Selecting the Right Source of Potassium for Fertigation

Dr. Munir Rusan, Consulting Director, Middle East
4R Nutrient Stewardship &

- Selecting the right source of K
- Cropping systems
  - Rainfed, Irrigated, Open & Protected agric., Soilless,
  - Fertigation
What is Fertigation?

- Fertigation = application of fertilizers through IW
- Practiced dominantly with pressurized drip-irrigation system
- Nutrient Management & Fertigation under pressurized drip-irrigation system are quite different compared to conventional approaches
Why Nutrient Management is Different under Pressurized Irrigation & Fertigation?
Traditional fertilization is not appropriate under pressurized irrigation.

Under pressurized irrigation, nutrient management is very challenging.

This can be achieved only with fertigation thru accurately applying 4R.
How to select the right source of Potassium?
Generally, Right Source of K must work in synchrony with:

- Other Rs (rate, time and place) and with the
- Surrounding environment of plant, soil, climate and management
- The right combination is crop and site-specific, depending on local soil and crop condition
Common K Fertilizers
<table>
<thead>
<tr>
<th></th>
<th>MOP</th>
<th>SOP</th>
<th>NOP</th>
<th>MKP</th>
<th>Langbeinite</th>
<th>KTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>KCl</td>
<td>K</td>
<td>K</td>
<td>K</td>
<td>K</td>
<td>K2SO4 .2MgSO4</td>
<td>K2S2O3</td>
</tr>
<tr>
<td>K2SO4</td>
<td></td>
<td></td>
<td>KNO3</td>
<td>KH2PO4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>K2S2O3</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

- All supply the same K nutrition
- Different sources have different elements associated with K
- Are these elements essential plant nutrients?

<table>
<thead>
<tr>
<th>K2O %</th>
<th>K</th>
<th>Cl</th>
<th>S</th>
<th>N</th>
<th>P</th>
<th>Mg</th>
</tr>
</thead>
<tbody>
<tr>
<td>60</td>
<td>K</td>
<td>K</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>50</td>
<td>K</td>
<td>S</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>46</td>
<td>K</td>
<td>N</td>
<td>-</td>
<td>-</td>
<td>P</td>
<td></td>
</tr>
<tr>
<td>34</td>
<td>K</td>
<td>S</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>22</td>
<td>K</td>
<td>S</td>
<td>-</td>
<td>-</td>
<td>P</td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>K</td>
<td>S</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
</tbody>
</table>
For Fertigation, the Right source of K should meet the following conditions?

- High K nutrient content in the solution
- Accessible and affordable
- Fully soluble at field temperature
- Fast dissolution in irrigation water
- No clogging of filters and emitters
- Compatible with other fertilizers
- Compatible with irrigation water quality
- Suitable for soil properties (physical & chemical)
- Cause No drastic changes in pH & EC of soil & water
- Low corrosively for control head and system
To apply 200 kg K$_2$O you need

- **KCl**: 333 kg, 60% K$_2$O
- **K$_2$SO$_4$**: 400 kg, 50% K$_2$O
- **KNO$_3$**: 435 kg, 46% K$_2$O
- **KH$_2$PO$_4$**: 588 kg, 34% K$_2$O
- **K$_2$S$_2$O$_3$**: 800 kg, 25% K$_2$O

**Nutrient content and Economical Considerations:**
- The higher the K$_2$O the lower the content of the companying elements
- The higher the K$_2$O the lower the cost per unit of K$_2$O
- Compare K$_2$O content

- **KCl** is the K fertilizer which has
  - Highest K content
  - Cheapest K fertilizer
  - KCl Cost less per Kg Fertilizer & per unit of K$_2$O
• **Solubility of fertilizers.**
  a. Fertilizers must be water soluble and compatible with each other and with IW

b. Fertilizer solution are rather concentrated salt solution

c. Fertilizer solution may become supersaturated causing precipitation that:

  a. Changes the composition

  b. Clog filters, pipes, nozzles, drippers
### Solubility of Potassium Fertilizers at 20°C

<table>
<thead>
<tr>
<th>Potash Fertilizers</th>
<th>Formula</th>
<th>Grade</th>
<th>Solubility kg/L</th>
<th>pH 1 g/L</th>
<th>Other nutrients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Potassium Chloride (MOP)</td>
<td>KCL</td>
<td>0-0-60</td>
<td>0.347</td>
<td>7.0</td>
<td>46% Cl</td>
</tr>
<tr>
<td>Potassium Nitrate (NOP)</td>
<td>KNO₃</td>
<td>13-0-46</td>
<td>0.313</td>
<td>7.0</td>
<td>13% N</td>
</tr>
<tr>
<td>Potassium Sulfate (SOP)</td>
<td>K₂SO₄</td>
<td>0-0-50</td>
<td>0.120</td>
<td>3.7</td>
<td>18% S</td>
</tr>
<tr>
<td>Potassium Thiosulfate (KTS)</td>
<td>K₂S₂O₃</td>
<td>0-0-25</td>
<td>1.500</td>
<td>-</td>
<td>17% S</td>
</tr>
<tr>
<td>Monobasic K-Phosphate (MKP)</td>
<td>KH₂PO₄</td>
<td>0-52-34</td>
<td>0.330</td>
<td>5.5</td>
<td>53% P₂O₅</td>
</tr>
</tbody>
</table>

- Nutrients dissolved in water are readily available to plant uptake
- The most soluble is K₂S₂O₃ and least soluble is K₂SO₄

- At 20°C: K₂S₂O₃ > KCl > KH₂PO₄ > KNO₃ > K₂SO₄

For example, according to the data in the table above:
- dissolve 400g KCl/L, will get only 347g dissolved & rest 53g remains undissolved → 208g K₂O/L
- dissolve 400g KNO₃/L, will get only 313g dissolved & rest 87g remains undissolved → 144g K₂O/L
- dissolve 400g K₂SO₄/L, will get only 120g dissolved & rest 280g remains undissolved → 60g K₂O/L

Recall the amounts undissolved will be unavailable & will cause clogging of irrigation system
Cooling effect

Recognize effect of temperature on solubility of fertilizers used

- Most dry fertilizers (such as KCl, Urea) absorb heat from the water upon dissolution (endothermic reaction):
  - Breaking bond between K and Cl releases energy
  - Making bond between water molecules and K and Cl needs energy which is absorbed from water
    - The temperature of the solution is lowered
    - Total solubility of the fertilizer decreases
  - Dilution of most liquid fertilizers (as KTS) generate heat (exothermic reaction):
    - The temperature of the solution is increased

→ Therefore liquid should be added before the dry fertilizer (urea or KCl), which have an endothermic reaction
# Corrosivity

Source should **not be corrosive** to the equipment used. Acid fertilizer solution tend to cause corrosion of metal components of irrigation system.

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<td>KH₂PO₄</td>
<td>5.5</td>
</tr>
</tbody>
</table>
Compatibility with Irrigation Water

Water Quality Parameters and the Right Source:
A. Concentration of total dissolved solids (TDS).
   The higher the TDS the lower the solubility of fertilizers

B. Anionic composition of IW (bicarbonate, sulfate, chloride and boron):
   1. Bicarbonate anions:
      a. Increases pH of the solution
      b. Decreases actual solubility of fertilizers
      c. Enhances precipitation of Ca and Mg

   2. **Chloride** anions tend to increase salinity and harm sensitive crops

   3. **Sulfate** containing fertilizer in hard water (Ca2+ > 2 meq/l), cause precipitation of Ca-sulfate (known as gypsum)

   4. **Phosphate** containing fertilizers in hard IW cause Ca-phosphate precipitates - difficult to dissolve out of emitters.
Compatibility among fertilizers

Recognize that:

- Solubility products of various fertilizers can react with each others and form precipitates, leading to clogging problems and reduce the actual nutrients concentration. For example:

  - Calcium nitrate with any sulfates = formation of CaSO₄ precipitate →
    \[ \text{Ca(NO}_3\text{)}_2 + K_2\text{SO}_4 \rightarrow \text{CaSO}_4 \text{ (gypsum)} + \ldots \]

  - Calcium nitrate with any phosphates = formation of Ca phosphate precipitate →
    \[ \text{Ca(NO}_3\text{)}_2 + \text{KH}_2\text{PO}_4 \rightarrow \text{CaHPO}_4 + \ldots \]

  - Magnesium nitrate with phosphate = formation of Mg phosphate precipitate →
    \[ \text{Mg(NO}_3\text{)}_2 + \text{KH}_2\text{PO}_4 \rightarrow \text{MgHPO}_4 + \ldots \]

  - Iron with phosphorus = formation of iron phosphates precipitate →
    \[ \text{Fe} + \text{KH}_2\text{PO}_4 \rightarrow \text{FeHPO}_4 + \ldots \]
• **Salt Index: Different sources of K fertilizers have different salt index**

- Source should have low salt index, so for salt sensitive crops use SOP or NOP not MOP

<table>
<thead>
<tr>
<th>Material and analysis</th>
<th>Salt Index</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Per equal wts. of materials</td>
</tr>
<tr>
<td><strong>Monopotassium phosphate</strong></td>
<td>8.4</td>
</tr>
<tr>
<td><strong>Potassium chloride</strong></td>
<td>120.1</td>
</tr>
<tr>
<td>Potassium sulfate</td>
<td>42.6</td>
</tr>
<tr>
<td>Pot. thiosulfate</td>
<td>68.0</td>
</tr>
</tbody>
</table>

* One unit equals 20 lb.
• Accompanying/Associated Elements

- Different K sources have different associated elements
  - NO3 and potential leaching and contaminating ground water
  - SO4 accelerate formation of **gypsiferous** soils in arid/semiarid env.
  - SO4 improves structure of sodic-calcareous soil
  - Cl accumulation in saline soils
- Phosphate promote precipitation with Ca, Mg and Micro

- Each of these elements may have positive or negative impact depending on the local soil-plant systems

  - The choice then is management, crop and site specific
K fertilizers should suit chemical & physical soil properties:

- Ensure maximum crop recovery efficiency
- Should have favorable effect on soil pH, structure, salinity
- Should not negatively affect availability of indigenous soil nutrients
  - P-Zn; Ca, Mg etc
- Should minimize losses of nutrients via leaching, fixation, volatilization
- Recognize distribution in soils with different texture
Nutrient distribution below dripper under different soil texture.
Promoting K fertilizers
Inappropriate way of advertisement of potassium fertilizer

- Chloride-free SOP fertilizer to avoid toxic effect of Cl
- SOP is the richest source of low-chloride potassium
- K nitrate is free of detrimental chloride
- Sulfate-free K fertilizer to avoid precipitation problems in fertigation
- Nitrate-free K fertilizers to avoid contamination of groundwater with nitrate
  - This may send a wrong message to the role of the essential nutrients

Indicate specific conditions for use or not use (management), such as:
- Avoid using KCl for crops sensitive to Cl and
- Avoid using K$_2$SO$_4$ where IW is high in Ca+Mg
- Avoid phosphate containing K fertilizers where IW is high in Ca and Mg
- Avoid using KNO$_3$ where there is a potential of NO$_3$ leaching to ground water
- Avoid using KNO$_3$ where there is a potential of NO$_3$ accumulation in products
Contribution of Cl from KCl vs that from IW

- Irrigation water: Allowable level of Cl in IW (FAO) = 4 meq Cl/L = 142 mg Cl/L = 142 ppm
- Application of 5000 m³/ha of IW with 4 meq Cl will supply = 710 kg Cl/ha
- Application of 200 kg/ha KCl will provide 95kg Cl/ha
- This accounts equals to: 95 / 710 = 13% of that provided by IW
CONCLUSIONS

- All K fertilizers provide the same K nutrition

- Selection of the source of K depends on local conditions of crop, soil, water, climate and management

- There is no single source that is the right choice for all conditions

- Each source can be a good choice under certain condition and not appropriate under another condition

- Economical and environmental aspects should also be considered before selecting the K source
Thank you

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