Selecting the Right Source of Potassium for Fertigation

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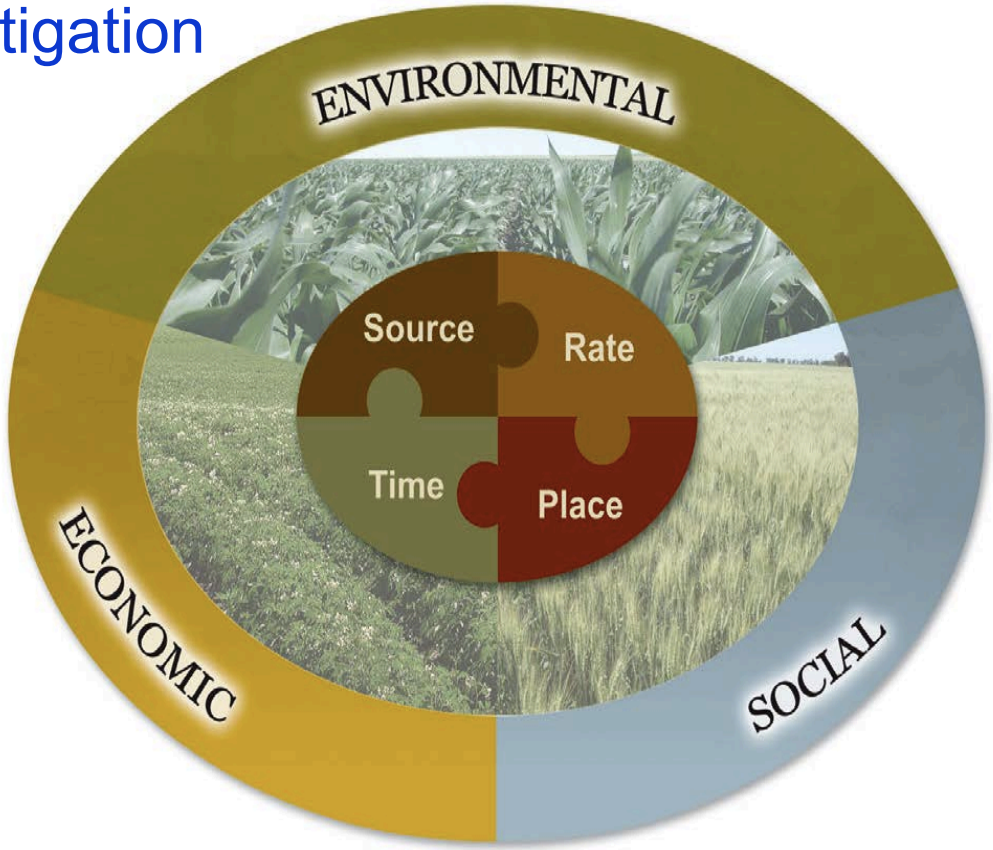
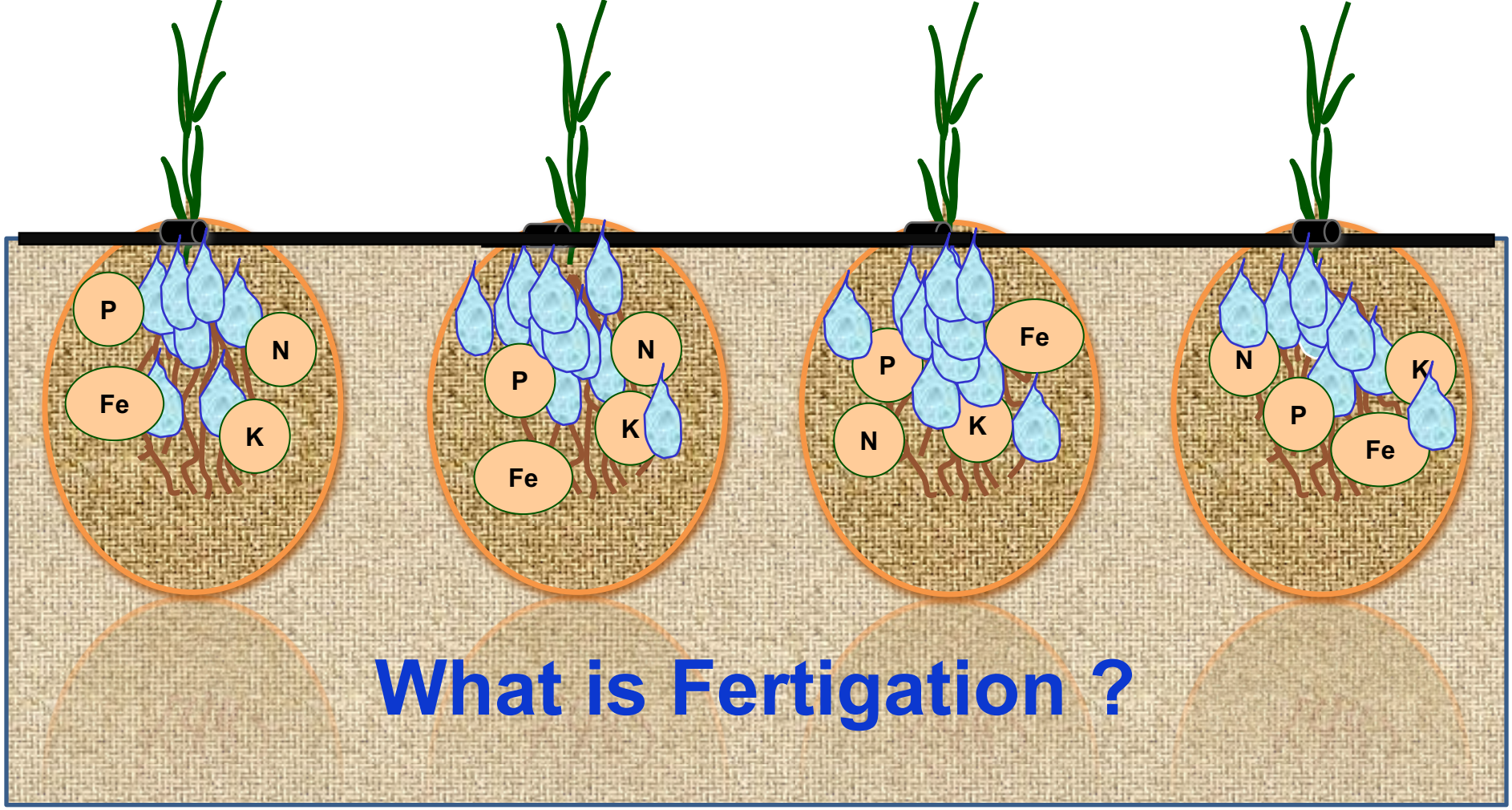
4R PLANT NUTRITION

4R Nutrient Stewardship &

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



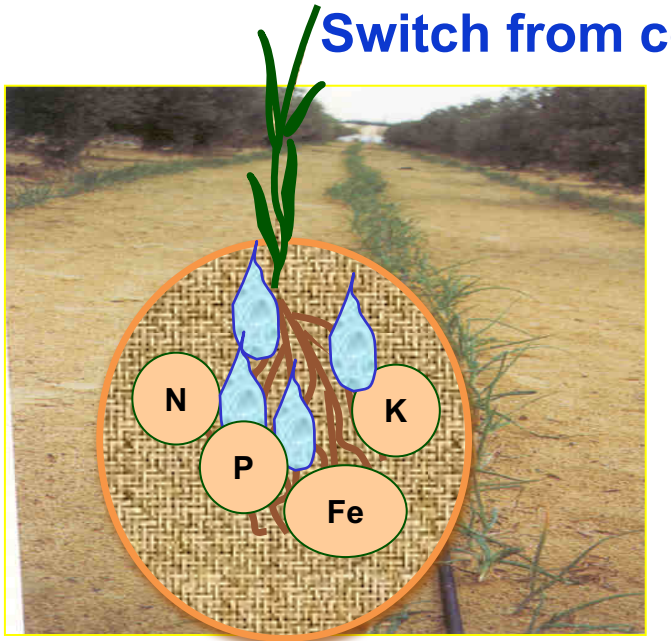


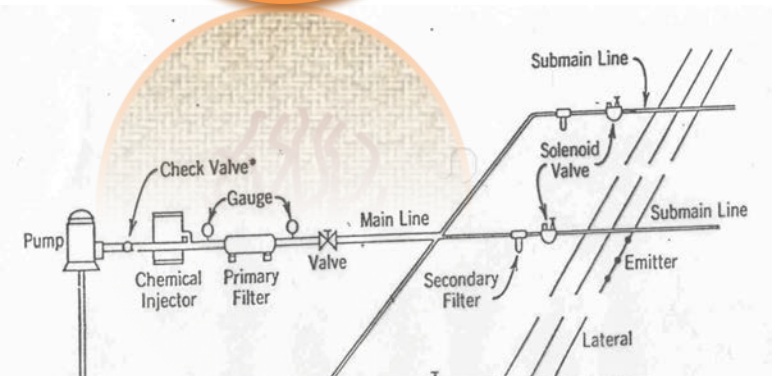
What is Fertigation ?

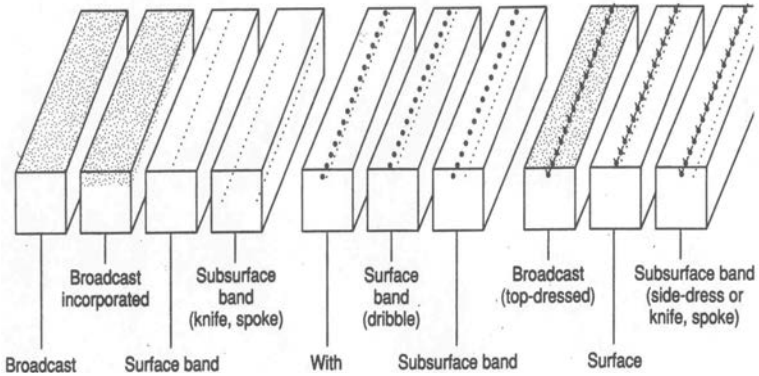
- Fertigation = application of fertilizers through IW
- Practiced dominantly with pressurized drip-irrigation system
- Nutrient Management & Fertigation under pressurized drip-irrigation system are quite different compared to conventional approaches

Why Nutrient Management is Different under Pressurized Irrigation & Fertigation ?

Switch from conventional open irrigation to pressurized
Switch from conventional fertilization to 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

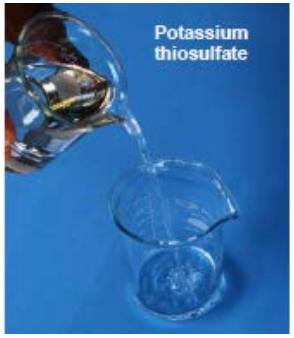
How to select the right source of Potassium ?

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

MOP	SOP	NOP	MKP	Langbeinite	KTS
KCl	K_2SO_4	KNO_3	KH_2PO_4	$K_2SO_4 .2MgSO_4$	$K_2S_2O_3$



60 % K_2O	50% K_2O	46% K_2O	34% K_2O	22% K_2O	25% K_2O
K	K	K	K	K	K
Cl	S	N	S	S	S
-	-	-	P	Mg	_

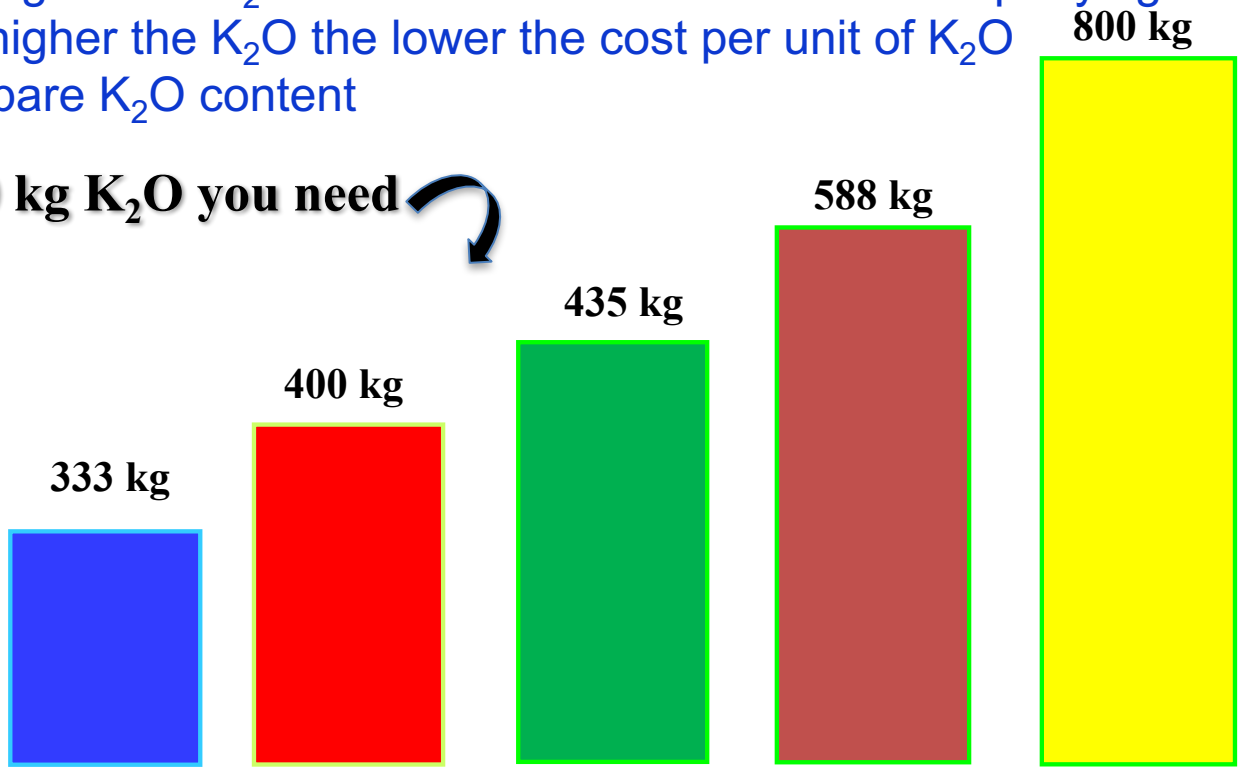
- All supply the same K nutrition
- Different sources have different elements associated with K
- Are these elements essential plant nutrients ? →

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

- **Nutrient content and Economical Considerations:**
  - The higher the K_2O the lower the content of the companying elements
  - The higher the K_2O the lower the cost per unit of K_2O
  - Compare K_2O content

To apply 200 kg K_2O you need



	KCl	K_2SO_4	KNO_3	KH_2PO_4	$K_2S_2O_3$
% K2O ➔	60 %	50%	46%	34%	25%

- **KCl is the K fertilizer which has**
  - **Highest K content**
  - **Cheapest K fertilizer**
    - **KCl Cost less per Kg Fertilizer & per unit of K_2O**

- **Solubility of fertilizers.**

a. Fertilizers must be water soluble and compatible with each others 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

Potash Fertilizers	Formula	Grade	Solubility kg/L	pH 1 g/L	Other nutrients
Potassium Chloride (MOP)	KCL	0-0-60	0.347	7.0	46% Cl
Potassium Nitrate (NOP)	KNO_3	13-0-46	0.313	7.0	13% N
Potassium Sulfate (SOP)	K_2SO_4	0-0-50	**0.120**	3.7	18% S
Potassium Thiosulfate (KTS)	$K_2S_2O_3$	0-0-25	**1.500**	-	17% S
Monobasic K-Phosphate (MKP)	KH_2PO_4	0-52-34	0.330	5.5	53% P_2O_5

- Nutrients dissolved in water are readily available to plant uptake
- The most soluble is $K_2S_2O_3$ and least soluble is K_2SO_4

  - At 20°C: → $K_2S_2O_3$ > KCl > KH_2PO_4 > KNO3 > K_2SO_4

For example, according to the data in the table above:

dissolve 400g KCl/L, will get only 347g dissolved & rest 53g remains undissolved→ 208g K_2O/L

dissolve 400g KNO_3/L, will get only 313g dissolved & rest 87g remains undissolved→144g K_2O/L

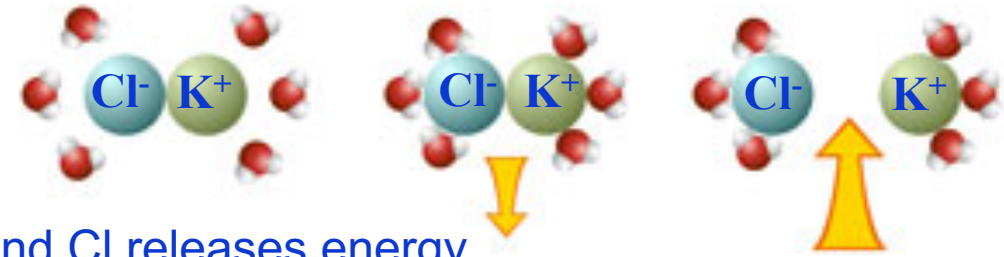
dissolve 400g K_2SO_4/L, will get only 120g dissolved & rest 280g remains undissolved→ 60g K_2O/L

➢ 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

Potash Fertilizers	Formula	pH 1 g/L
Potassium Chloride (MOP)	KCL	7.0
Potassium Nitrate (NOP)	KNO_3	7.0
Potassium Sulfate (SOP)	K_2SO_4	3.7
Potassium Thiosulfate (KTS)	$K_2S_2O_3$	-
Monobasic K-Phosphate (MKP)	KH_2PO_4	5.5

- **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 (Ca^{2+} > 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 $CaSO_4$ precipitate →*

      $Ca(NO_3)_2 + K_2SO_4 \rightarrow CaSO_4$ **(gypsum) + …..**

    - *Calcium nitrate with any phosphates = formation of Ca phosphate precipitate →*

      $Ca(NO_3)_2 + KH_2PO_4 \rightarrow CaHPO_4 +$ **…..**

    - *Magnesium nitrate with phosphate = formation of Mg phosphate precipitate →*

      $Mg(NO_3)_2 + KH_2PO_4 \rightarrow MgHPO_4 +$ **…..**

    - *Iron with phosphorus = formation of iron phosphates precipitate →*

      $Fe + KH_2PO_4 \rightarrow FeHPO_4 +$ **…..**

- **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

Salt index values of K fertilizer materials.		
	Salt Index	
Material and analysis	Per equal wts. of materials	Per unit of nutrients*
Monopotassium phosphate	8.4	0.097
Potassium chloride	**120.1**	**1.936**
Potassium sulfate	42.6	0.852
Pot. thiosulfate	68.0	2.720
* One unit equals 20 lb.		

- **Accompanying/Associated Elements**

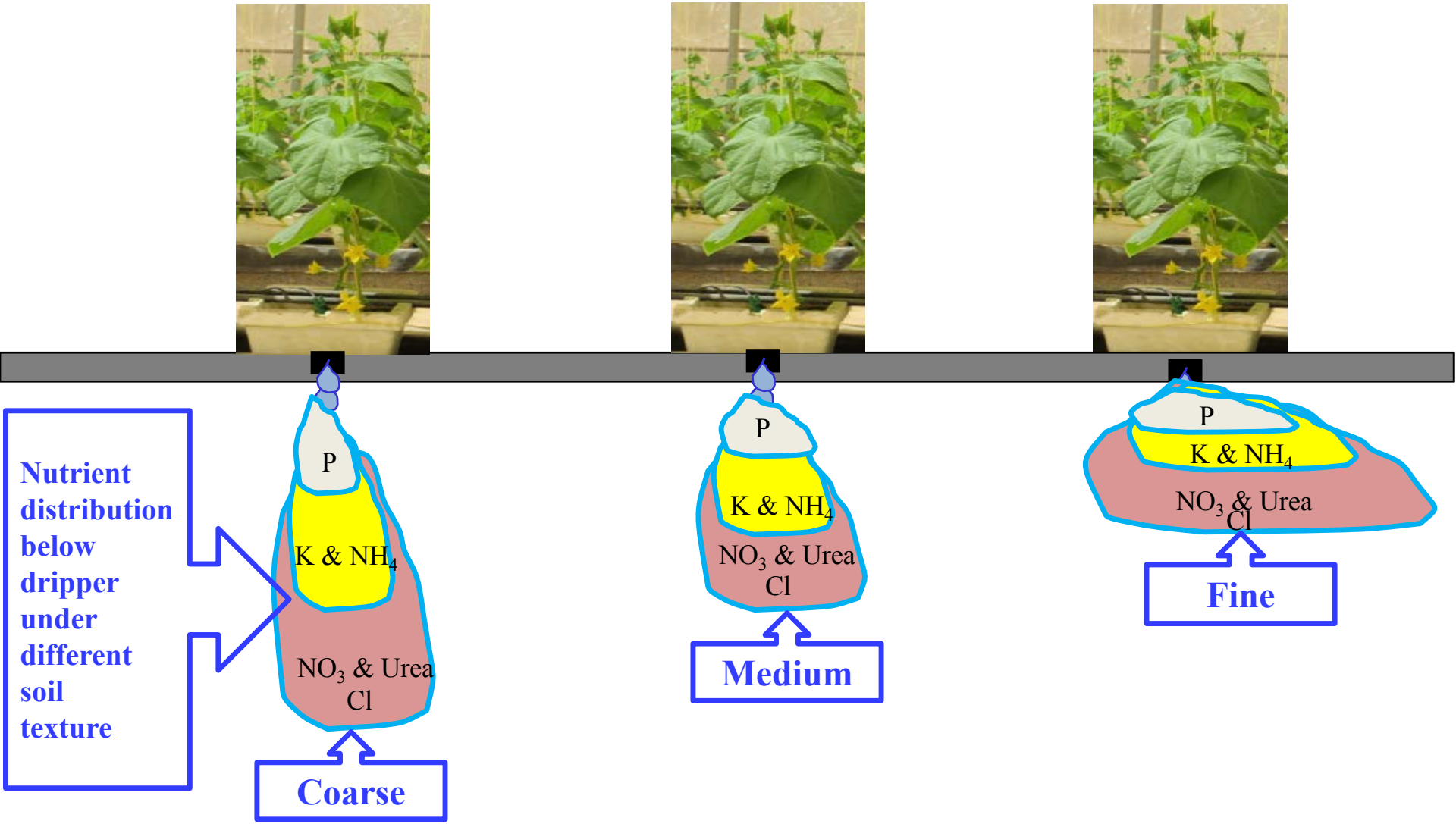
  - Different K sources have different associated elements
    - NO3 and potential leaching and contaminating ground water
    - SO4 accelerate formation of **gypsiferous** soils in arid/semiarid env.
    - SO4 improves structure of sodic-calcareous soil
    - Cl accumulation in saline soils
    - Phosphate 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
P
K & NH_4
NO_3 & Urea
Cl
Coarse
P
K & NH_4
NO_3 & Urea
Cl
Medium
P
K & NH_4
NO_3 & Urea
Cl
Fine

Promoting K fertilizers

Inappropriate way of advertisement of potassium fertilizer

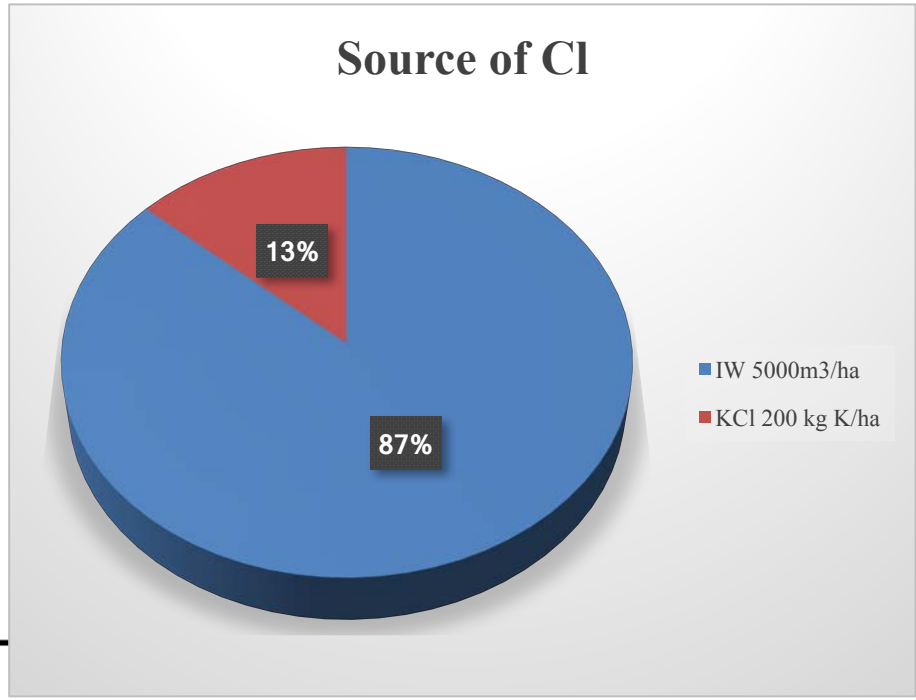
- Chloride-free SOP fertilizer to avoid toxic effect of Cl
- SOP is the richest source of low-chloride potassium
- K nitrate is free of detrimental chloride
- Sulfate-free K fertilizer to avoid precipitation problems in fertigation
- Nitrate-free K fertilizers to avoid contamination of groundwater with 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_2SO_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



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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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