# Potassium: Use and Application and Availability in Soils

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## Plant Physiology of Potassium

- Activator of enzymes
- Involved in stomatal function
- Helps to regulate ion balances in cells
- Involved in sugar synthesis
- Increases oil content in pistachio fruit
- Contributes to cold hardiness

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## Potassium Deficiency

- Leaves become pale during summer
- Leaflets fold upward and curl in
- Yellow tips that progress inward; tissue eventually browns
- Slow growth
- Small leaves
- Low yield

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## Physiology of Potassium

- Most potassium needed by bearing trees is to supply the fruit
- Most of K uptake in bearing trees is for kernel fill
- 29 lbs $K_2O$ removed per 1000 lbs of nuts removed
- 27 lbs $K_2O$ needed to supply tree growth

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## Leaf analysis levels

| Critical Value | Adequate |
|---|---|
| 1.6% | 1.8 – 2.2% |

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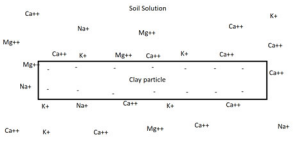
## Potassium in Soils

- Potassium is immobile in soils because it is loosely bound onto negatively charged clay and organic matter
- Clay and organic matter forms the "CEC"
- The size of your CEC is dependent on how much clay and organic matter you have

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## Cation Exchange Capacity

- The CEC acts as a reservoir for positively charged ions
  - K, Ca, Mg? Good!
  - Na: bad!
- When thinking about cations, you also must be thinking about the CEC size
- Lab tests will give you ppm K, %K on the CEC, or both
  - %K is usually more useful, since it gives you an idea of how much of the CEC is taken up by K
- *Rough* rule of thumb: soils are "deficient" in K with either less than 200 ppm OR 2% of the CEC
- It's best to just apply what has been lost via crop removal

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## Potassium Fixing Soils

- Ammonium acetate test not appropriate for soils that fix K
- Fixed K becomes available over time
  - Rate can change based on soil
- Do not add K fertilizers far in advance of tree needs in K fixing soils

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## Cation antagonism

- Carrier proteins for nutrient uptake is not always specific to an ion
  - Worse for cations of similar charge and/or size
  - Example: $K^+$ and $Na^+$, $K^+$ and $NH_4^+$
  - Also $Ca^{2+}$, $Mg^{2+}$, $K^+$
  - $Cl^-$ and $NO_3^-$
- But you can have ion antagonism in extreme cases
  - E.g. Ca deficiency in high Mg soils such as serpentine
  - Depression of one cation with application of fertilizer containing another
- Not much evidence that there is an ideal cation 'ratio' that is perfect across all sites
  - Maintaining this may be expensive

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## Soil Tests

- Ammonium Acetate extraction:
  - Supposed to measure available K
  - Not great at estimating available K in fixing soils
- Water soluble (saturated paste extraction):
  - Only removes water soluble K
  - No sufficiency standards developed
- AA tests will tell you ppm in soil
- Labs will calculate %K for you
- CEC in most cases is estimated
  - Can be VERY inaccurate if recently applied gypsum, lime and sampler took no steps to exclude it

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## Potassium Fertilizers

- $K_2O$: Potassium Oxide, known as potash. Not actually in fertilizers! 83%K

| Source | Formula | % $K_2O$ | Solubility@ 20 C (grams/liter) | % $K_2O$ in a saturated solution | Cost per lb $K_2O$ |
|---|---|---|---|---|---|
| Potassium Chloride | KCl | 63 | 255 | 16.1 | $0.41 |
| Potassium Sulfate | $K_2SO_4$ | 54 | 111 | 5.4 | $0.67 |
| Potassium Nitrate | $KNO_3$ | 47 | 209 | 11.2 | $1.33 |
| Potassium Thiosulfate | $K_2S_2O_3$ | 25 | complete | 25 | $1.38 |

Solubility data may differ by manufacturer, or if the amount of impurities is high

Costs are quotes from 2019, and actual prices may differ

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## Previous Research

- Patrick Brown, Brent Holtz, and Quipeng Zeng looked at K fertilization in a mature pistachio orchard in a San Joaquin series soil
- They added 0, 100, 200, 300 lbs of K/acre
- Looked at three different sources: $K_2SO_4$, KCl, $KNO_3$
- Trial lasted 3 years, with K split into 4 applications per year

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## Zeng, Brown, and Holtz.

- No difference between K source
- Yield maximized at 200 lbs/year

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## Solubility

- Tells you the maximum amount of a salt that will dissolve in pure water at a given temperature
- Solubility of potassium fertilizer does not change how potassium ultimately behaves in the soil
  - But there are tricks that can reduce the importance of fixation
- **Easily soluble fertilizer applied early in the season (or last year) in potassium fixing soils can still be fixed**
- The key to potassium fertilizer application is applying a product that works for you in a way that is *appropriate for your soil*

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## Solubility of Fertilizers and Application

- Solubility can become be an issue in fertigation, particularly if you like to apply all of your K over a small number of applications
- Higher soluble fertilizers are more efficient lb/lb, (You can deliver the same amount of dissolved $K_2O$ in less water than lower soluble fertilizers) but there are no differences in 'available' potassium

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## Fertigation vs Banding?

| Treatment | 1996 | 1997 | 1998 | 1999 |
|---|---|---|---|---|
| No K | 2192 | 2500 | 2868 | 2904 d |
| 0.38 kg SOP | 2382 | 2719 | 2916 | 3313 bc |
| 0.75 kg SOP | 2305 | 2797 | 2792 | 3335 abc |
| 0.38 kg MKP | 2251 | 2862 | 3067 | 3727 a |
| 0.38 kg KTS | 2345 | 2867 | 2824 | 3015 cd |
| 0.75 kg SOP banded | 2275 | 2978 | 2585 | 3534 ab |

- Banded SOP achieved similar yields in year three to fertigated SOP (same rate)
- MKP was (not significantly) best – unknown if this was due to P or something else

Adapted from: Edstrom, J.P. and Meyer, R.D., 2006, August. Potassium fertilizer application in drip and micro-jet irrigated almonds. In *V International Symposium on Irrigation of Horticultural Crops 792* (pp. 257-263).

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## Fertigation vs soil application?

| ppm potassium (via ammonium acetate extraction) of soils after 2.5 lbs K had been 'broadcast' under the emitter or fertigated | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 0 feet from emitter | | | 1 foot from emitter | | | 2 feet from emitter | | |
| Soil depth | Broadcast | Fertigated | Control | Broadcast | Fertigated | Control | Broadcast | Fertigated | control |
| 0-6″ | 2131 | 520 | 270 | 164 | 512 | 250 | 164 | 305 | 289 |
| 6-12″ | 2714 | 414 | 141 | 137 | 395 | 137 | 141 | 180 | 98 |
| 12-18″ | 3284 | 332 | 113 | 109 | 258 | 102 | 121 | 117 | 70 |
| 18-24″ | 3288 | 230 | 74 | 78 | 407 | 70 | 78 | 94 | 94 |
| 24-30″ | 1634 | 100 | 70 | 74 | 228 | 66 | 74 | 63 | 106 |
| 30-36″ | 176 | 66 | 90 | 86 | 90 | 82 | 98 | 86 | 86 |

Adapted from: Uriu, K., R.M. Carlson, D.W. Henderson, H. Schulbach, and T.M. Aldrich. 1980. Potassium fertilization of prune trees under drip irrigation. J. Amer. Soc. Hort. Sci. 105:508–510.

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## Fertilizer Application Strategies

- Banding SOP works in any soil type, as long as it is banded in the *wetted zone* of your irrigation system
  - Because surface-applied K mostly stays put, fertilizer that can only be dissolved by rain will not be in the root zone
- In K-fixing soils: banding saturates the fixation capacities of a soil, ensuring K is available for uptake
- Fertigation can avoid fixation, *but only if it's applied in season*
- Banding can be a great addition to fertigation, especially in non-fixing soils

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## When to fertilize

- If your trees are very deficient (< 1.6% K):
  - Apply high rates and monitor leaf levels closely
  - 100-200 lbs $K_2O$/acre overcame deficiencies in a loam soil
- If your trees are not deficient, apply to replace what's been removed
  - It's always better to maintain levels rather than remedy deficient trees

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## Maintenance fertilization rates

| Yield (kernel lbs/acre) | $K_2O$/acre |
|---|---|
| 1000 | 55 |
| 2000 | 84 |
| 3000 | 113 |
| 4000 | 142 |
| 5000 | 171 |

29 lbs $K_2O$ removed with every 1000 lbs kernels

27 lbs $K_2O$ needed for tree growth

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## When to fertilize

- Non-potassium fixing soils
  - Apply whenever you like, however you like
  - Band? Make sure it's in the wetted zone
- Potassium fixing soils
  - Fertigation: start a little before trees need it (nut fill/Stage 3), split applications between April-August
  - If soil applying, **BAND** to overcome fixation, and ensure the fertilizer is in the wetted zone
  - You can do both!

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Thank you!

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