as % of K added decreased regularly with all three methods once added K exceeded about 500 mg/kg

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ACKNOWLEDGEMENTS

The authors thank Hideomi Minoshima and Jiayou Deng for technical assistance. Research was made possible by grants from the Lodi Winegrape Commission and the California Department of Food & Agriculture.

METHODS

Soils

- 24 soil samples used from two cotton fields and four wine grape vineyards in the San Joaquin Valley of California
- Initial soil properties are shown in Table 1.

Treatments

- Soil samples mixed with KCl in water at a rate of K equal to 2x Kfix value (Table 1)
- Samples incubated moist for 24 hours, followed by air drying
- Subsamples analyzed in triplicate for NH_4OAc-K, TPB-K, and Kfix
- Process was repeated 3 times with the remaining soil
- Analyses performed at rates of 2x, 4x, 6x, and 8x initial Kfix values

- Additional samples mixed with KCl in water at a rate equal to CEC (Table 1).
- Samples incubated moist for 16 days, air dried, and analyzed in triplicate as above

Ammonium acetate-extractable K[4] (NH_4OAc-K)

- 2.5-3 g soil saturated and extracted overnight with 1 M NH_4OAc (pH 7) using a mechanical vacuum extractor
- K determined by flame emission spectrometry

K fixation potential[3] (Kfix)

- 3 g soil shaken in 30 mL of 2 mM KCl for 1 h
- Extracted for 30 minutes with 10 mL 4 M NH_4Cl, and centrifuged
- K measured by flame emission spectrometry
- K fixation potential was calculated as the difference between a blank and the measured K solution concentrations

Sodium tetraphenylboron-extractable K[1,2] (TPB-K)

- 1 g soil extracted for 5 minutes with 3 mL of extracting solution (0.2 M NaTPB + 1.7 M NaCl + 0.01 M EDTA)
- Quenched with 25 mL of 0.5 M NH_4Cl + 0.11 M $CuCl_2$
- Samples heated to boiling for 30-45 minutes to dissolve precipitate
- Samples shaken by hand, then filtered
- K measured by flame emission spectrometry

Estimates of K fixation potential from NH_4OAc-K, TPB-K

- Extracted K values subtracted from K added plus initial NH_4OAc-K/TPB-K values
- Gives amount added that was not recovered by the given extraction method

DISCUSSION & SUMMARY

1. For most samples, estimated K fixation potential began to plateau at high values of added K
   - It is not clear if a maximum value was reached, even with K addition equal to CEC

2. Kfix and NH4OAc produce similar results
   - Both methods use NH_4 to displace K in the extraction step

3. TPB-K method gives lower estimates of K fixation potential than Kfix or NH_4OAc-K methods
   - Some, but not all, of the added potassium is "weakly fixed" but still plant available.

4. For high CEC low Kfix soils (DON A - Fig 1(f)), significant K fixation potential at very high application rates
   - Unexpected result, as these samples are dominated by smectite rather than vermiculite
   - Additional work adding larger increments of K would be helpful to better understand this result