Can crops adapt to the threat of desertification

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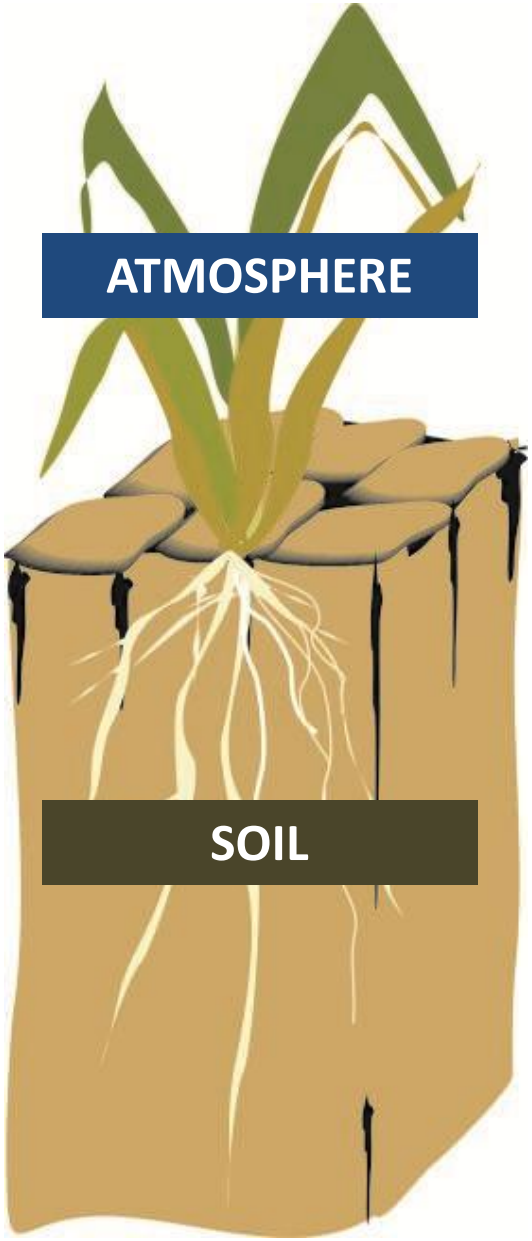


Stress	Significance
Heat	12 % of global agricultural area[1] (Continental areas of Asia and North America)
Cold/frost	13 % of global agricultural area[2]
Others (Ozone, …)	No global area estimates
Water	27 % of global agricultural area[2]
Phosphorus	30 % of global agricultural area[3]
Nitrogen	Low organic matter soils
Acidification (pH < 5,5)	25 % of global agricultural area[4]
Compaction	25% (AT, Alpenvorland[6]) - 30 % (DT, Meklenburg-Vorpommern[7]) of agricultural area
Salinisation (EC>4 dS m^{-1})	7 % of land area, 50 % of irrigated area[5]

$Real_{2000}$ / potential yield = 40 %[1]

Sources: Teixeira et al. (2013) Agric. Forest Meteorol. 170 und eigene Berechnung; [2]FAO/IIASA (2000); [3]MacDonald et al. (2011) PNAS 108; [5]Lynch et al. (2004) Field Crops Res. 90; [6]Murer et al. (2012) Die Bodenkultur; [7]Frielinghaus et al. (s.a.) Beiträge Bodenschutz

Desert/semi-desert

Desert/semi-desert annual gross primary production (GPP): 90 g m^2 y^{-1}

Agricultural plantation

Cultivated land annual gross primary production (GPP): 650 g m^2 y^{-1}

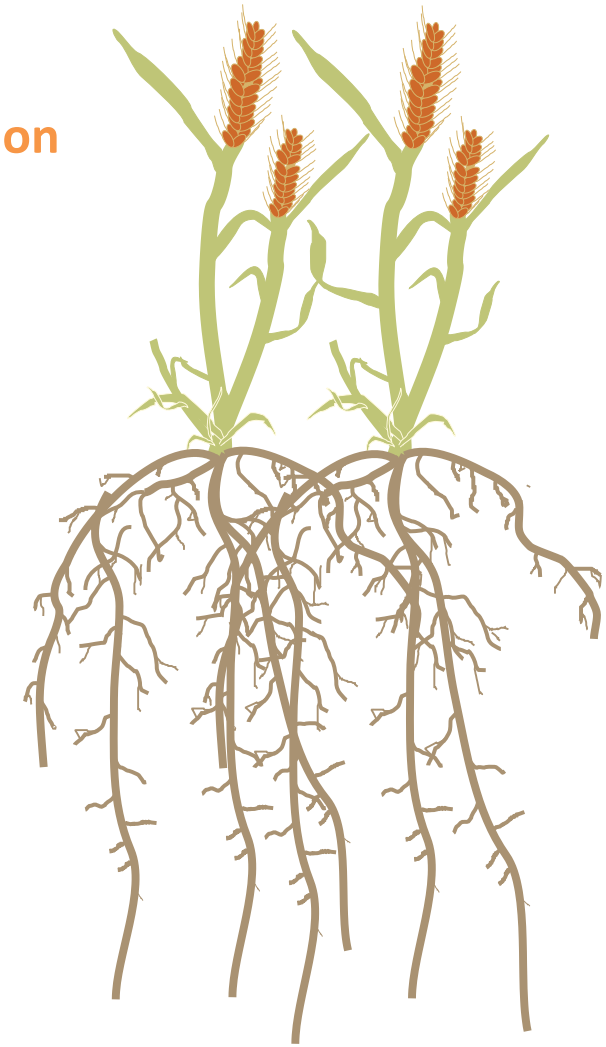
Two main reasons for limited ecosystem productivity

- Restricted **time** of the year adapted for plant growth.
- Low **leaf area** for absorption of incoming radiation („small plants“)

Stress → **Strain**

Heat and radiation

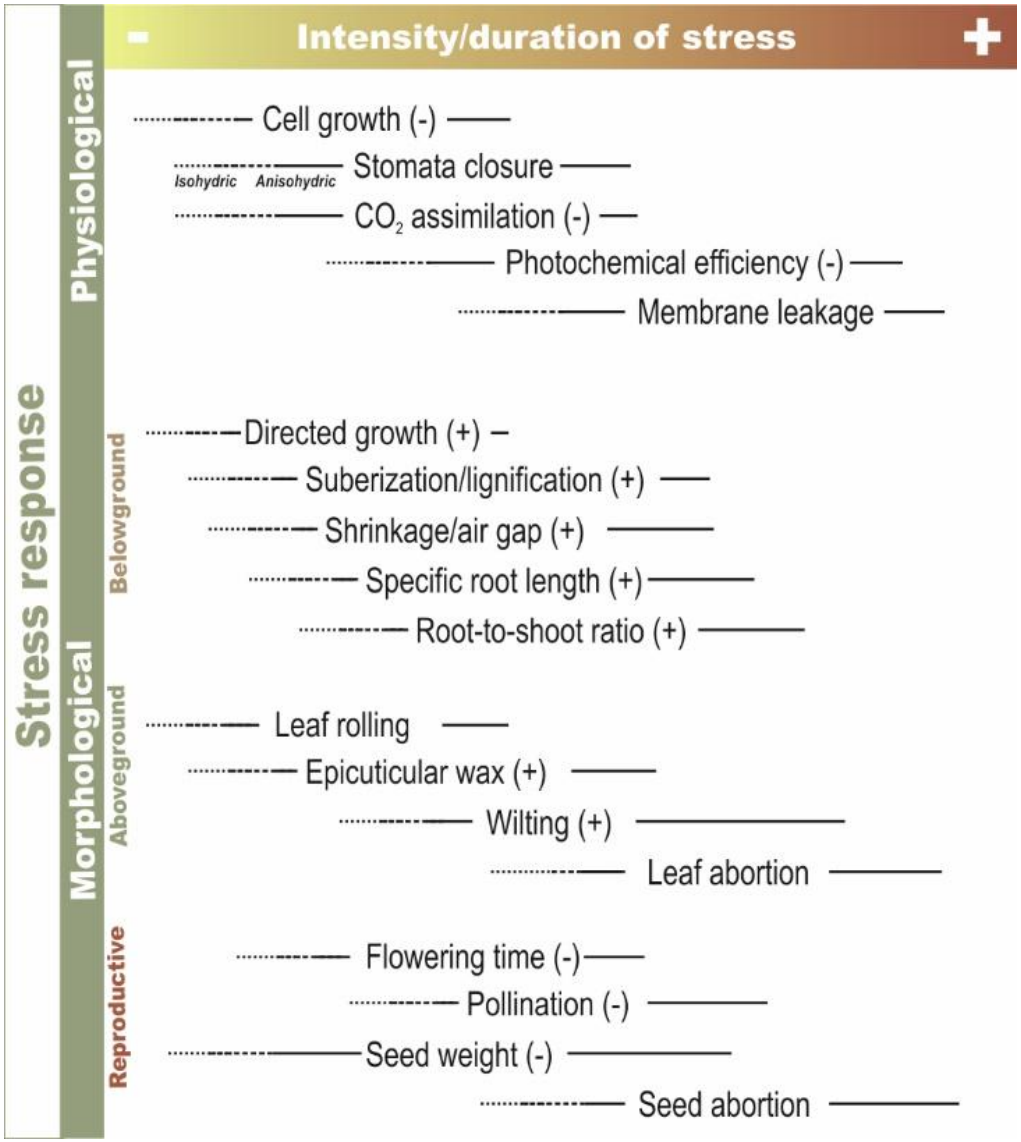
Water



- Shortening of development stages.
- Increased water losses.
- Increased assimilate costs for „defense“.
- Physiological damage (Dehydration, cavitation, ROS, protein degradation).

Plants in stress environments are programmed to survive not to produce.

Stress response cascade: Example water stress



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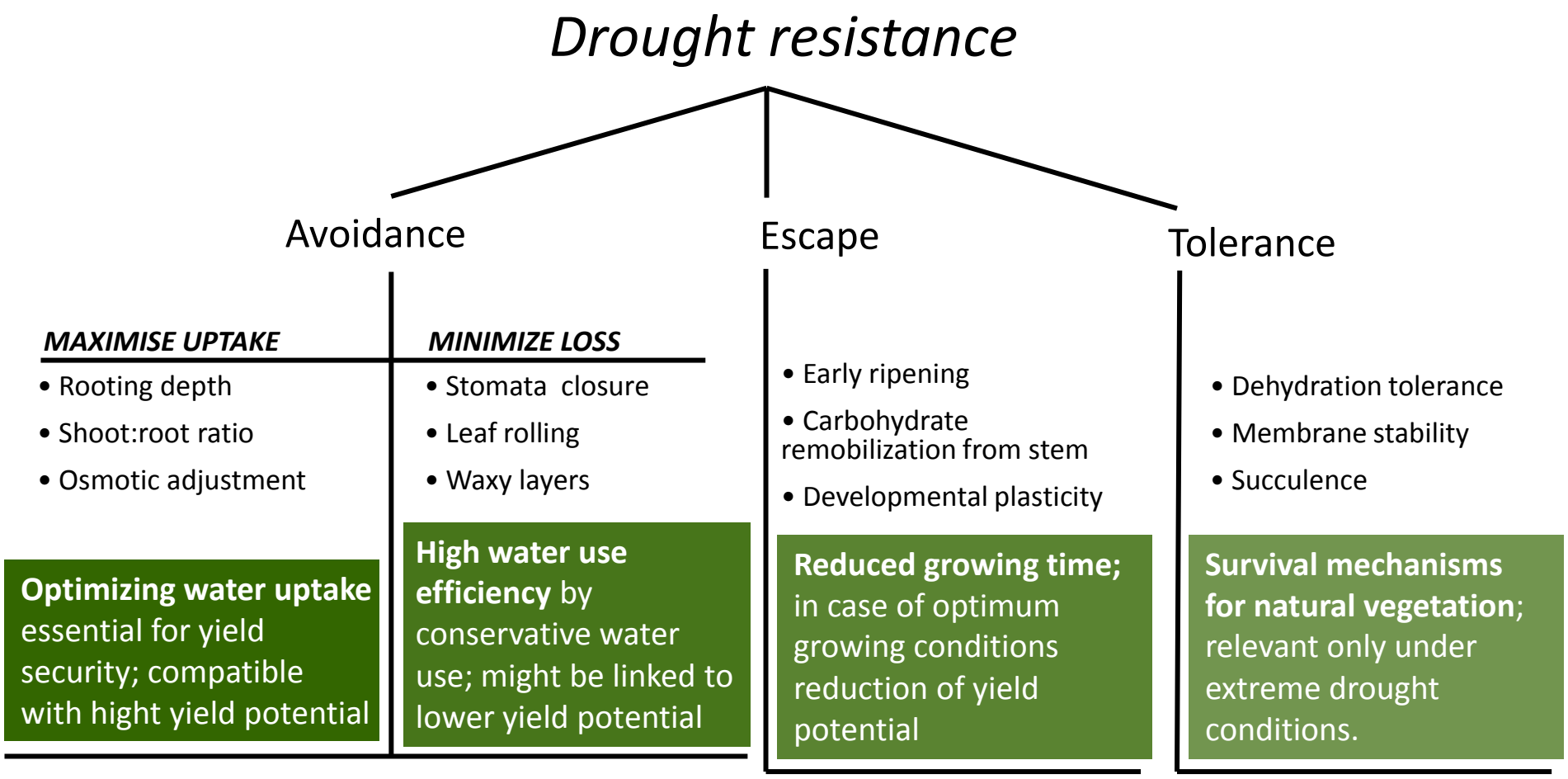
What mechanisms can be used to make crops resist desertification while ensuring farmer‘s survival ?

Levitt's framework for stress resistance breeding



"Any trait can confer resistance, just design the right scenario …" (Tardieu 2011)

Efficiency of plant strategies in different drought environments

	Supply driven	Storage driven	Residual moisture
Drought escape	+	+++	++
Water saving	-	+	+++
Water spending	+++	++	+

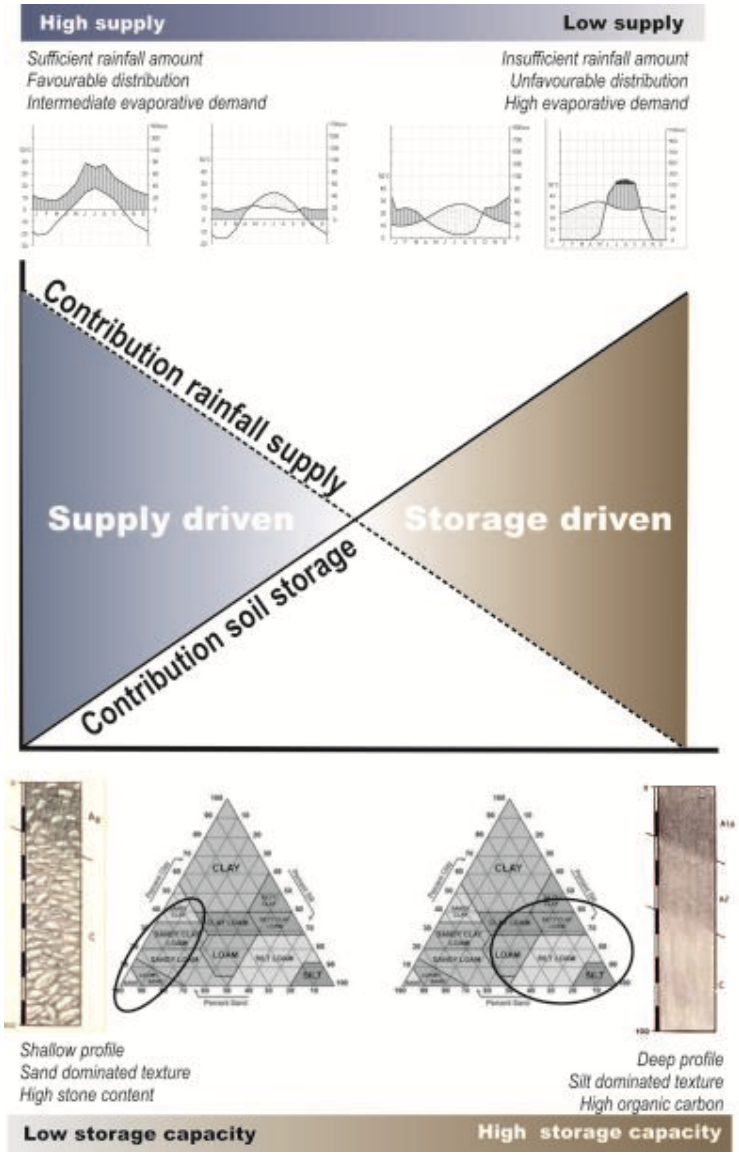
Key traits

Drought escape: Early flowering/maturity

Water saving: Stomata closure, leaf area reduction, leaf surface, tiller reduction, (reduced root conductance)

Water spending: Deep rooting, fine root density, root hairs

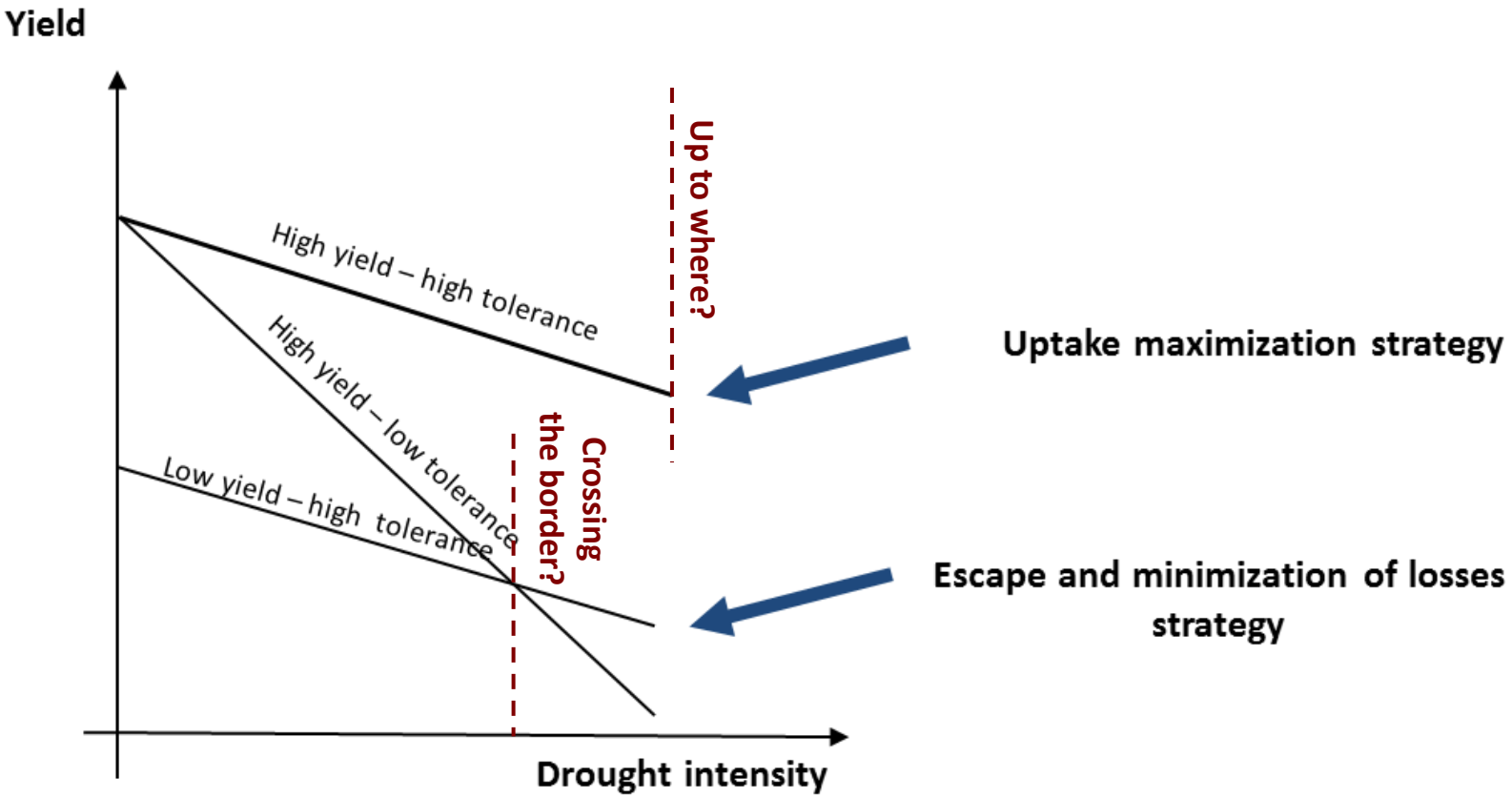
The drought environment under desertification



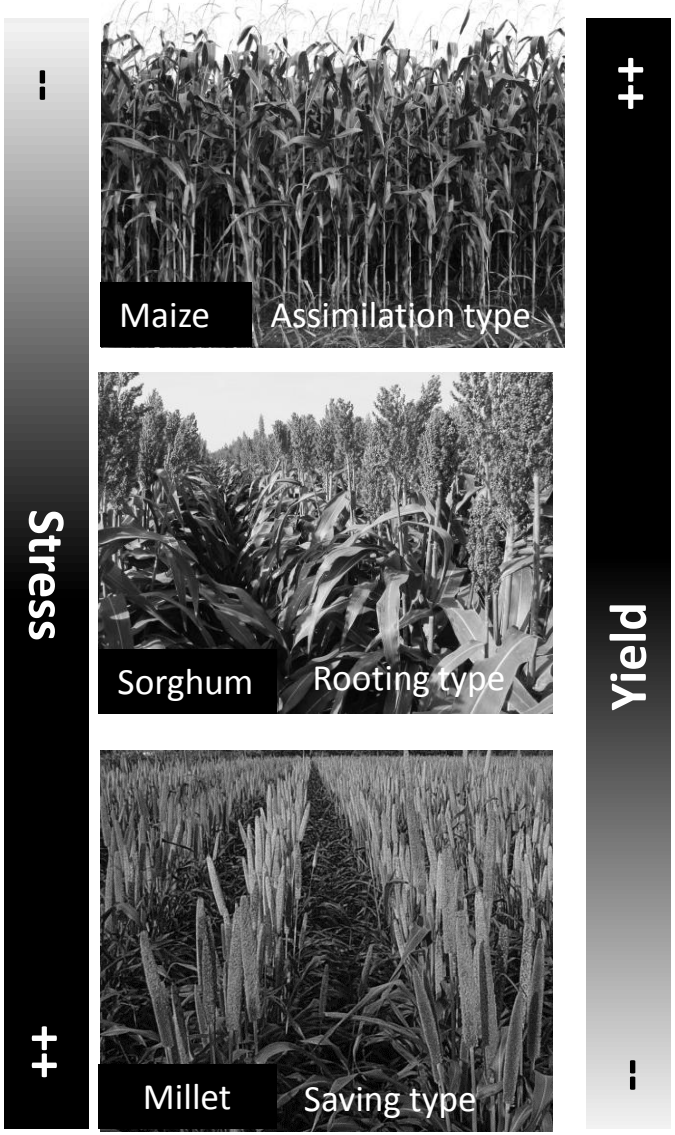
Desertification will reduce soil storage capacity in environments with low rainfall input!

- Plant strategies based on optimizing uptake (e.g. deep rooting) will loose ground.
- Restoring soil storage is a precondition for many plant resistance mechanisms to be effective.
- Conservative and balanced use of limited resources will come into the focus.

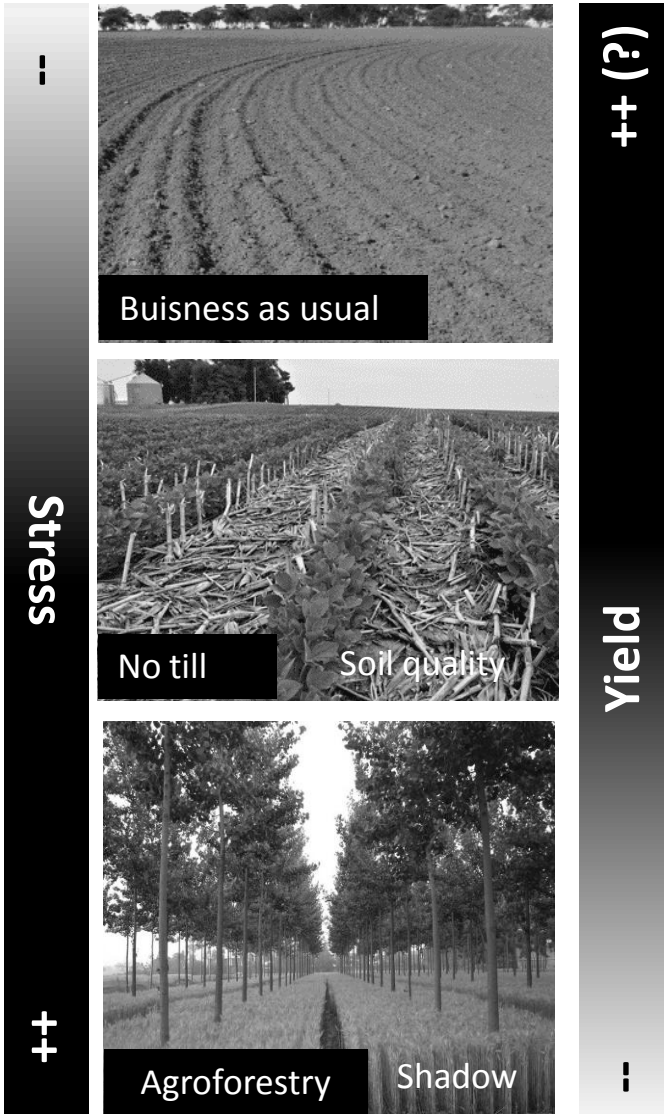
Where will desertification bring us?



Shift in crops….



… adaptation in management



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