Determination of crop transpiration

(dual crop coefficient approach)

in FAO Irrigation and Drainage Papers Nr 56 and 66

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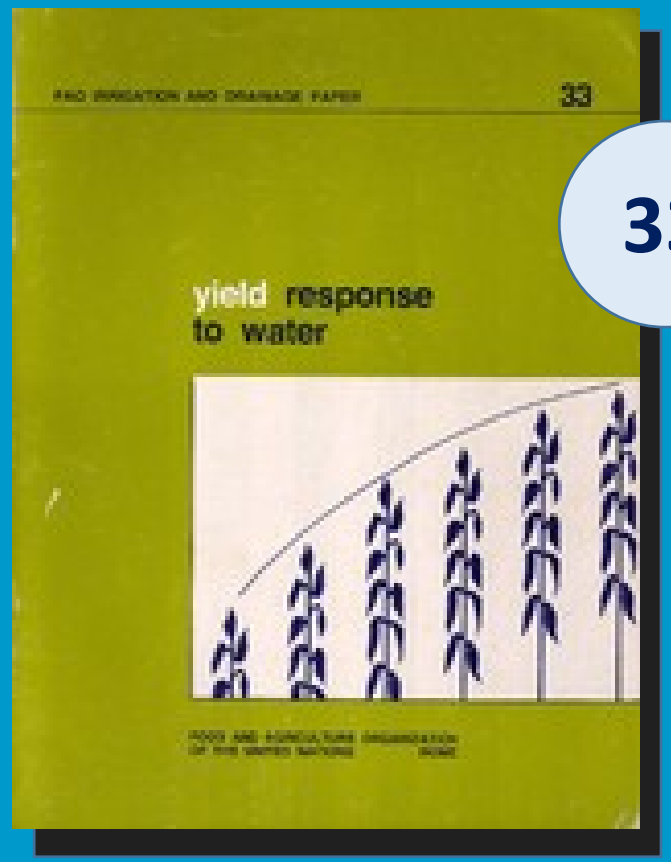

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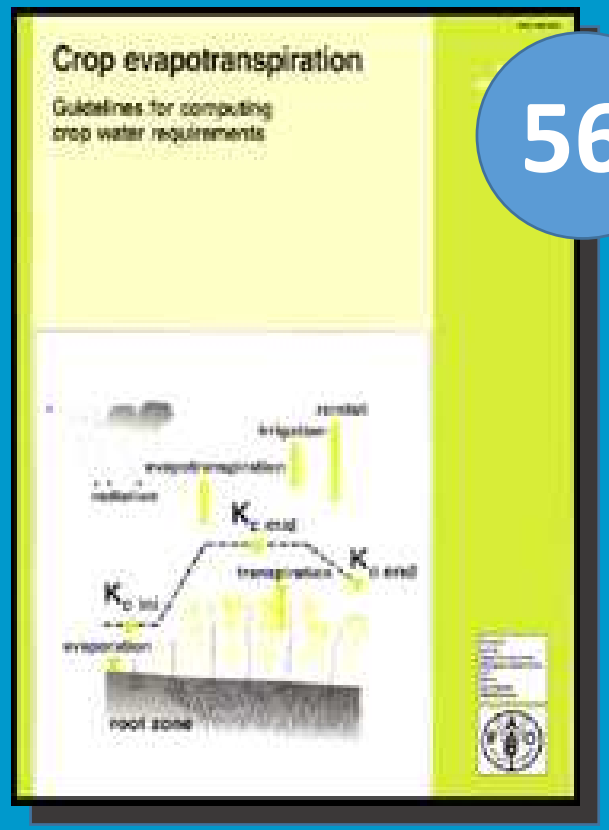
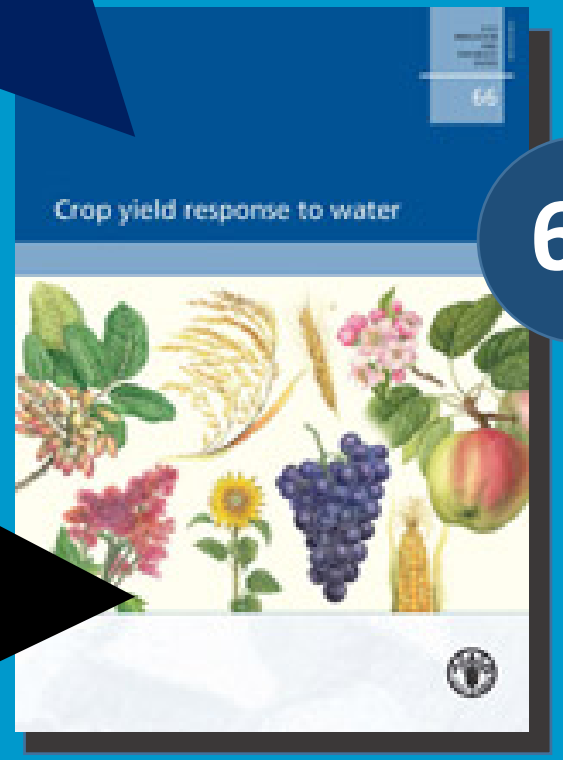
Yield
response to water



56

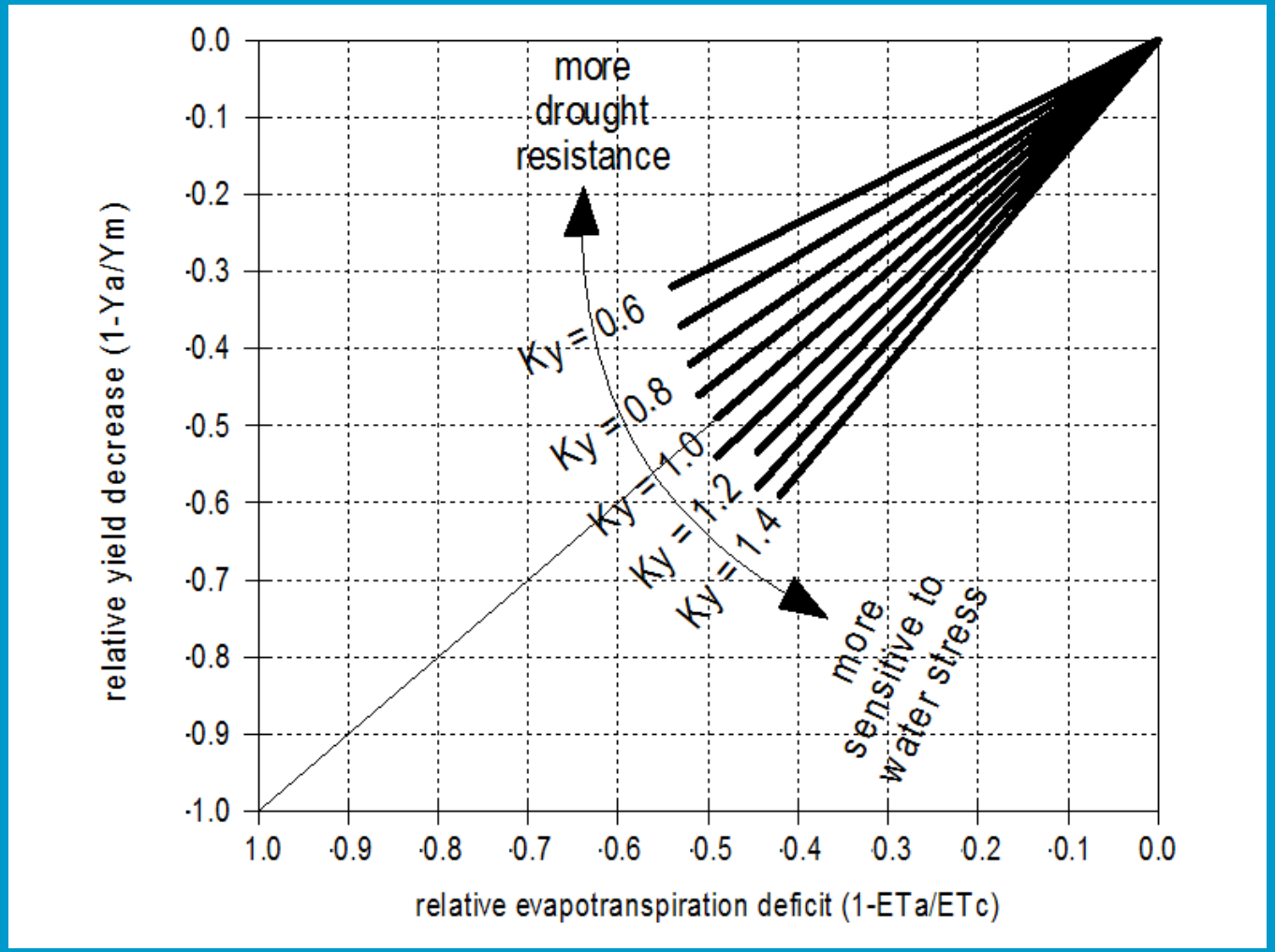
Crop evapotranspiration

guidelines to compute crop water requirements



66

Crop yield
response to water



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Yield response to water

Crop yield ← **Ky** → **ET: Evapotranspiration**

yield response coefficient

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Crop yield response to water

Evaporation

Transpiration

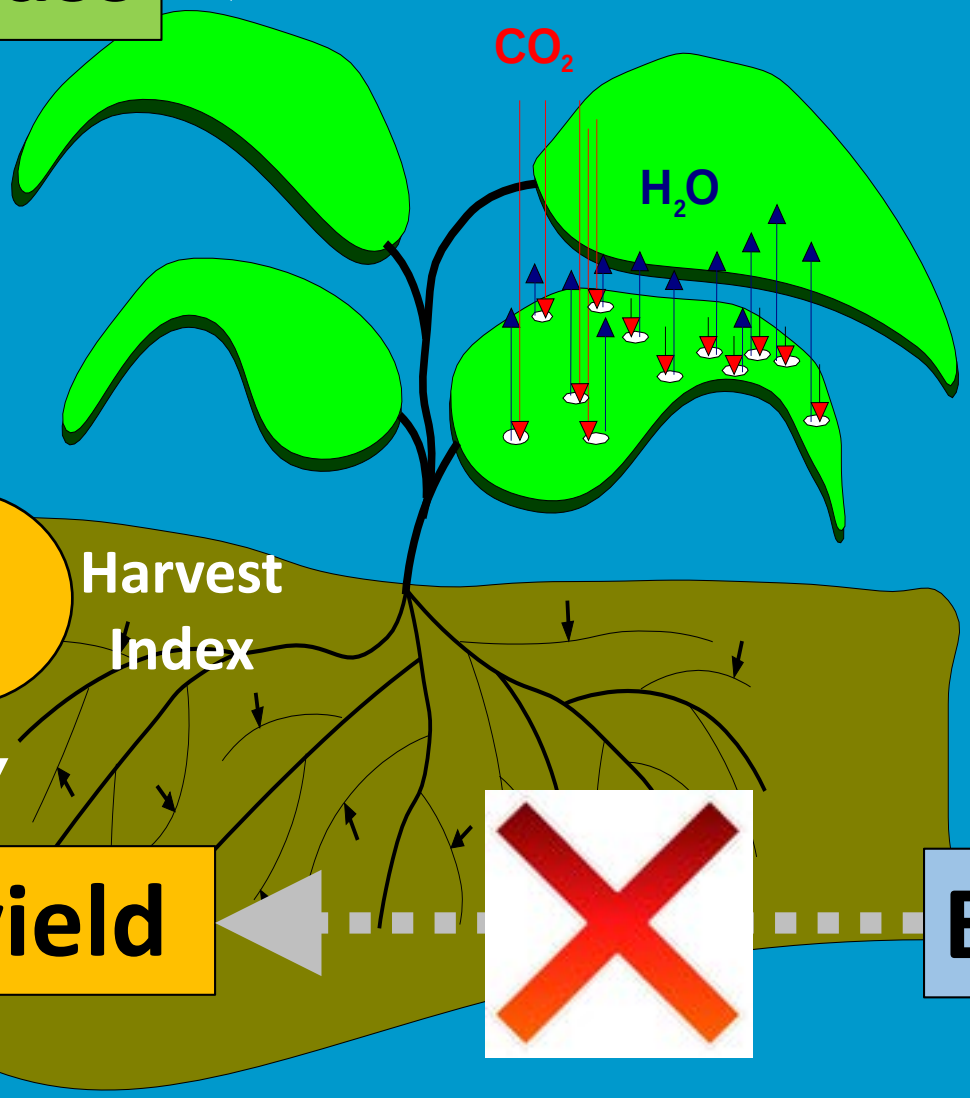
Biomass

WP

biomass Water Productivity

crop specific

$$\frac{\text{kg(biomass)}}{\text{m}^2\text{.mm(water)}}$$



AQUACROP

HI

Harvest Index

Crop yield

ET: Evapotranspiration

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Crop yield response to water

Biomass

WP

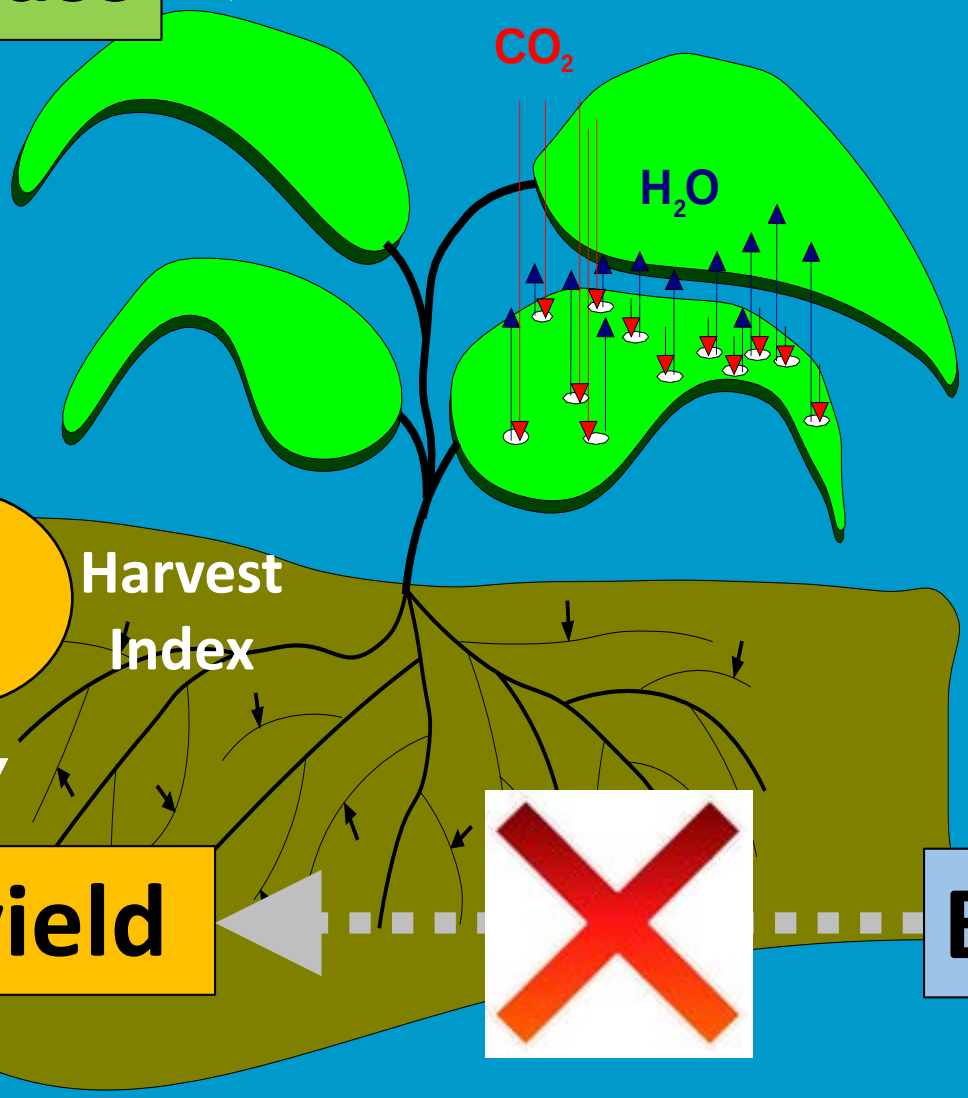
Evaporation

Transpiration

dual crop coefficient

56

Crop evapotranspiration



HI

Harvest Index

Crop yield

ET: Evapotranspiration

K_e x ETo =

K_{cb} x ETo =

Evaporation

Transpiration

dual
crop coefficient

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Crop evapotranspiration

basal crop coefficient

soil evaporation coefficient

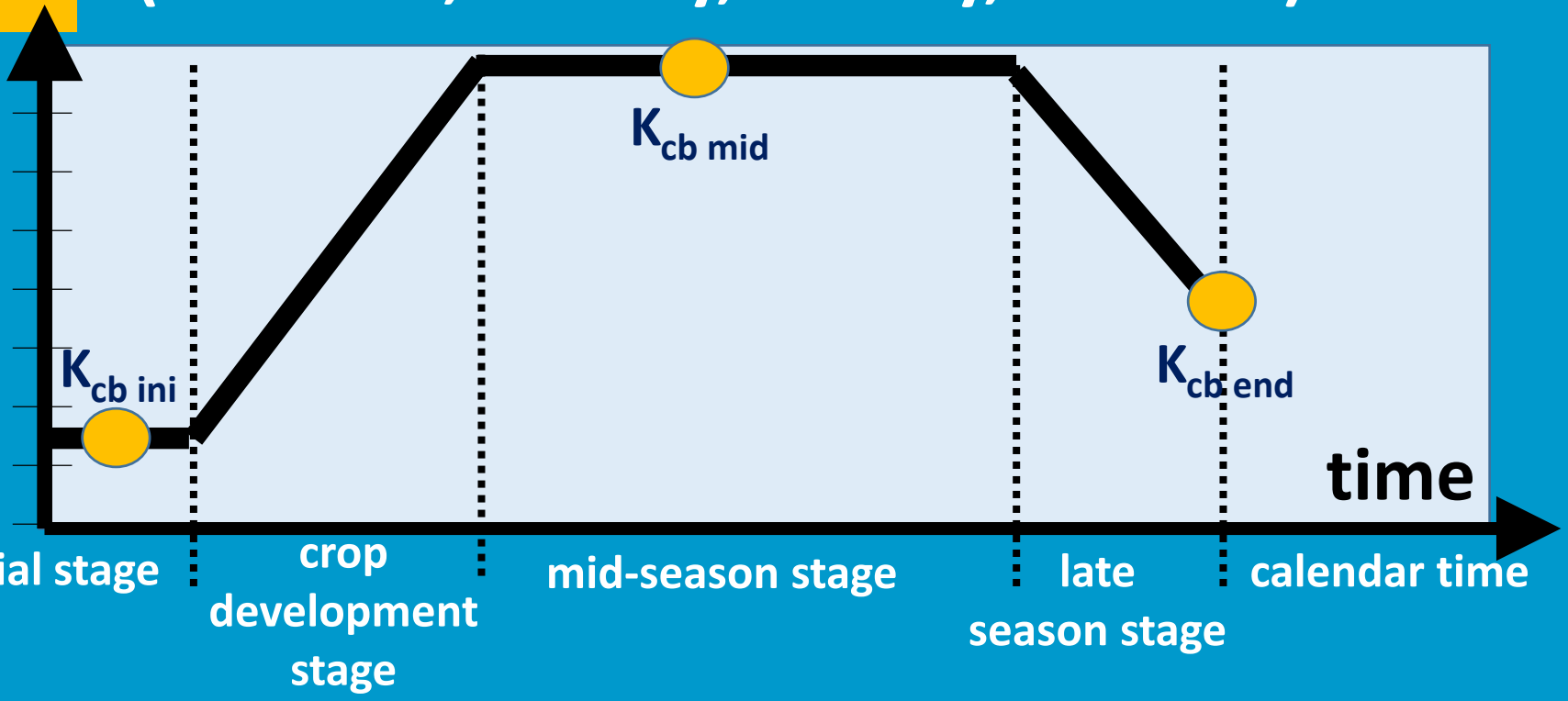
proportional to fraction of soil
that is exposed and wetted

FAO Penman-Monteith → ETo

evaporating power
of the atmosphere

Optimal conditions

(no water, fertility, salinity, … stress)



Transpiration = K_{cb} ETo

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Crop evapotranspiration

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Crop yield response to water

Crop transpiration coefficient

Kc_{Tr}

Transpiration = Kc_{Tr} ETo

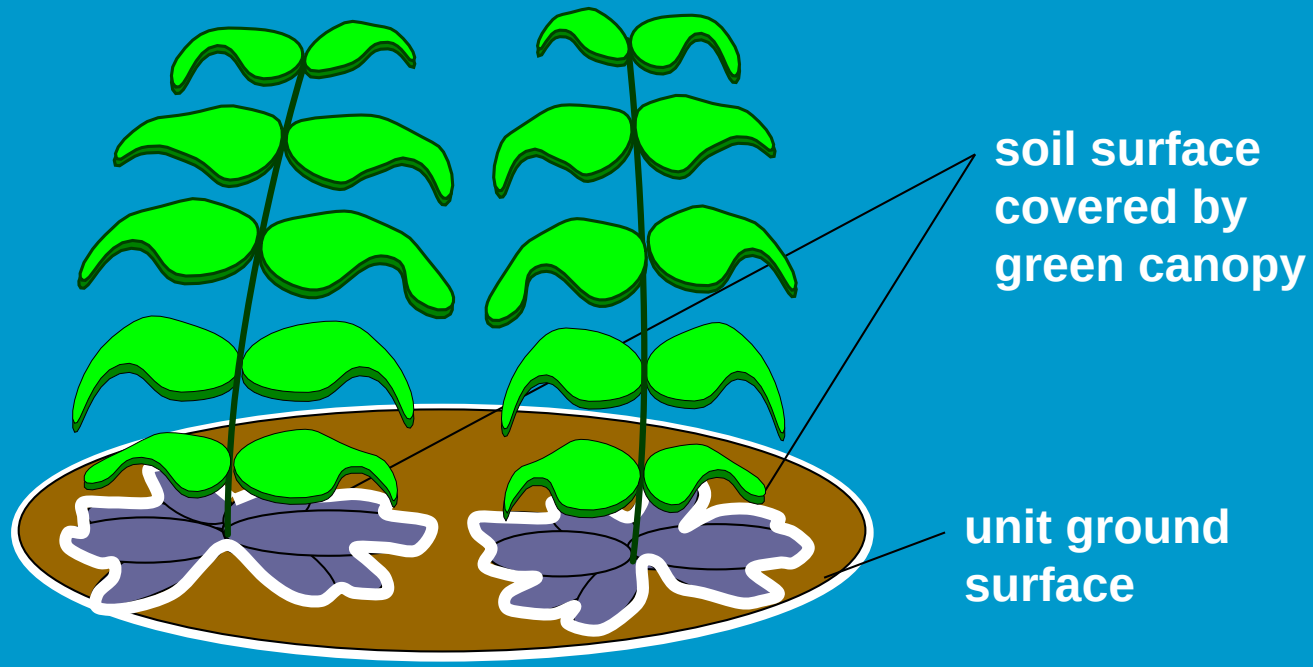
Instead of Leaf Area Index (LAI)

AquaCrop uses **green canopy cover (CC)**

$$CC = \frac{\text{soil surface covered by the green canopy}}{\text{unit ground surface area}}$$

ranges from 0 (bare soil) to 1 (full canopy cover)

0 % → 100 %



Green Canopy Cover (CC)

Winter wheat
(Walshoutem, Belgium)

Optimal conditions (no water, fertility, salinity, … stress)

Crop transpiration coefficient ~ CC (green Canopy Cover)

0.0 (sowing) → 0.85 ..1.00 (maximum CC)

$$Kc_{Tr} = Kc_{Tr,x} \times CC^*$$

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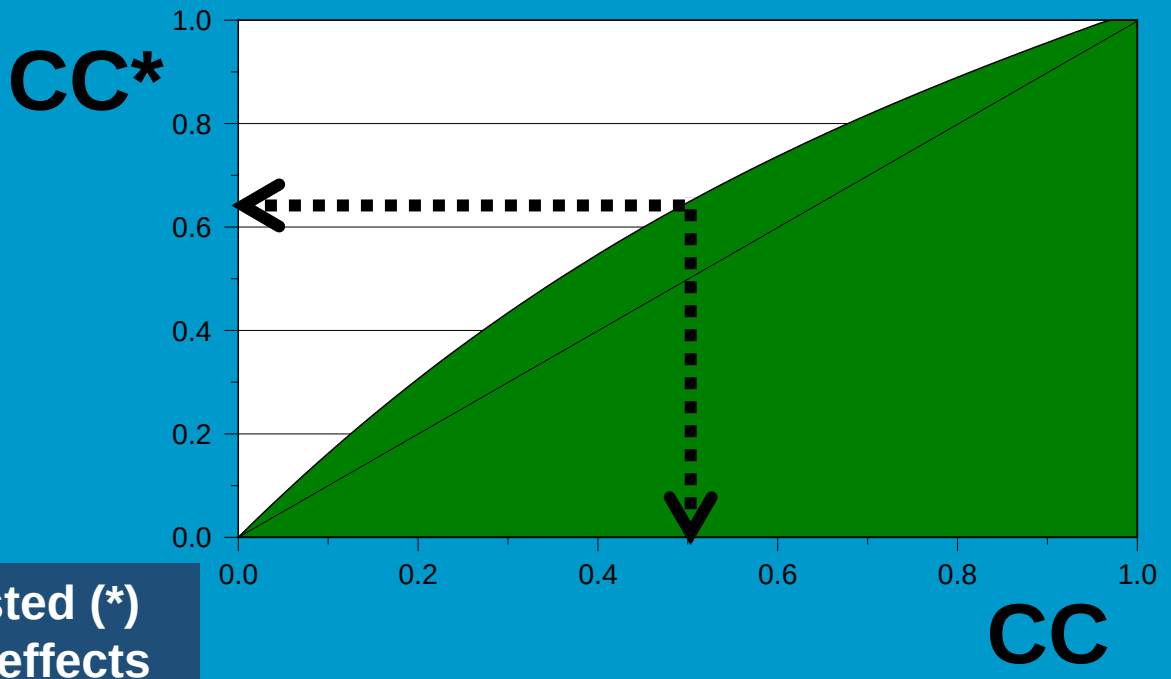
Crop yield response to water

.. 1.05 … 1.10 ..
proportional factor
(crop specific)

ageing effect
starting at mid-season

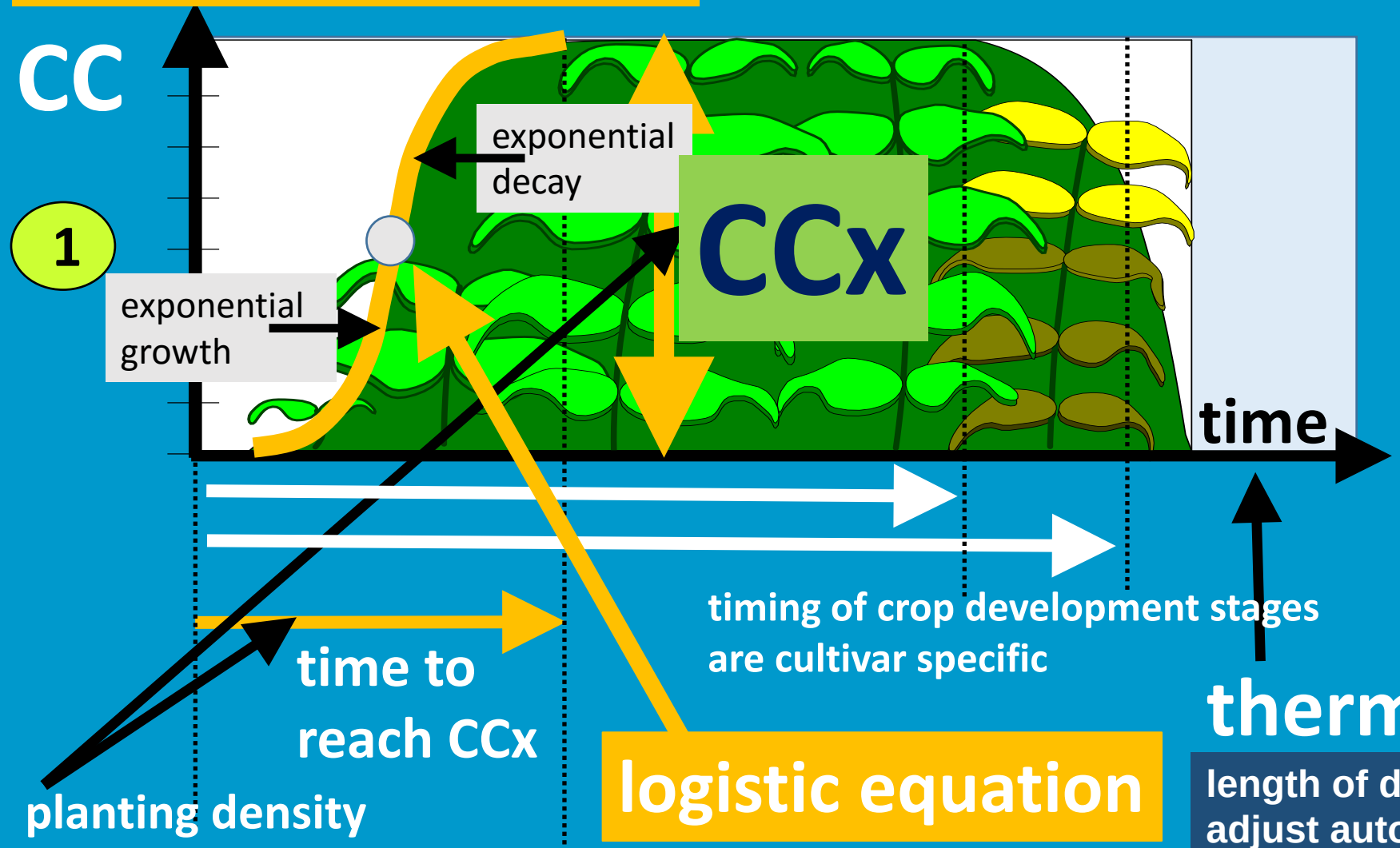
characteristics that distinguish the crop from the reference grass (when CC = 1)

Canopy Cover adjusted (*) for micro-advective effects



Optimal conditions

(no water, fertility, salinity, … stress)



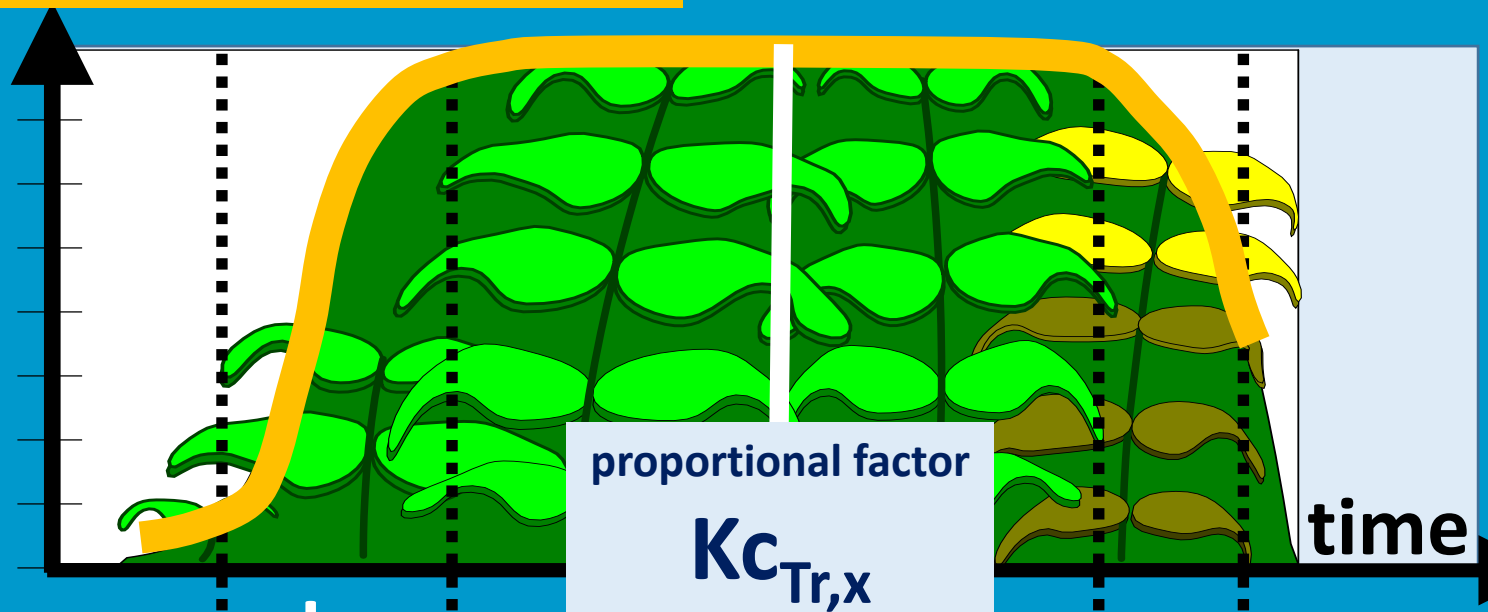
Canopy Cover

length of development stages adjust automatically to the different temperature regimes in the various years

parameters affected by management

Optimal conditions

(no water, fertility, salinity, … stress)



Canopy Cover

proportional factor

$Kc_{Tr,x}$

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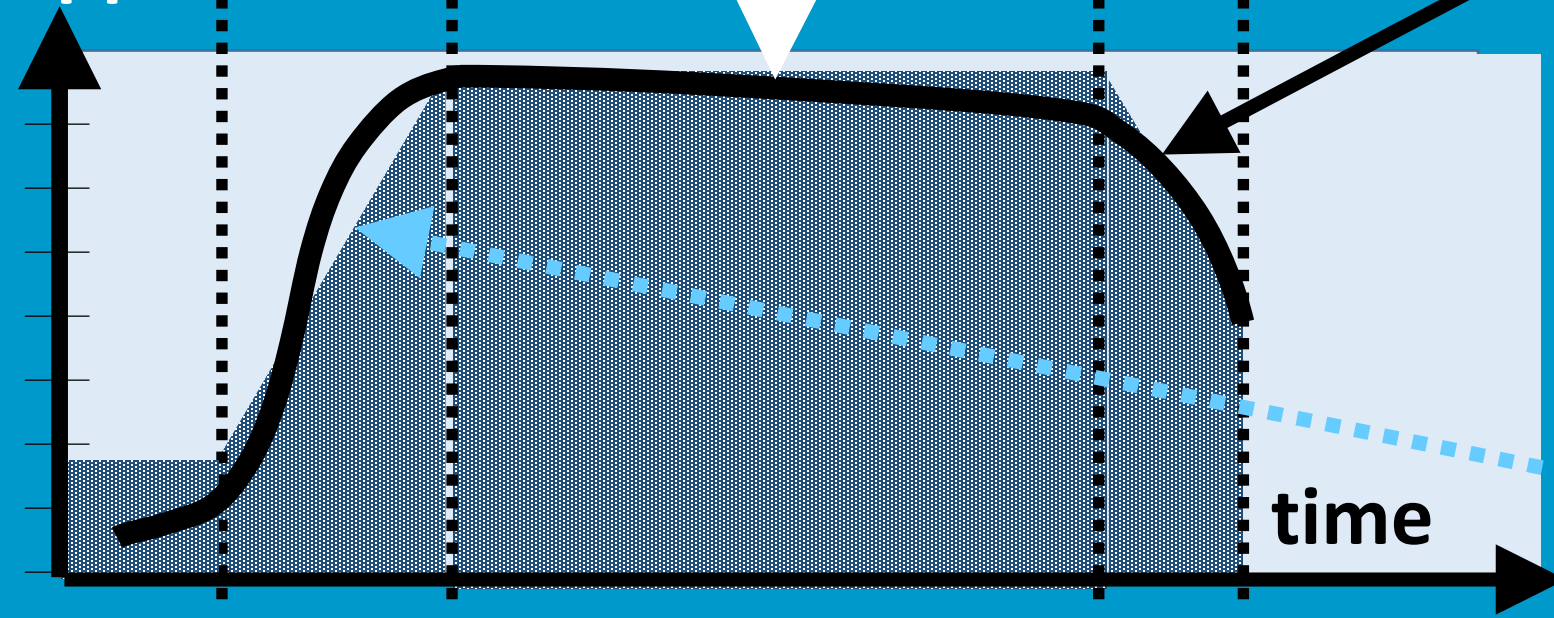
Crop yield response to water

$= Kc_{Tr,x} \times CC^*$

2 step approach



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$= K_{cb}$

Optimal conditions → **Non-optimal conditions**

stresses

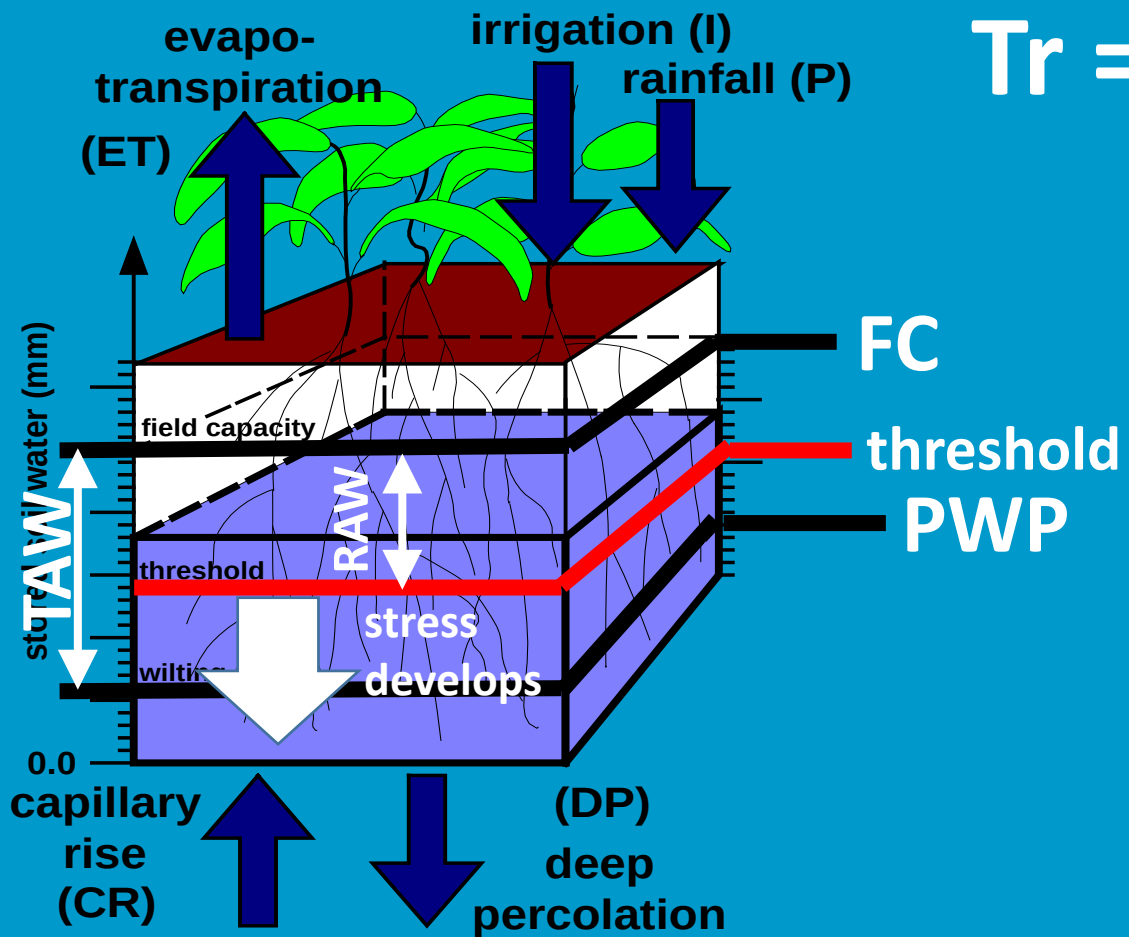
water stress

effect on
crop transpiration

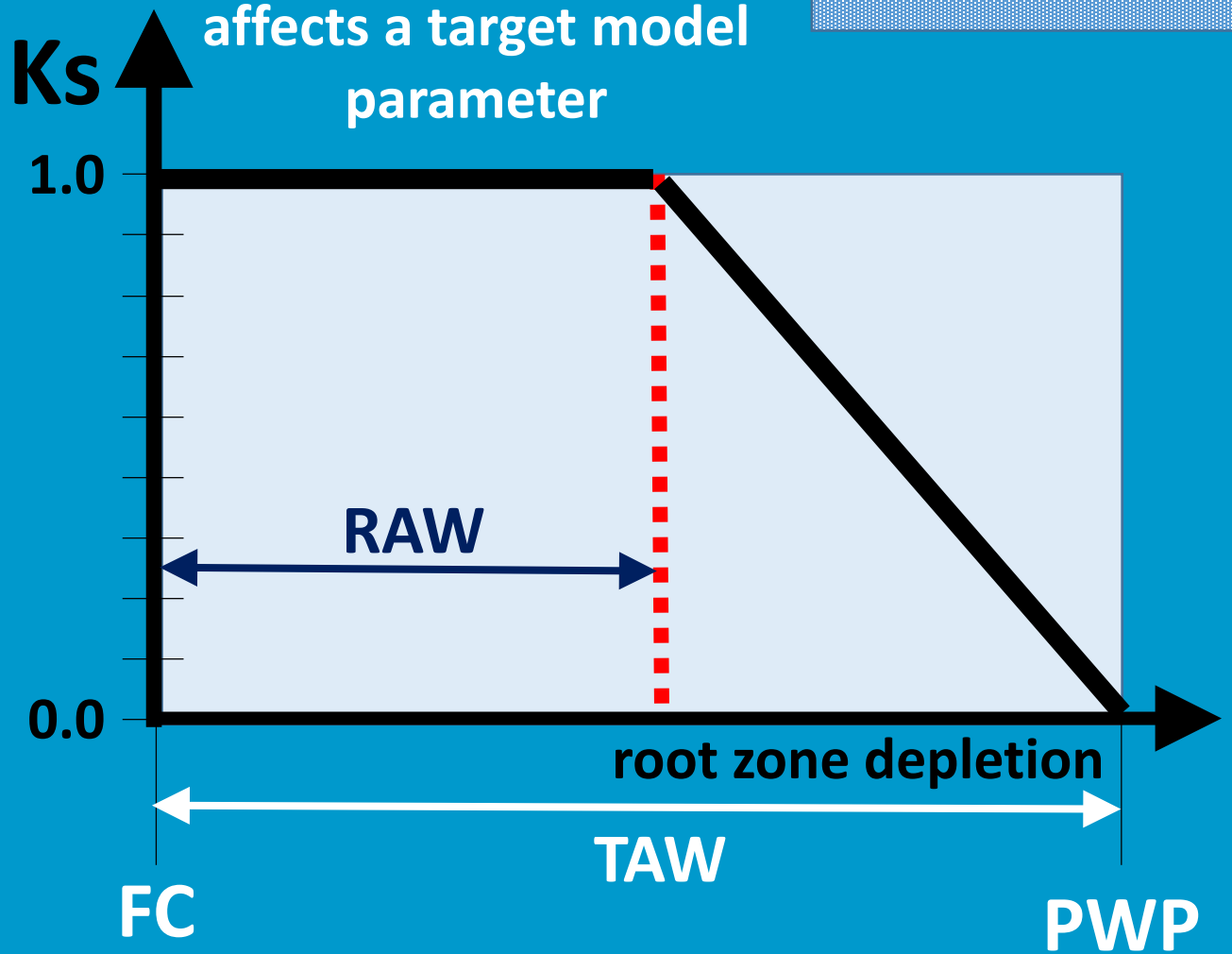
$$Tr = Ks\,[K_{cb}]\,ETo$$

stress coefficient
1 (no stress) → 0 (full stress)

$$Tr = Ks\ K_{cb}\ ETo$$



Ks is a modifier which affects a target model parameter



Optimal conditions

stresses

Non-optimal conditions

water stress

effect on
crop transpiration

$Tr = Ks\ [K_{cb}]\ ETo$

56

Crop
evapotranspiration

Ks_{exp}

Ks_{sen}

effect on
stomatal closure

Ks_{sto}

effect on
canopy development

$Tr = Ks_{sto}\ [Kc_{Tr,x}\ CC^*]\ ETo$

Ks is a modifier which affects a target model parameter

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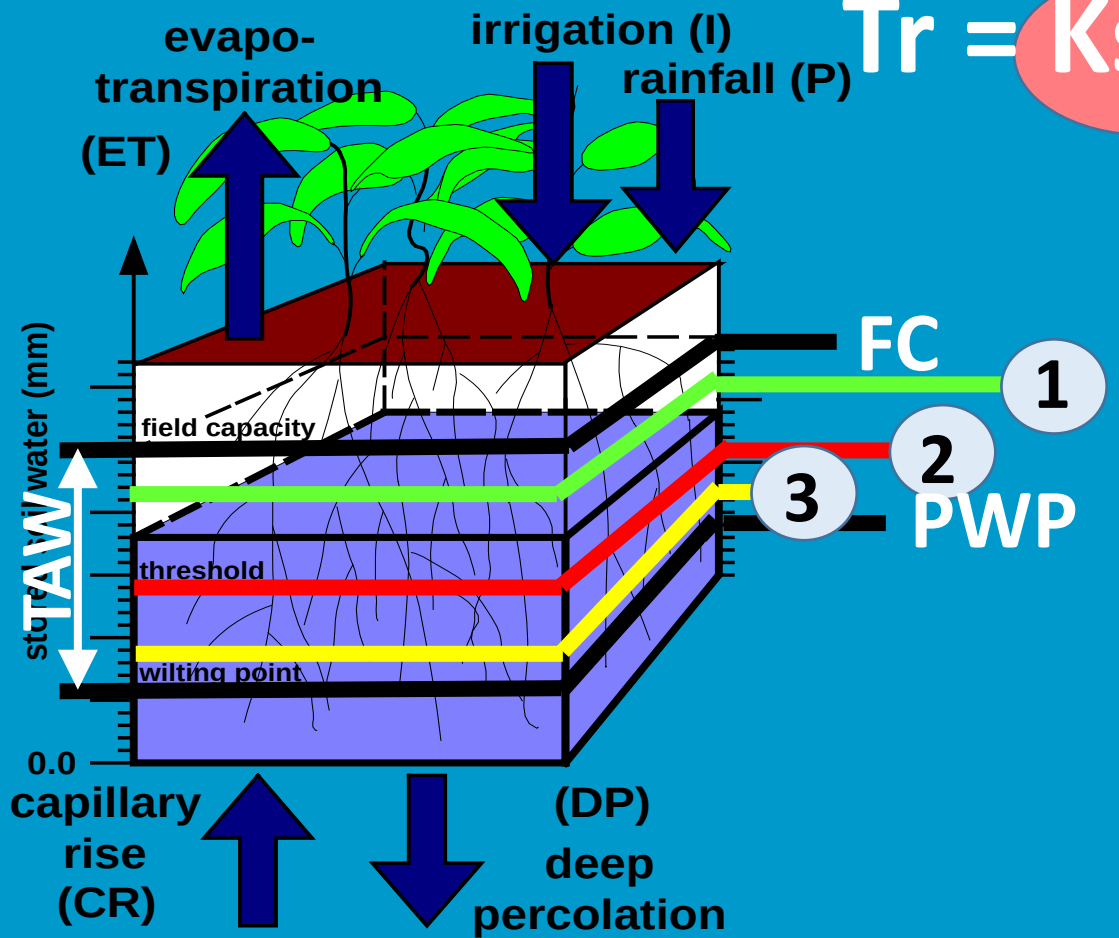
Crop yield
response to water

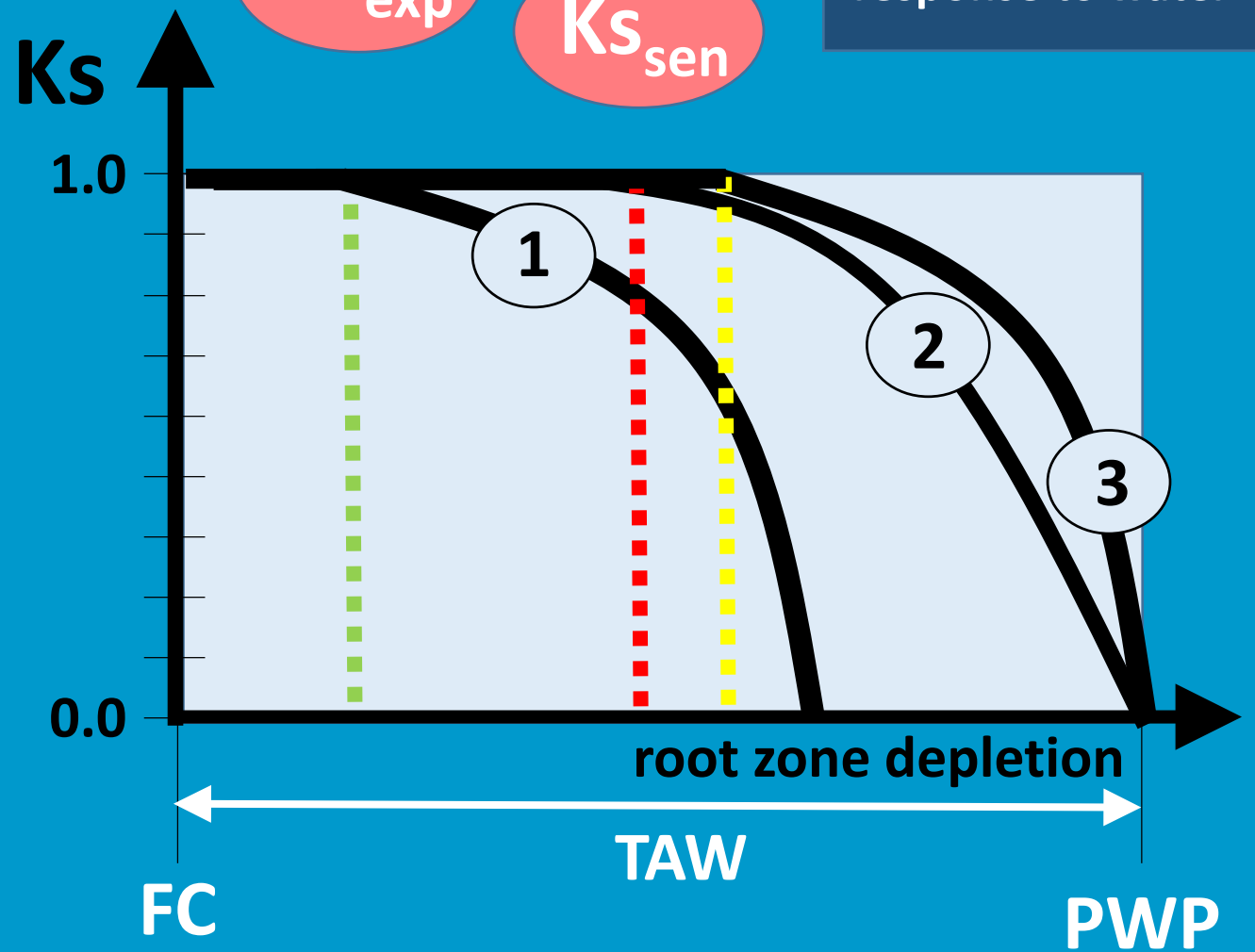
Crop yield response to water

$$Tr = Ks_{sto}\,[Kc_{Tr,x}\ CC^*]\ ETo$$

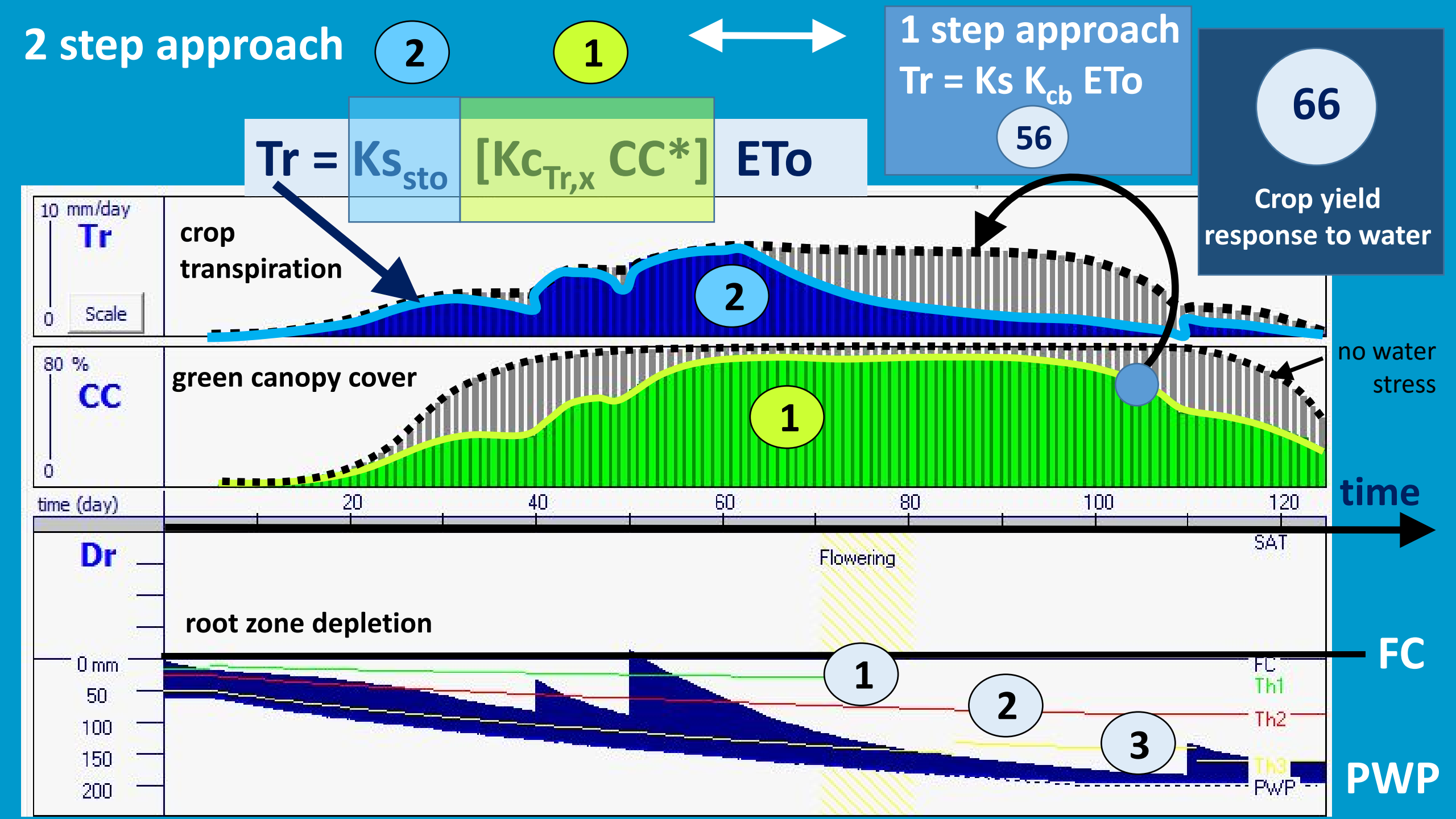
Ks_{exp}

Ks_{sen}





Ks is a modifier which affects a target model parameter


2 step approach
2
1
1 step approach
Tr = Ks Kcb ETo
56
66
Crop yield response to water
Tr = Kssto [KcTr,x CC*] ETo
10 mm/day
Tr
0
Scale
crop transpiration
2
no water stress
80 %
CC
0
green canopy cover
1
time (day)
20
40
60
80
100
120
time
Dr
root zone depletion
Flowering
SAT
0 mm
50
100
150
200
1
2
3
FC
Th1
Th2
Th3
PWP
FC
PWP

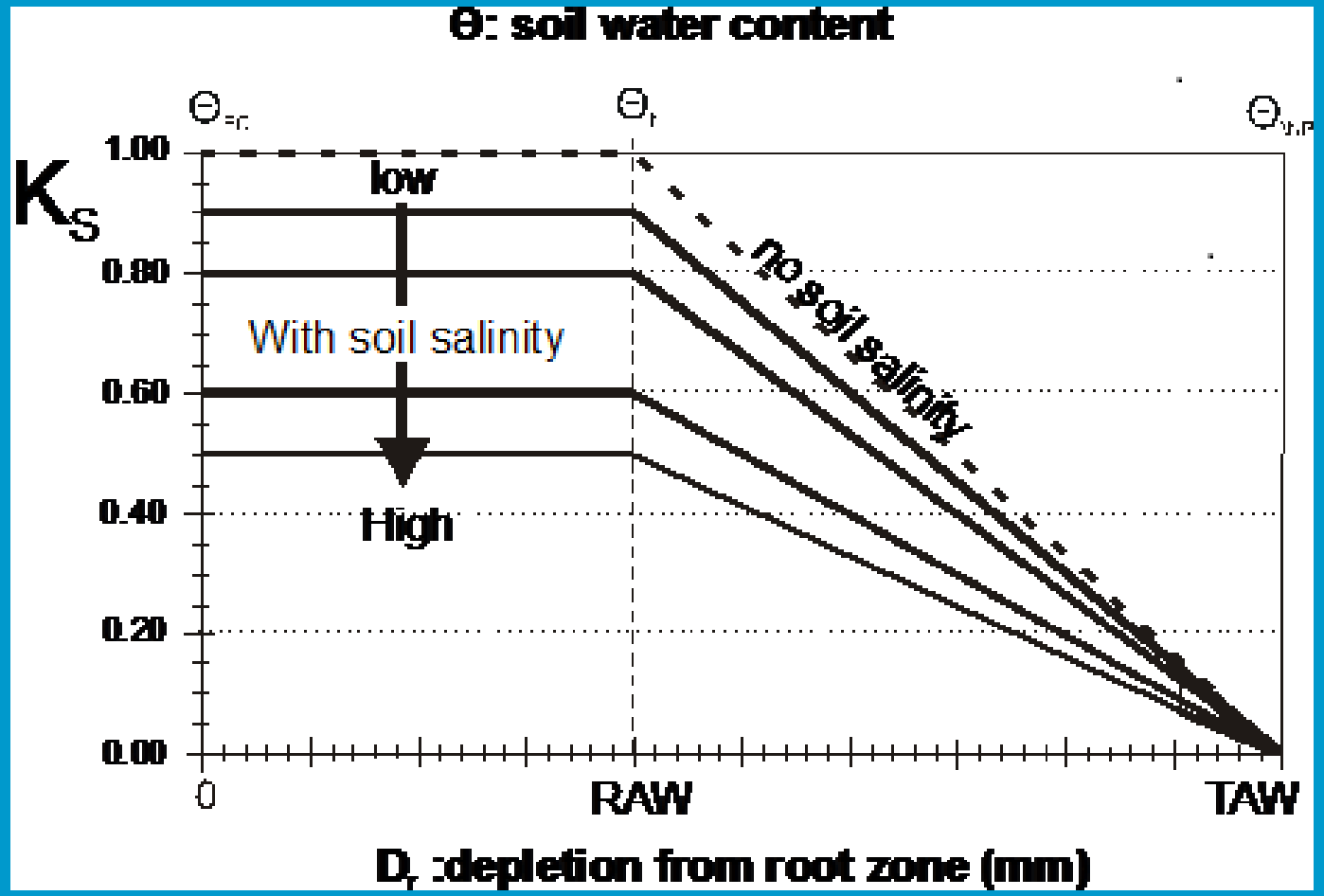
Optimal conditions → Non-optimal conditions

stresses

soil water stress

soil salinity stress

$$Tr = Ks\,[K_{cb}]\,ETo$$



Crop evapotranspiration

Optimal conditions

stresses

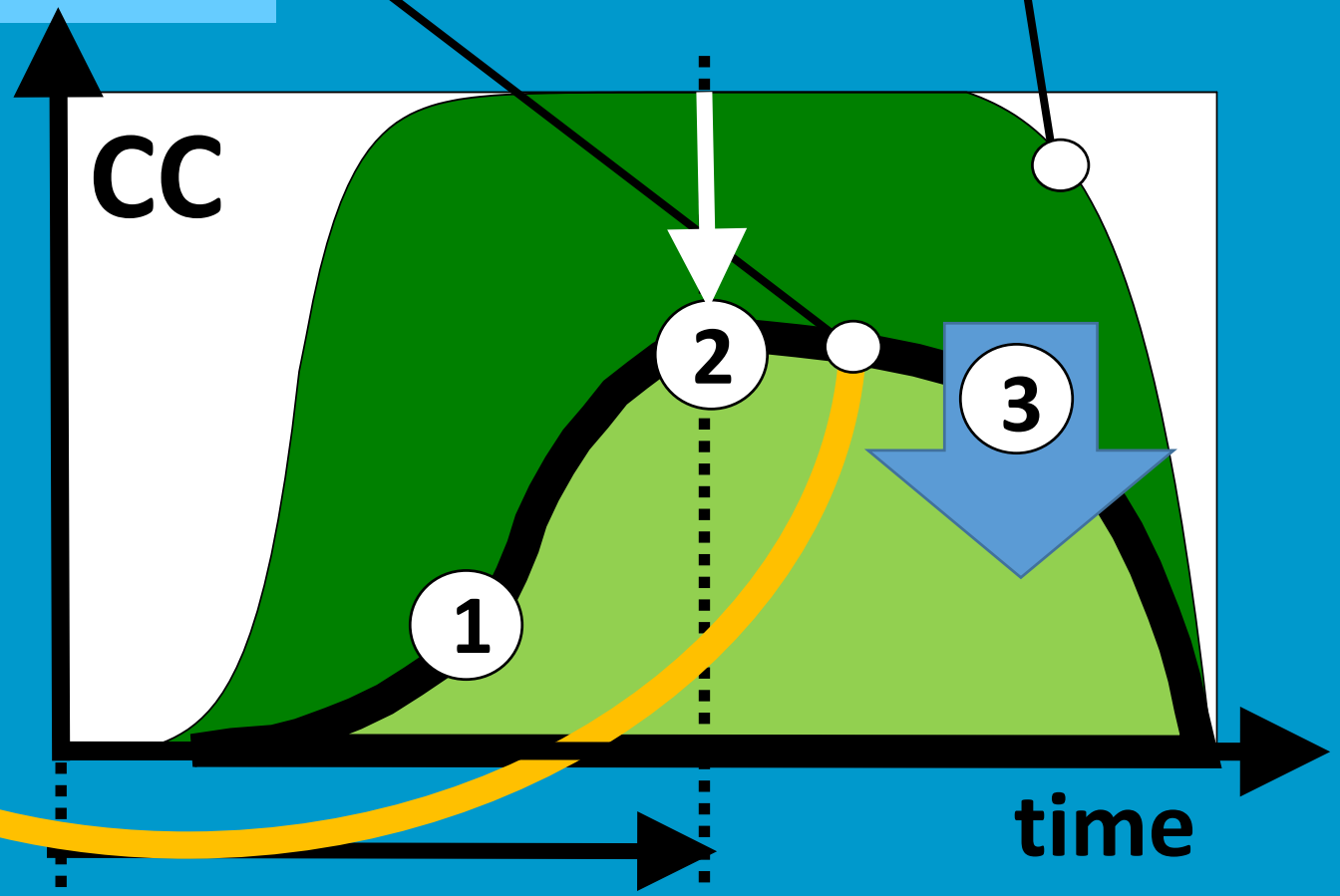
Non-optimal conditions

soil water stress

soil salinity stress

soil fertility stress

$$Tr = Ks_{sto} [Kc_{Tr,x} CC^*] ETo$$

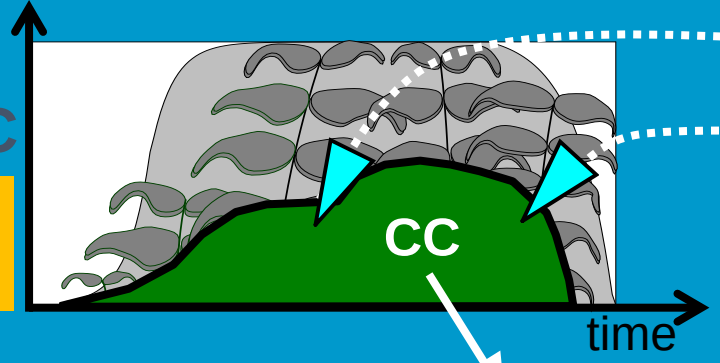


66

Crop yield response to water

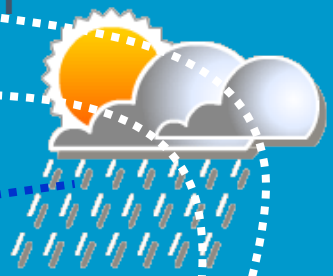
AQUACROP

1 **Canopy development**



leaf expansion

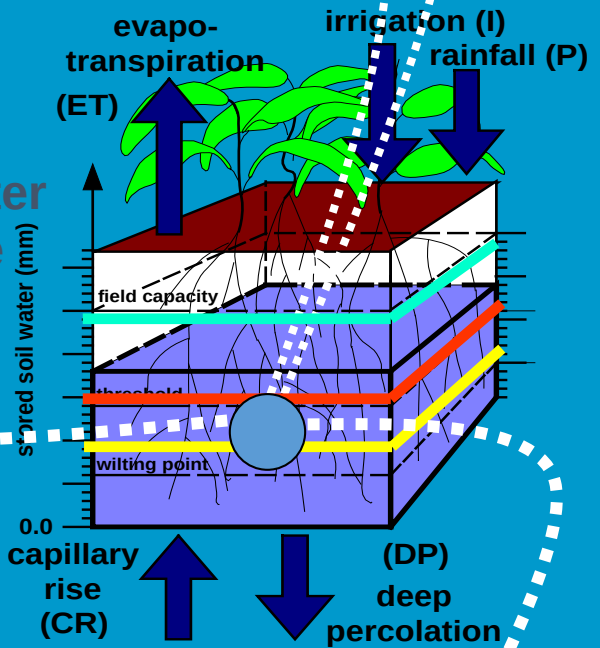
canopy senescence



2 **Crop transpiration**

$$Tr = Ks\ Kc_{Tr}\ ETo$$

soil water balance



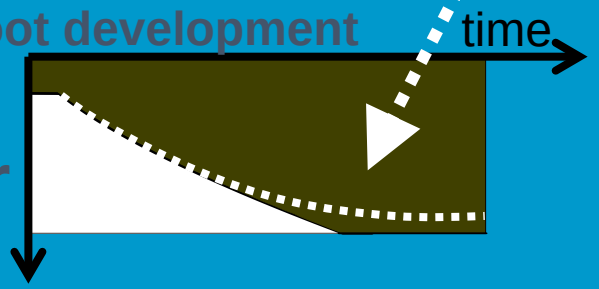
stomatal closure

WP* Biomass Water Productivity

Biomass **3**

root zone expansion

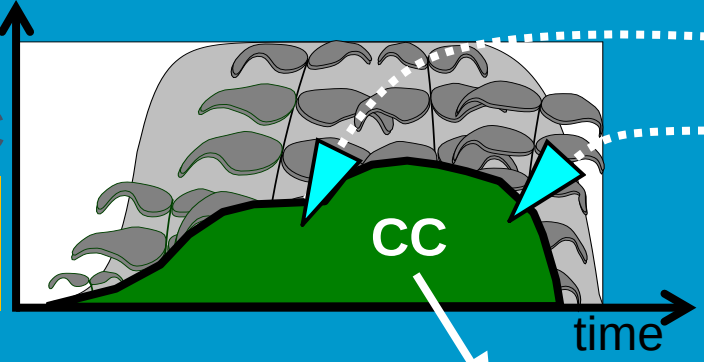
Root development



AQUACROP

1 **Canopy development**

CC



leaf expansion

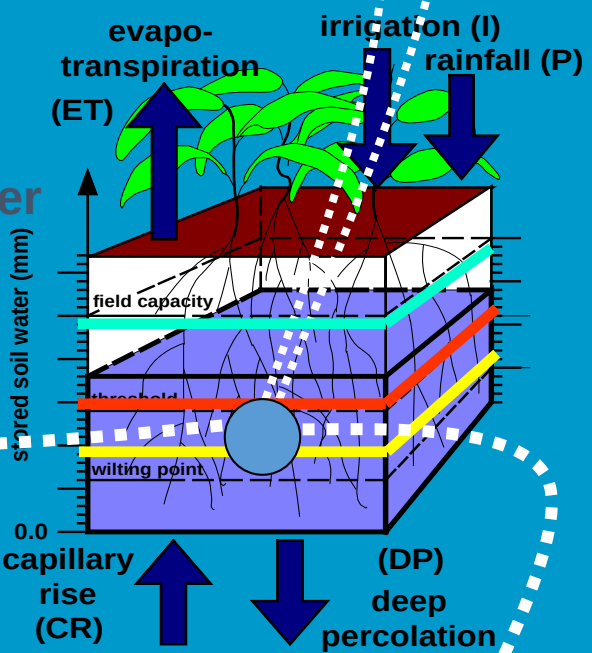
canopy senescence

2 **Crop transpiration**

$$Tr = Ks\ Kc_{Tr}\ ETo$$

soil water balance

stomatal closure



Biomass Water Productivity

Biomass **3**

Harvest Index

Y

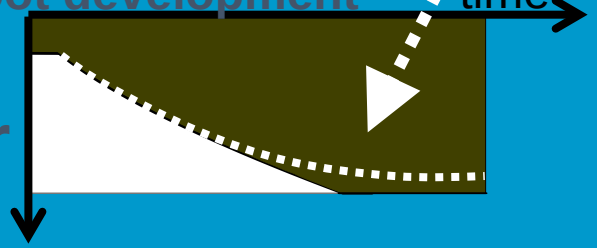
Yield **4**

root zone expansion

Root development

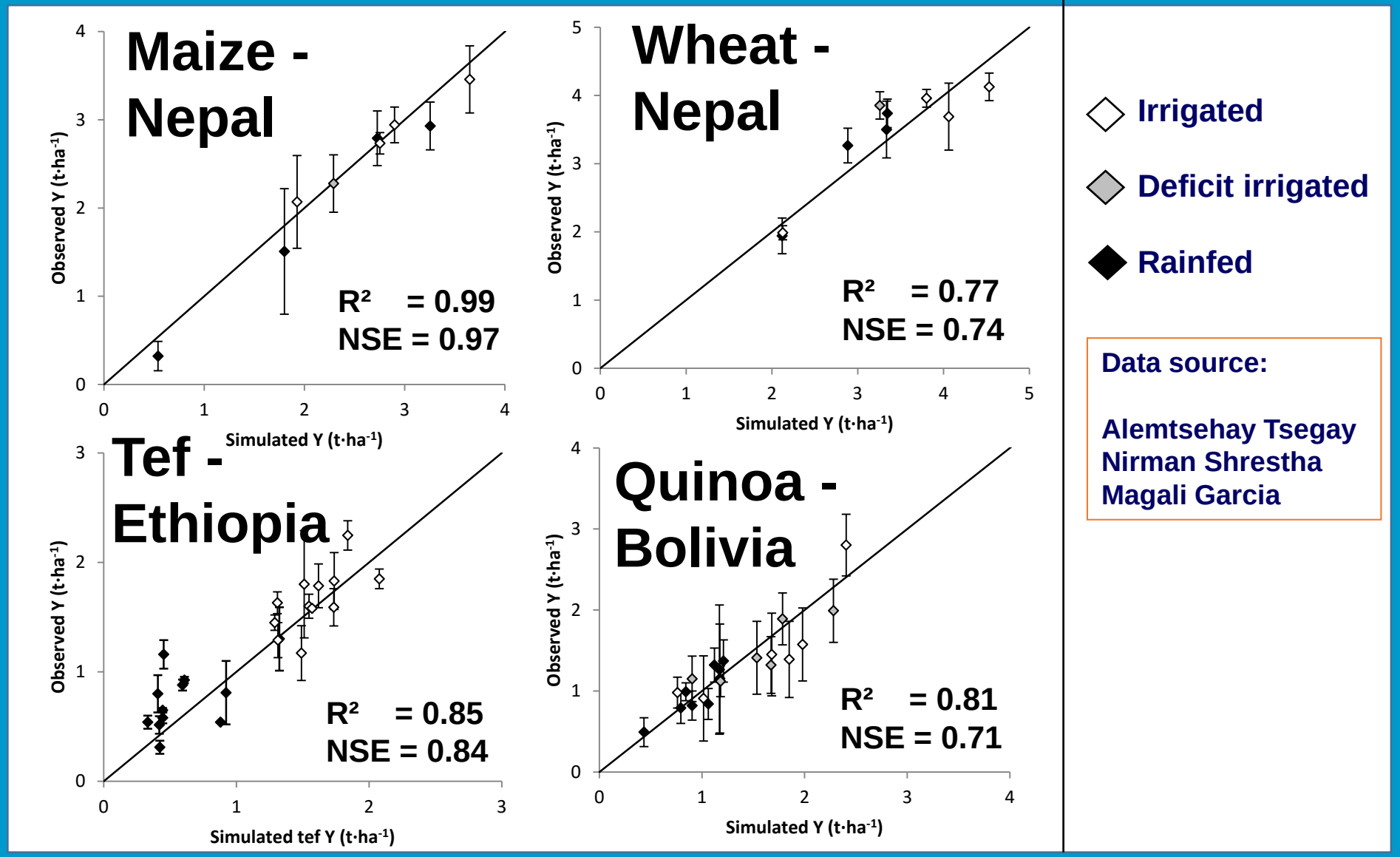
time

Zr



soil fertility and water stress

crop yield



Data source:

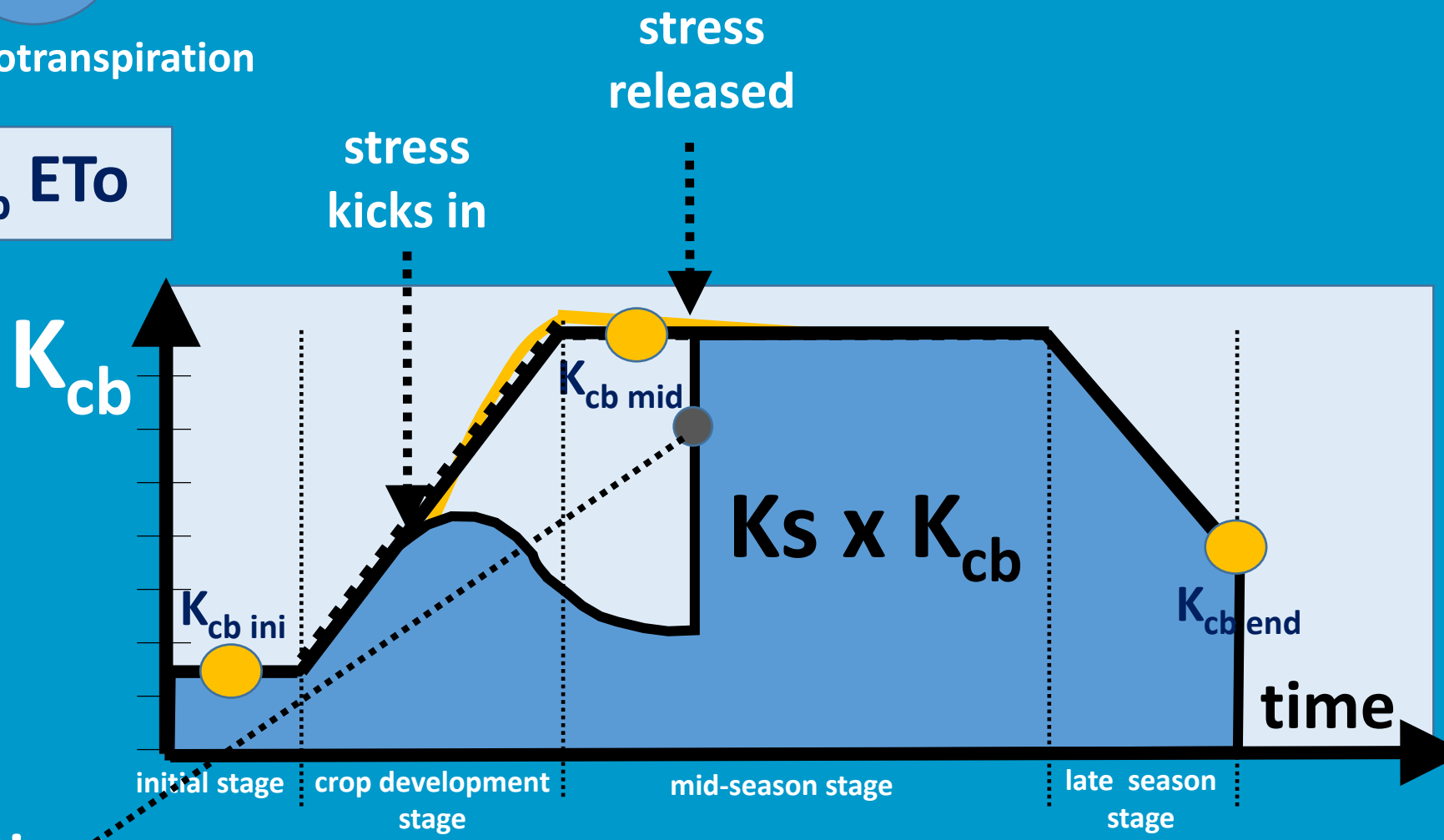
Alemtsehay Tsegay
Nirman Shrestha
Magali Garcia

Van Gaelen, H. et al. (Agricultural Sciences, 2014)

Conclusion

Crop evapotranspiration

Transpiration = Ks K_{cb} ETo



1 stress coefficient

- simple to use and to calibrate
- no memory of the effect of previous stresses on the Crop Canopy development

Conclusion

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Crop evapotranspiration

$$Transpiration = Ks\ K_{cb}\ ETo$$

irrigation scheduling

1 stress coefficient

- ❑ simple to use and to calibrate
- ❑ no memory of the effect of previous stresses on the Crop Canopy

Operational Window: no or mild stress

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Crop yield response to water

Ks_{sen} Ks_{exp}

$$Transpiration = Ks_{sto}\ [Kc_{Tr,x}\ CC^*]\ ETo$$

3 stress coefficients

- ❑ more complex to use, to calibrate
- ❑ memory of the effect of previous stresses

biomass

optimize water productivity

crop yield

crop yield response to water