CONFERENCE

IRRIGATION

QUELLES STRATÉGIES POUR ÉCONOMISER L'EAU ?
WHAT STRATEGIES FOR WATER SAVINGS ?

REGARDS CROISÉS EUROPÉENS

SHARING EUROPEAN VIEWS

13 - 14
nov. 2019
MONTPELLIER
FRANCE

irstea — LA SCIENCE AU CŒUR DE L'ENVIRONNEMENT

l'Europe s'engage en Occitanie

UNION EUROPÉENNE

La Région Occitanie Pyrénées - Méditerranée

PROJET COFINANCÉ PAR LE FONDS EUROPÉEN AGRICOLE POUR LE DÉVELOPPEMENT RURAL
L'EUROPE INVESTIT DANS LES ZONES RURALES

Liberté • Égalité • Fraternité
RÉPUBLIQUE FRANÇAISE

Réseau Rural Français 2014 - 2020

UNIVERSITÉ MONTPELLIER — MUSE — KEY INITIATIVE WATERS
MONTPELLIER UNIVERSITY OF EXCELLENCE

INVESTISSEMENTS D'AVENIR

G-eau — Gestion de l'Eau, Acteurs, Usages

Montpellier SupAgro

AFEID — Association Française pour l'Eau, l'Irrigation et le Drainage

AIRMF — Association des Irrigants des Régions Méditerranéennes Françaises

AGRICULTURES & TERRITOIRES — CHAMBRE D'AGRICULTURE OCCITANIE

AGRICULTURES & TERRITOIRES — CHAMBRE D'AGRICULTURE PROVENCE-ALPES-CÔTE D'AZUR

AQUA VALLEY

Irrigation efficiency and optimization
The Optirrig model

Bruno Cheviron, Claire Serra-Wittling, Juan-David Dominguez-Bohorquez, Magalie Delmas, Bruno Molle

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G-eau
Gestion de l'Eau, Acteurs, Usages

Water savings from improvements of...
Irrigation efficiency

As defined in the "cascade scheme" of Serra-Wittling & Molle 2017
[Invited report for the French Ministry of Agriculture]

<u>Color code</u>

Fraction due to Irrigation Water

Fraction due to Rain Water

Rain Water   Irrigation Water

Into the plot (Pi)

Distribution Efficiency Ed=Ai/Pi

Applied (Ai)

Application Efficiency Ea=Si/Ai

Reaches soil (Si)

Storage Efficiency Es=RZi/Si

Root Zone (RZi)

Consumption Efficiency Ec=AETi/RZi

For AET (AETi)

Transpiration Efficiency Et=Tpi/AETi

For Tp (Tpi)

Crop Yield
Yi

Water savings from improvements of...
Irrigation efficiency

As defined in the "cascade scheme" of Serra-Wittling & Molle 2017
[Invited report for the French Ministry of Agriculture]

Color code

Fraction due to Irrigation Water

Fraction due to Rain Water

Rationale

- ✓ Calculation of efficiencies and losses in 5 successive stages from irrigation water distribution to crop transpiration

- ✓ Complete mixing of rain water (RW) and irrigation water (IW) in soil with time-variable volume fractions carried on through the "cascade scheme"

- ✓ Challenge for metrology and modelling: quite tricky to code but physically sound and yields promising results

Rain Water   Irrigation Water

Into the plot (Pi)

Distribution Efficiency $Ed=Ai/Pi$
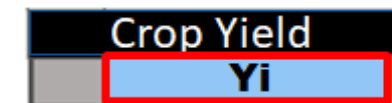
Applied (Ai)

Application Efficiency $Ea=Si/Ai$

Reaches soil (Si)

Storage Efficiency $Es=RZi/Si$

Root Zone (RZi)

Consumption Efficiency $Ec=AETi/RZi$

For AET (AETi)

Transpiration Efficiency $Et=Tpi/AETi$

For Tp (Tpi)

Crop Yield
Yi

Water savings from improvements of...
Irrigation efficiency

Rain Water   Irrigation Water

Into the plot (Pi)

Leaks from equipments ← Distribution Efficiency Ed=Ai/Pi

Applied (Ai)

Stage 1

$E=Ed=Ai/Pi$

↓ ↘

Applied   *Brought in*

IRRIGATION

QUELLES STRATÉGIES POUR ÉCONOMISER L'EAU ?
WHAT STRATEGIES FOR WATER SAVINGS ?

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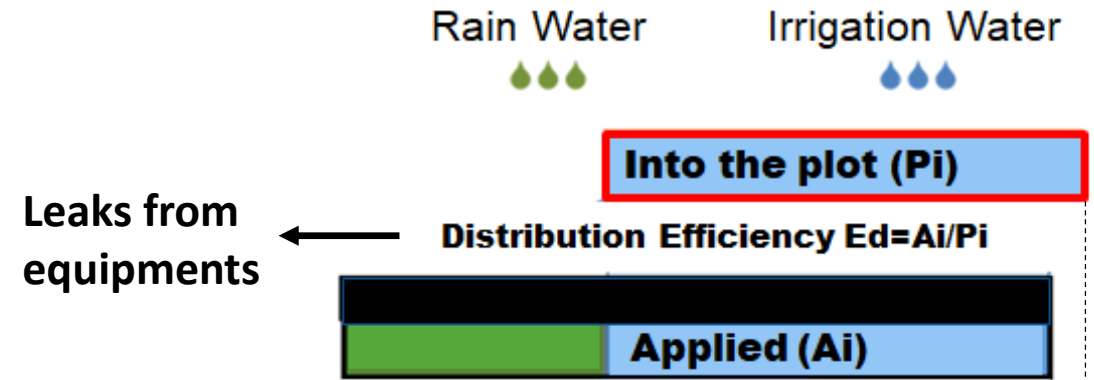
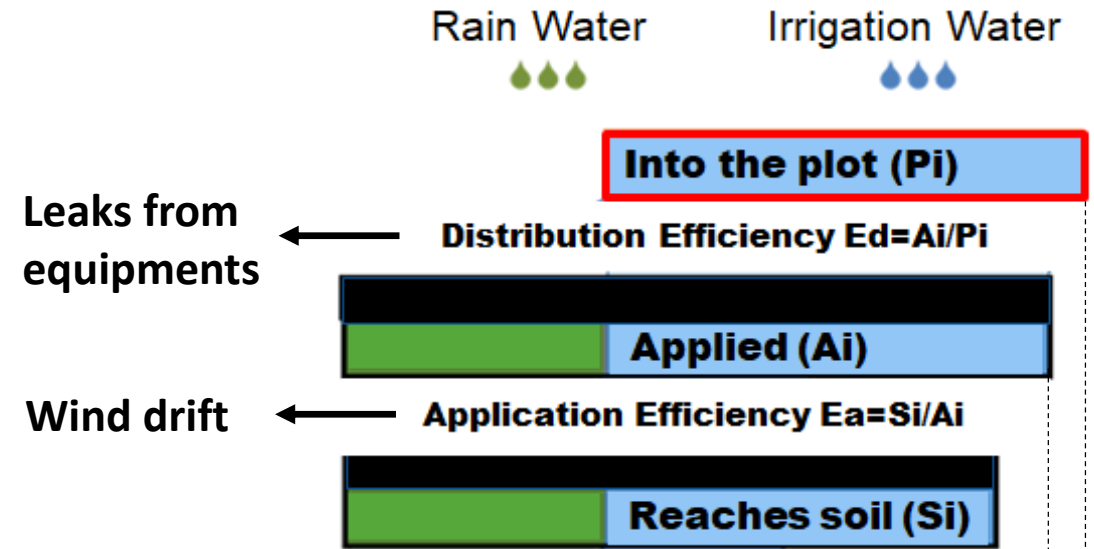# Water savings from improvements of…
Irrigation efficiency

Stage 2

$$E = Ed \cdot Ea = Si/Pi$$

↓ ↘

Reaches soil   *Brought in*

IRRIGATION

QUELLES STRATÉGIES POUR ÉCONOMISER L'EAU ?
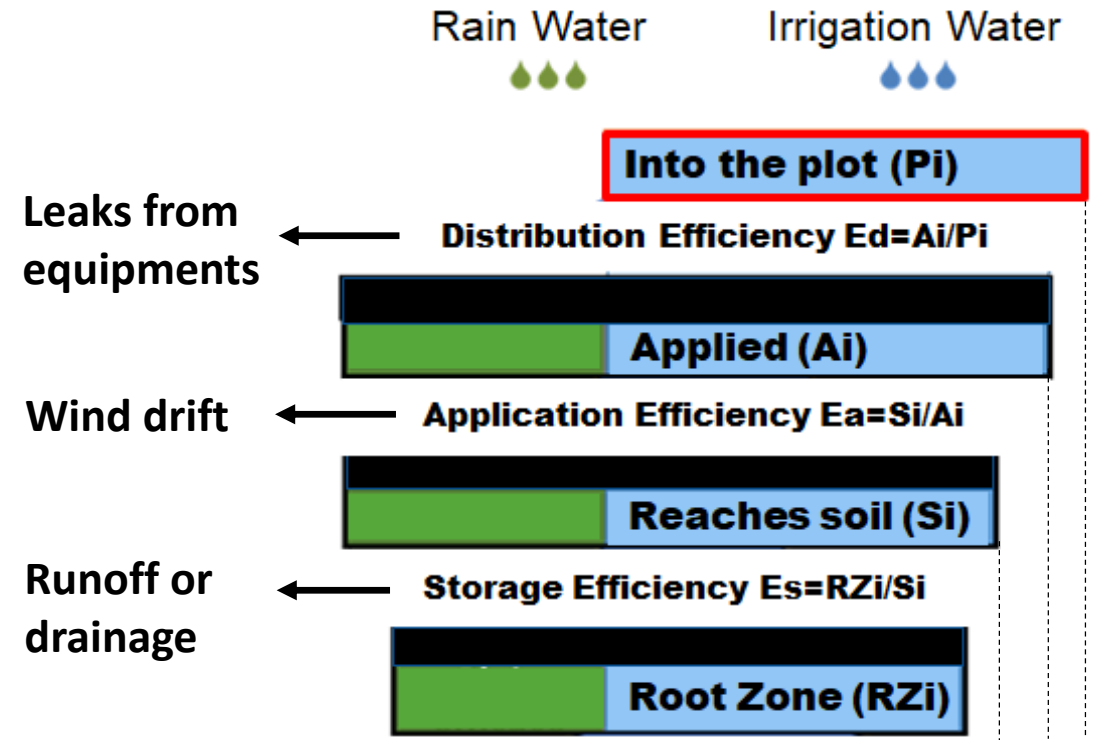WHAT STRATEGIES FOR WATER SAVINGS ?

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Water savings from improvements of...
Irrigation efficiency

Stage 3

$$E = E_d \cdot E_a \cdot E_s = R_{zi}/P_i$$

Stored in root zone   *Brought in*

Rain Water   Irrigation Water

Into the plot (Pi)

Leaks from
equipments   ← Distribution Efficiency $E_d = A_i/P_i$

Applied (Ai)

Wind drift   ← Application Efficiency $E_a = S_i/A_i$

Reaches soil (Si)

Runoff or
drainage   ← Storage Efficiency $E_s = R_{Zi}/S_i$

Root Zone (RZi)

Water savings from improvements of... Irrigation efficiency

Stage 4

$$E = Ed.Ea.Es.Ec = AETi/Pi$$

Evapotranspirated   *Brought in*

Rain Water   Irrigation Water

Into the plot (Pi)

Leaks from equipments ← Distribution Efficiency Ed=Ai/Pi

Applied (Ai)

Wind drift ← Application Efficiency Ea=Si/Ai

Reaches soil (Si)

Runoff or drainage ← Storage Efficiency Es=RZi/Si

Root Zone (RZi)

Weeds or excessive storage ← Consumption Efficiency Ec=AETi/RZi

For AET (AETi)

IRRIGATION QUELLES STRATÉGIES POUR ÉCONOMISER L'EAU ?
WHAT STRATEGIES FOR WATER SAVINGS ?

13 - 14 nov. 2019   MONTPELLIER FRANCE
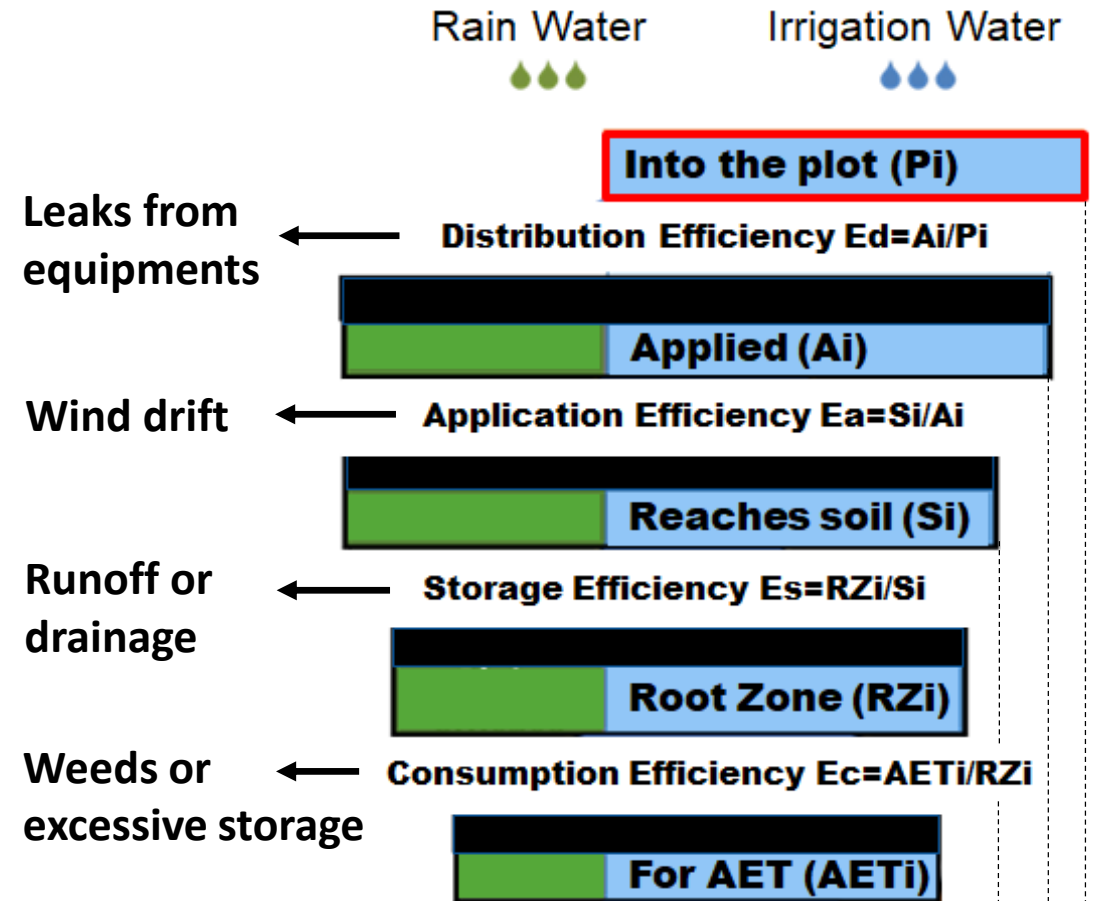
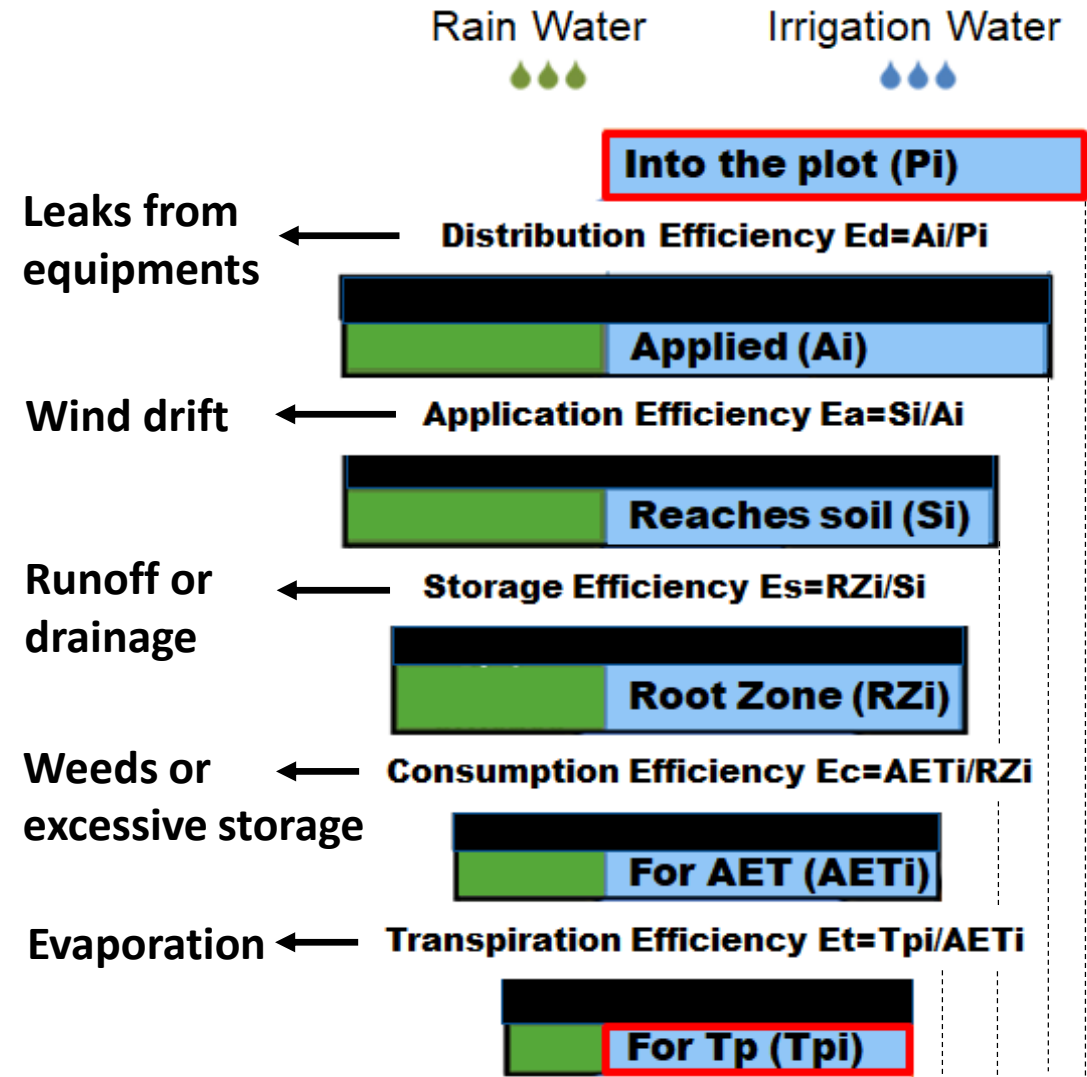# Water savings from improvements of...
Irrigation efficiency

Stage 5

$$E = E_d \cdot E_a \cdot E_s \cdot E_c \cdot E_t = T_{pi}/P_i$$

Finally transpirated   *Brought in*

Rain Water   Irrigation Water

Into the plot (Pi)

Leaks from equipments ← Distribution Efficiency $E_d = A_i/P_i$

Applied (Ai)

Wind drift ← Application Efficiency $E_a = S_i/A_i$

Reaches soil (Si)

Runoff or drainage ← Storage Efficiency $E_s = RZ_i/S_i$

Root Zone (RZi)

Weeds or excessive storage ← Consumption Efficiency $E_c = AET_i/RZ_i$

For AET (AETi)

Evaporation ← Transpiration Efficiency $E_t = T_{pi}/AET_i$

For Tp (Tpi)

Water savings from improvements of...
Irrigation efficiency

Stage 5

$$E=E_d.E_a.E_s.E_c.E_t=T_{pi}/P_i$$

$$E=[0,1] \times ... \times [0,1] \in [0,1]$$

Examples
$E=0.90^5 = 0.69$
$E=0.75^5 = 0.24$

Real-life realistic range

Quite drastic effect, nope?

Rain Water   Irrigation Water

Into the plot (Pi)

Leaks from
equipments ← Distribution Efficiency Ed=Ai/Pi

Applied (Ai)

Wind drift ← Application Efficiency Ea=Si/Ai

Reaches soil (Si)

Runoff or
drainage ← Storage Efficiency Es=RZi/Si

Root Zone (RZi)

Weeds or
excessive storage ← Consumption Efficiency Ec=AETi/RZi

For AET (AETi)

Evaporation ← Transpiration Efficiency Et=Tpi/AETi

For Tp (Tpi)
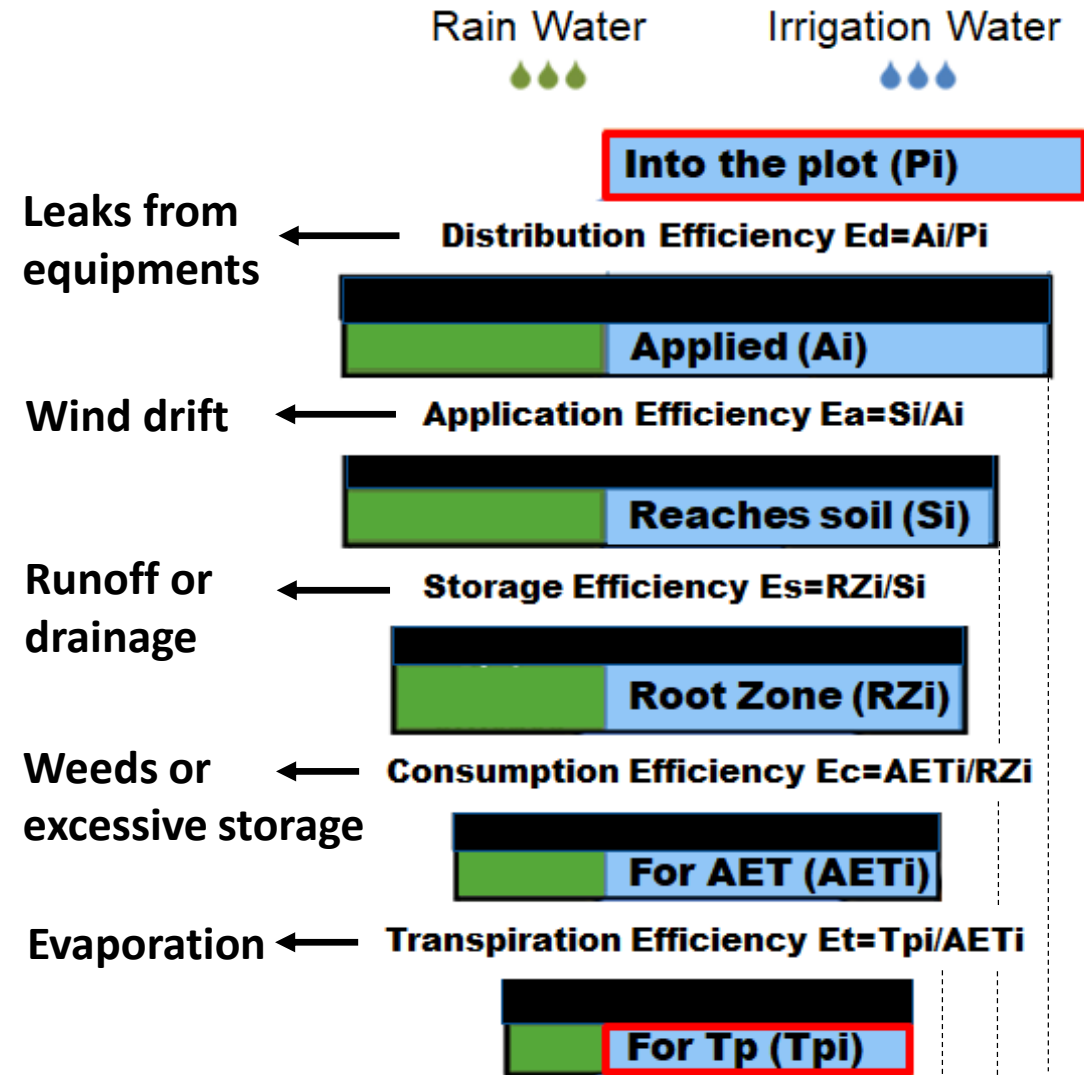
Water savings from improvements of...
Irrigation efficiency

Stage 5

$$E=Ed.Ea.Es.Ec.Et=Tpi/Pi$$

Efficiency E=Tpi/Pi   mm/mm or [-]
Productivity P=Yi/Pi   (ton/ha)/mm
Profitability F=Fi(Yi)/Pi   (€/ha)/mm

"Then I should definitely increase
my irrigation water efficiency"

Rain Water   Irrigation Water

Into the plot (Pi)

Leaks from equipments ← Distribution Efficiency Ed=Ai/Pi

Applied (Ai)

Wind drift ← Application Efficiency Ea=Si/Ai

Reaches soil (Si)

Runoff or drainage ← Storage Efficiency Es=RZi/Si

Root Zone (RZi)

Weeds or excessive storage ← Consumption Efficiency Ec=AETi/RZi

For AET (AETi)

Evaporation ← Transpiration Efficiency Et=Tpi/AETi

For Tp (Tpi)

Crop Yield
Yi
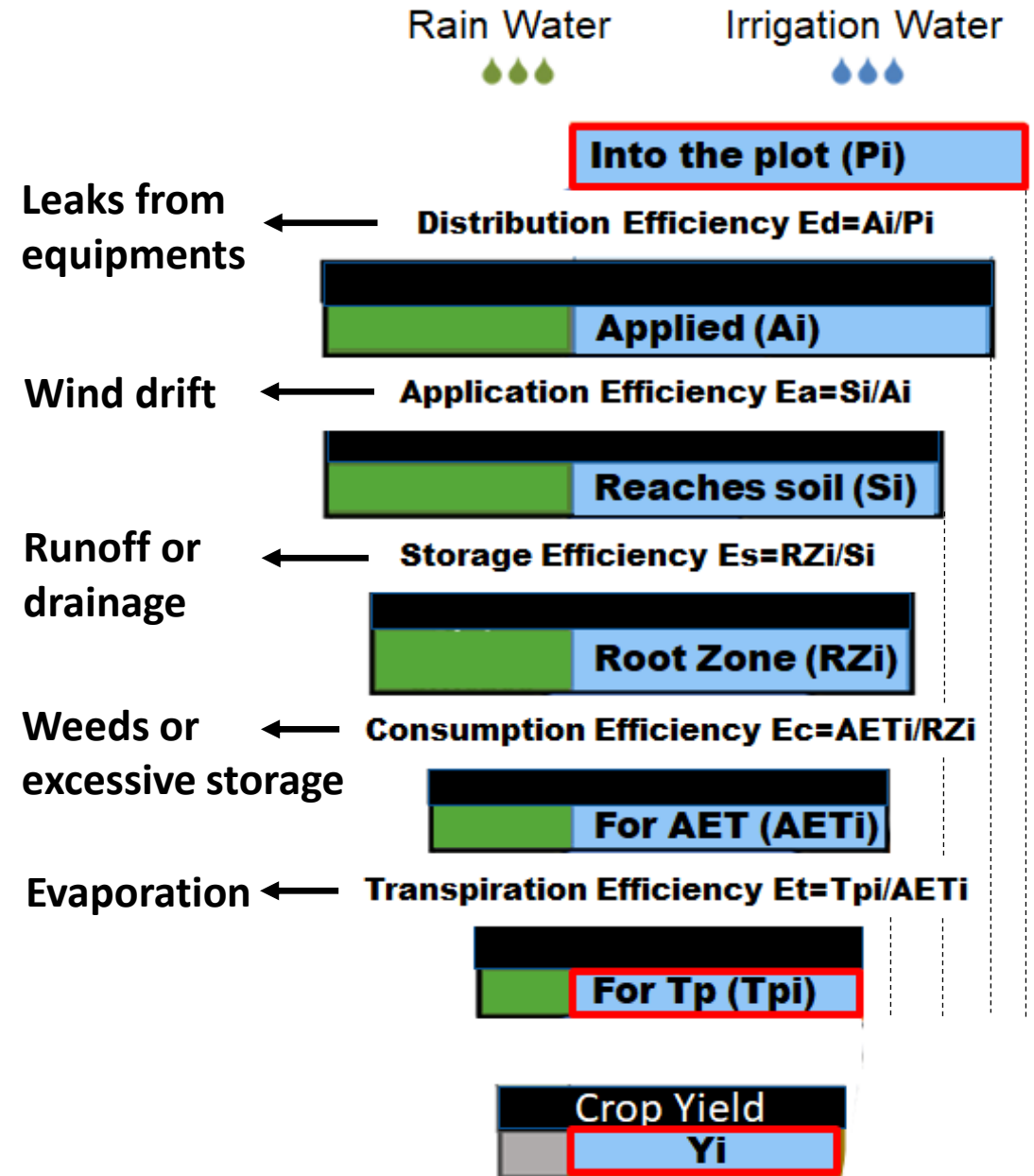
Water savings from improvements of...
Irrigation efficiency

Technical losses

Various upstream losses

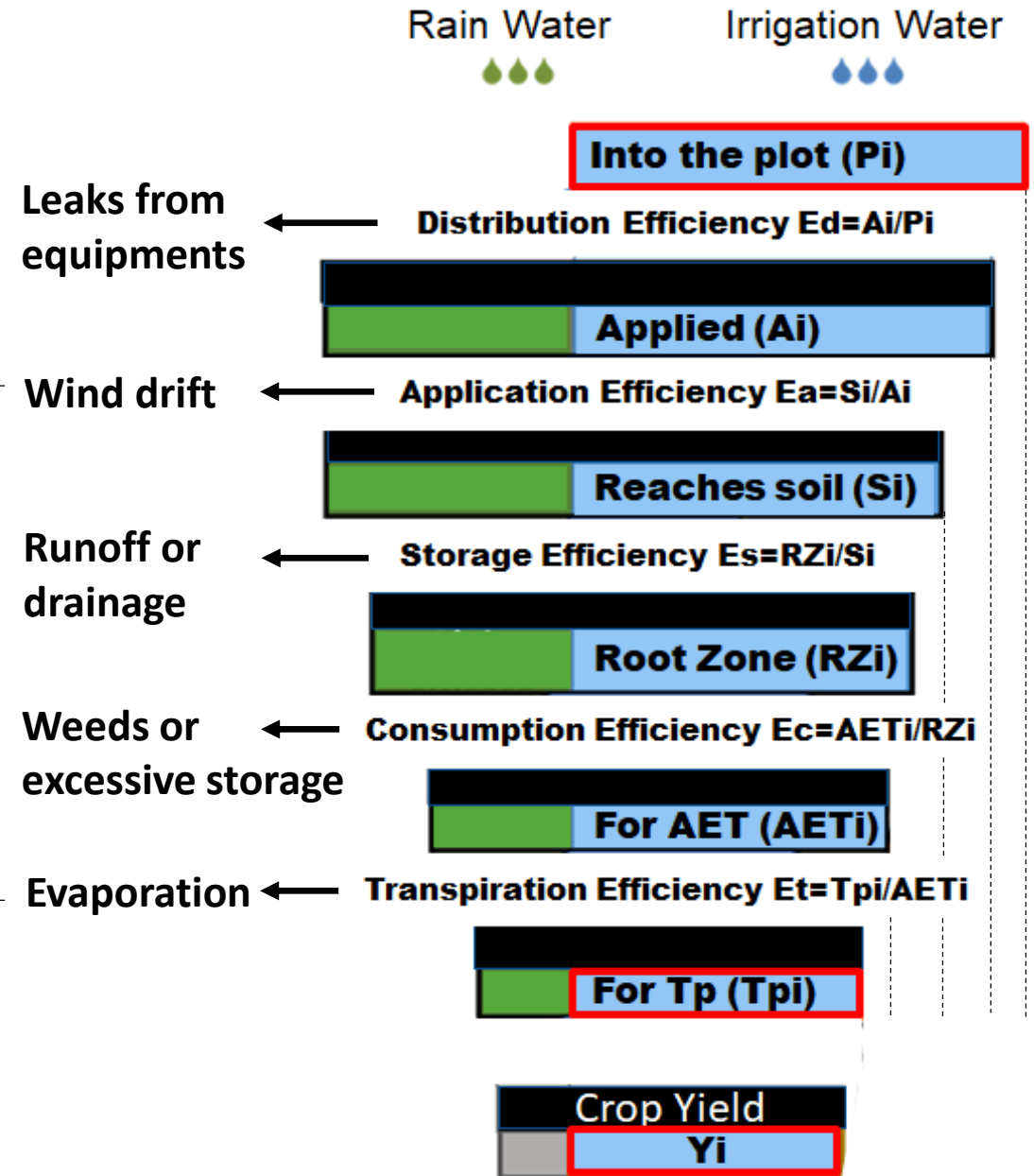*Improper, defective or miscontrolled plot equipment*

Tactical losses

Dummy, default or too constrained *irrigation strategy*

"Then I should definitely increase my irrigation water efficiency"

"Yes buddy and you should really start by reducing the losses"

Rain Water   Irrigation Water

Into the plot (Pi)

Leaks from equipments ← Distribution Efficiency Ed=Ai/Pi

Applied (Ai)

Wind drift ← Application Efficiency Ea=Si/Ai

Reaches soil (Si)

Runoff or drainage ← Storage Efficiency Es=RZi/Si

Root Zone (RZi)

Weeds or excessive storage ← Consumption Efficiency Ec=AETi/RZi

For AET (AETi)

Evaporation ← Transpiration Efficiency Et=Tpi/AETi

For Tp (Tpi)

Crop Yield
Yi

Water savings from improvements of...
Irrigation efficiency

Generation, analysis & optimization of crop irrigation scenarios

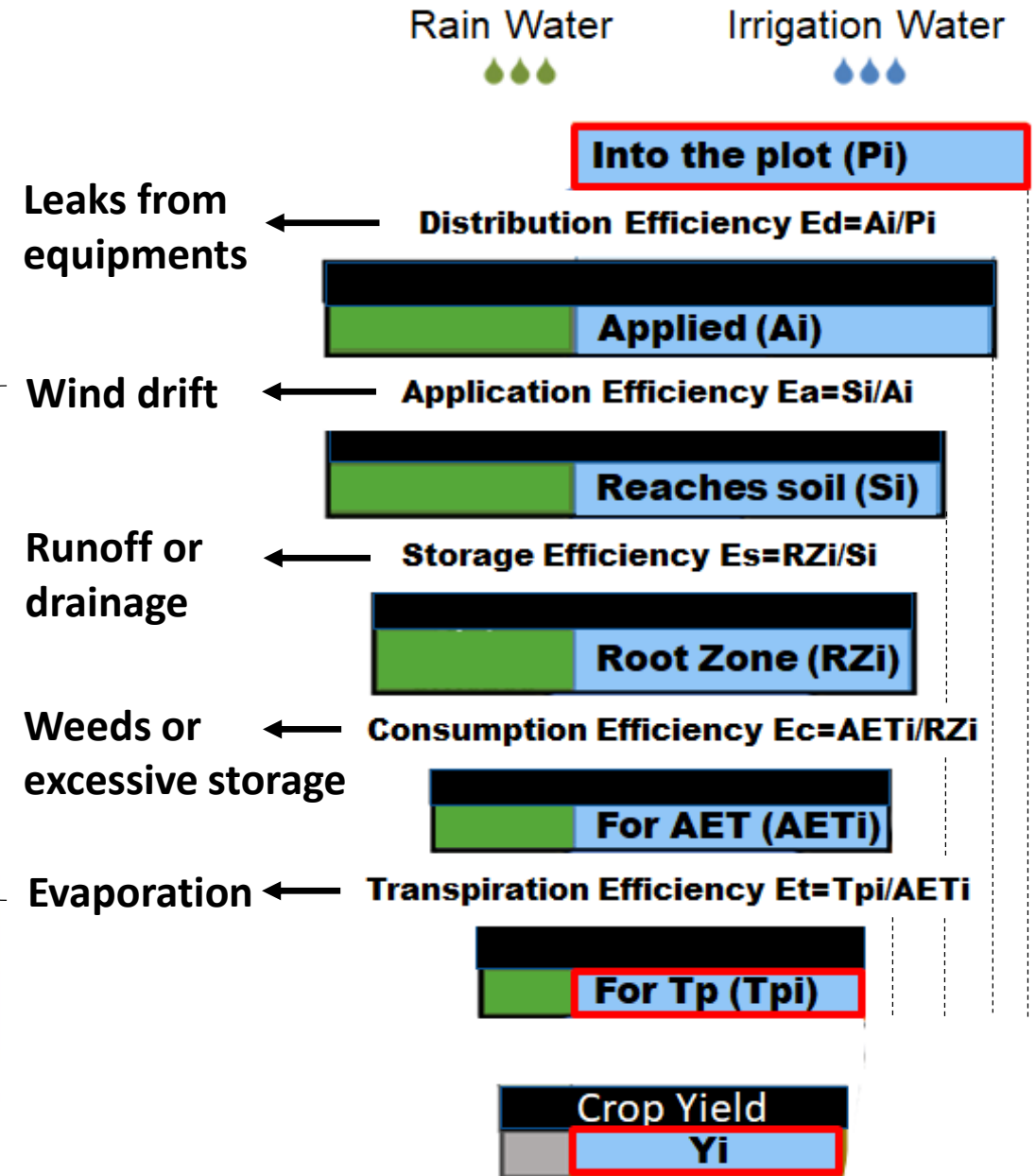*Dedicated module that handles irrigation water efficiency*

Tactical improvements *vs. Tactical losses*

Improving irrigation strategy by tuning irrigation scenarios

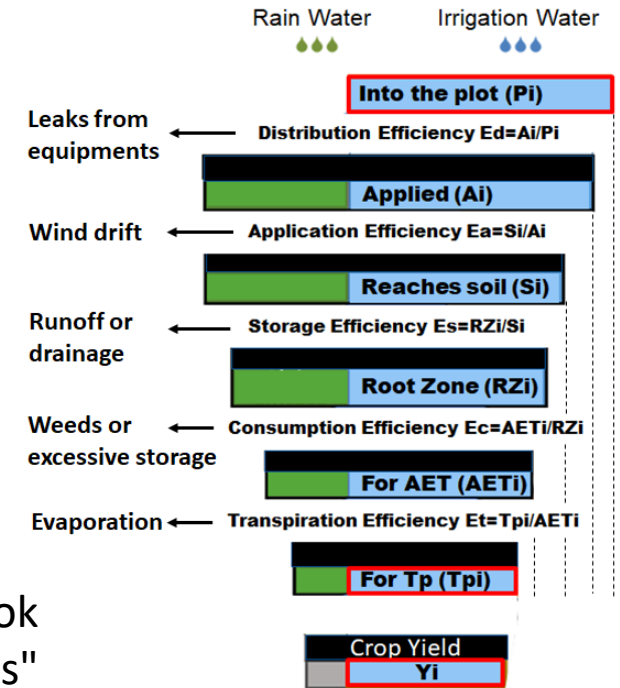"Then I should definitely increase my irrigation water efficiency"

"Yes buddy and you should really start by reducing the losses"

Rain Water   Irrigation Water

Into the plot (Pi)

Leaks from equipments ← Distribution Efficiency $Ed = Ai/Pi$

Applied (Ai)

Wind drift ← Application Efficiency $Ea = Si/Ai$

Reaches soil (Si)

Runoff or drainage ← Storage Efficiency $Es = RZi/Si$

Root Zone (RZi)

Weeds or excessive storage ← Consumption Efficiency $Ec = AETi/RZi$

For AET (AETi)

Evaporation ← Transpiration Efficiency $Et = Tpi/AETi$

For Tp (Tpi)

Crop Yield

Yi

Water savings from improvements of...
Irrigation efficiency

**Efficiency module
Output example 1**

Rain Water   Irrigation Water

Into the plot (Pi)

Leaks from equipments ← Distribution Efficiency Ed=Ai/Pi

Applied (Ai)

Wind drift ← Application Efficiency Ea=Si/Ai

Reaches soil (Si)

Runoff or drainage ← Storage Efficiency Es=RZi/Si

Root Zone (RZi)

Weeds or excessive storage ← Consumption Efficiency Ec=AETi/RZi

For AET (AETi)

Evaporation ← Transpiration Efficiency Et=Tpi/AETi

For Tp (Tpi)

Crop Yield
Yi

Total soil profile reserve from sowing to harvest (mm)

"Ahem these irrigations took place just before rain events"

Réserve due à l'irrigation (R1I+R2I+R3I)
Réserve due à la pluie (R1P+R2P+R3P)
Irrigation (I)
Pluie (P)

*Original legend in French
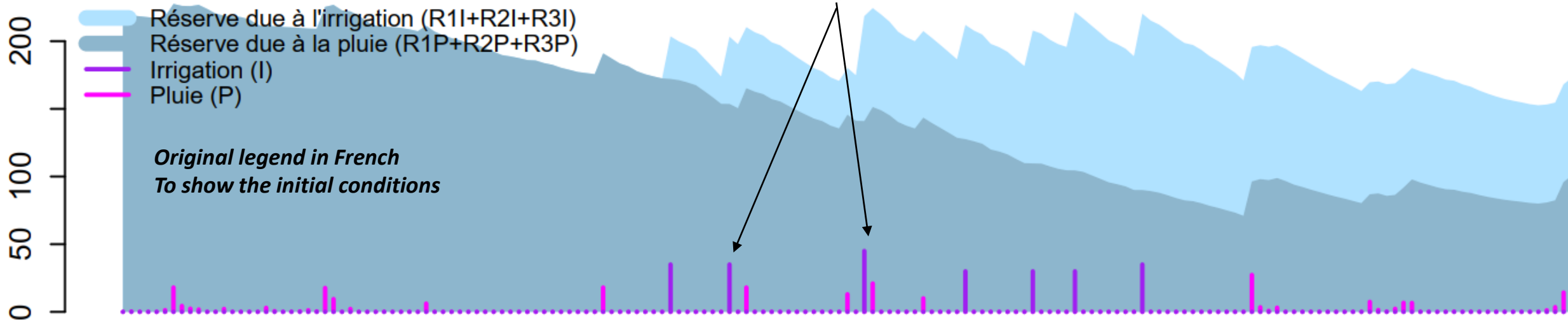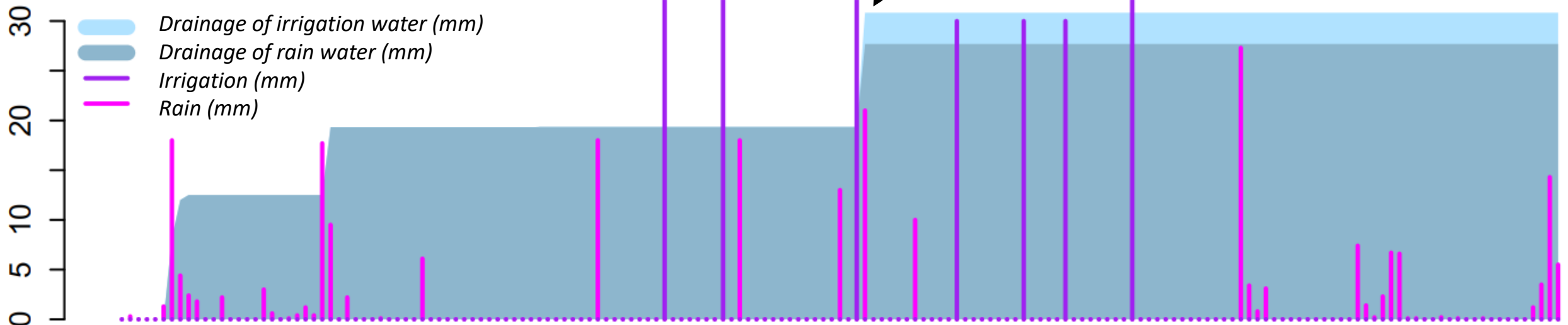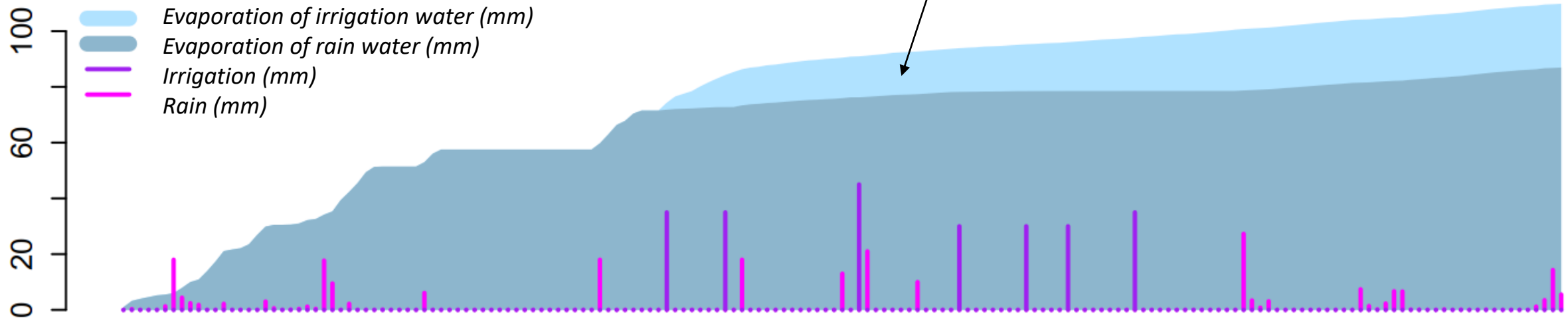To show the initial conditions*
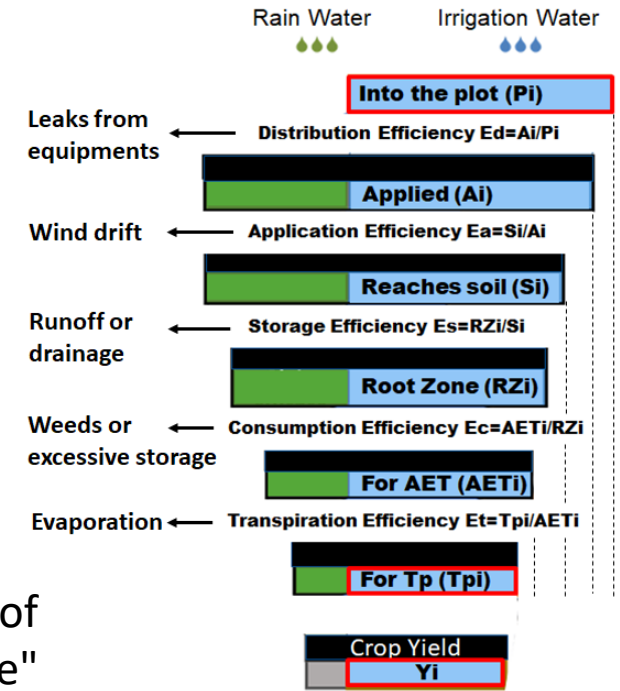
Water savings from improvements of...
Irrigation efficiency

**Efficiency module
Output example 3**
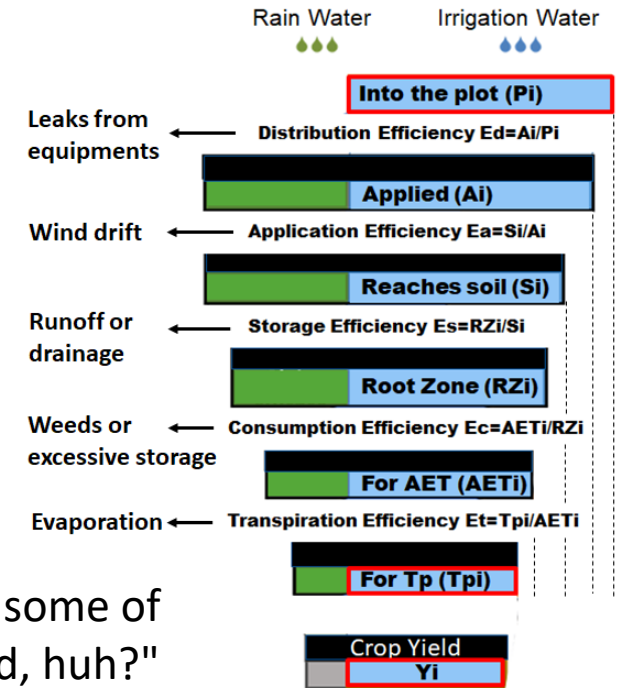
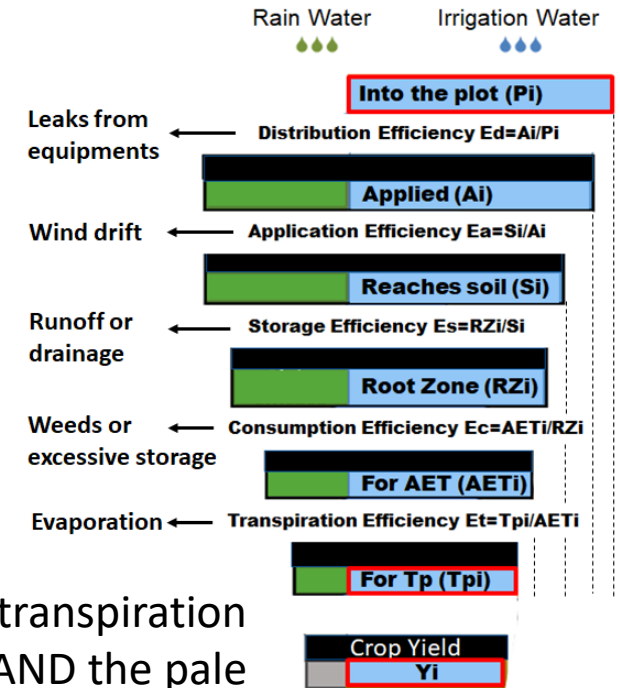*Cumulative soil evaporation from sowing to harvest (mm)*

"Some of it is evaporated, some of it expectedly transpirated, huh?"

Rain Water   Irrigation Water

Into the plot (Pi)

Leaks from equipments   ← Distribution Efficiency Ed=Ai/Pi

Applied (Ai)

Wind drift   ← Application Efficiency Ea=Si/Ai

Reaches soil (Si)

Runoff or drainage   ← Storage Efficiency Es=RZi/Si

Root Zone (RZi)

Weeds or excessive storage   ← Consumption Efficiency Ec=AETi/RZi

For AET (AETi)

Evaporation   ← Transpiration Efficiency Et=Tpi/AETi

For Tp (Tpi)

Crop Yield
Yi

Legend:
- Evaporation of irrigation water (mm)
- Evaporation of rain water (mm)
- Irrigation (mm)
- Rain (mm)

Water savings from improvements of...
Irrigation efficiency

**Efficiency module
Output example 4**

Rain Water | **Irrigation Water**

Into the plot (Pi)

Leaks from equipments ← Distribution Efficiency Ed=Ai/Pi

Applied (Ai)

Wind drift ← Application Efficiency Ea=Si/Ai

Reaches soil (Si)

Runoff or drainage ← Storage Efficiency Es=RZi/Si

Root Zone (RZi)

Weeds or excessive storage ← Consumption Efficiency Ec=AETi/RZi

For AET (AETi)

Evaporation ← Transpiration Efficiency Et=Tpi/AETi

For Tp (Tpi)

Crop Yield
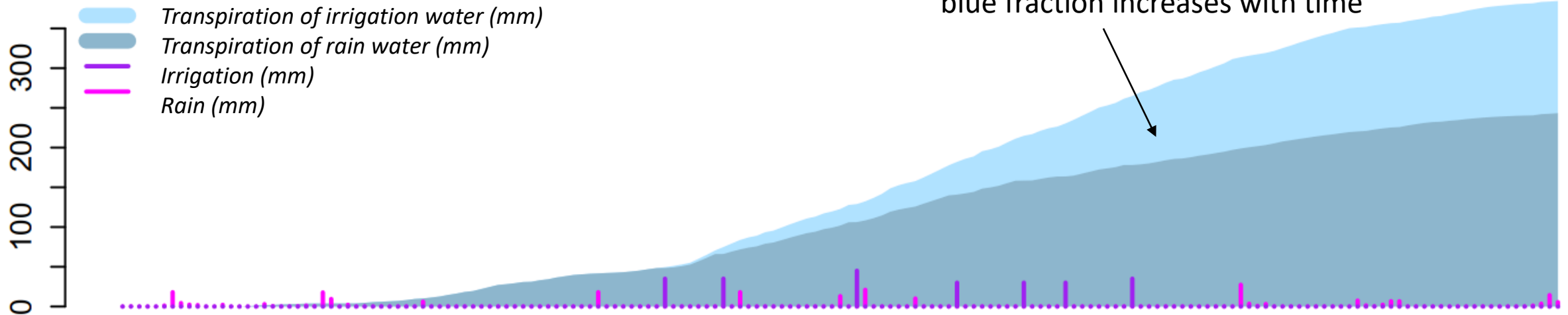**Yi**

Cumulative crop transpiration from sowing to harvest (mm)
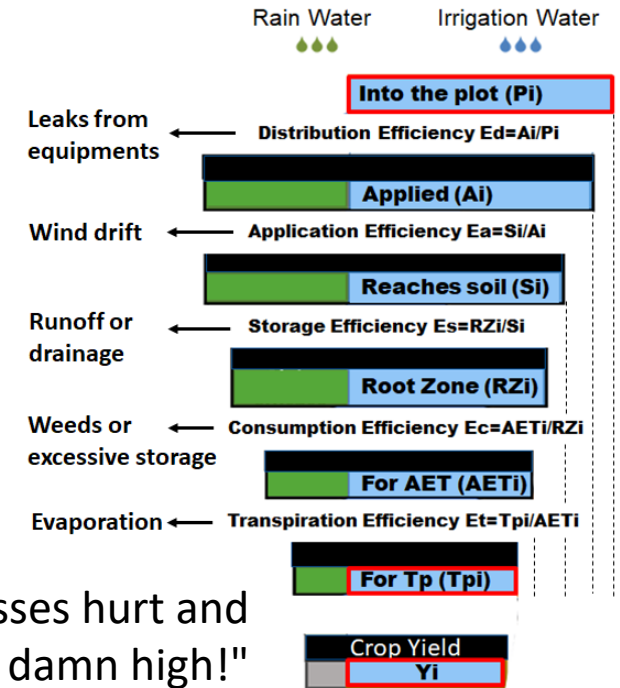
"Seems good as more transpiration than evaporation occurs AND the pale blue fraction increases with time "

Transpiration of irrigation water (mm)
Transpiration of rain water (mm)
Irrigation (mm)
Rain (mm)

Water savings from improvements of...
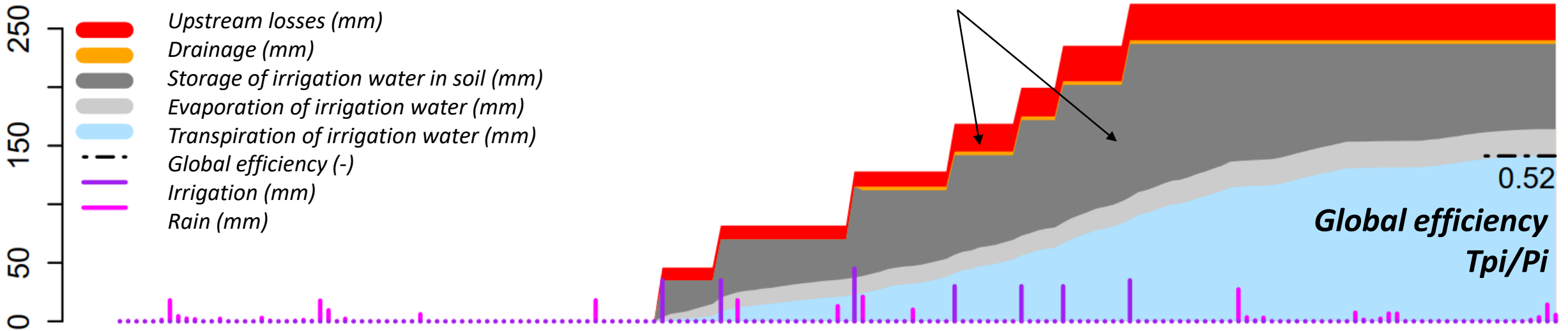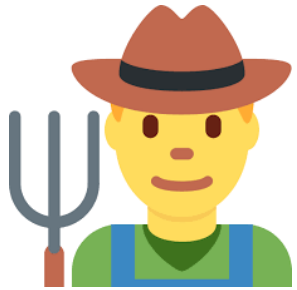Irrigation efficiency

Efficiency module
Output example 4

Summary of the key terms in the efficiency cascade scheme

"Ouch my upstream losses hurt and irrigation storage is so damn high!"

Rain Water   Irrigation Water

Into the plot (Pi)
Leaks from equipments ← Distribution Efficiency Ed=Ai/Pi
Applied (Ai)
Wind drift ← Application Efficiency Ea=Si/Ai
Reaches soil (Si)
Runoff or drainage ← Storage Efficiency Es=RZi/Si
Root Zone (RZi)
Weeds or excessive storage ← Consumption Efficiency Ec=AETi/RZi
For AET (AETi)
Evaporation ← Transpiration Efficiency Et=Tpi/AETi
For Tp (Tpi)

Crop Yield
Yi

Legend:
- Upstream losses (mm)
- Drainage (mm)
- Storage of irrigation water in soil (mm)
- Evaporation of irrigation water (mm)
- Transpiration of irrigation water (mm)
- Global efficiency (-)
- Irrigation (mm)
- Rain (mm)

0.52

Global efficiency
Tpi/Pi

IRRIGATION
QUELLES STRATÉGIES POUR ÉCONOMISER L'EAU ?
WHAT STRATEGIES FOR WATER SAVINGS ?

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Water savings from improvements of...
Irrigation efficiency

"I need to evaluate or reformulate my irrigation strategies, especially in a context of limited resource availability"

" is here for you, and can be tuned to save water by improving irrigation efficiency... but instead of an autograph I made a little drawing for you"

Water savings from improvements of...
Irrigation efficiency

"Think about it:

1- Maximum crop yield is obtained for higher irrigation amounts than these of maximum irrigation efficiency

2- Reducing irrigation to improve efficiency is a virtous behavious that may need/deserve a financial reward"