

Potential future evolutions of crop response to fertilization: NUEs a & Ymax

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IMAGE team

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Nitrogen use efficiency and Ymax of cropping systems

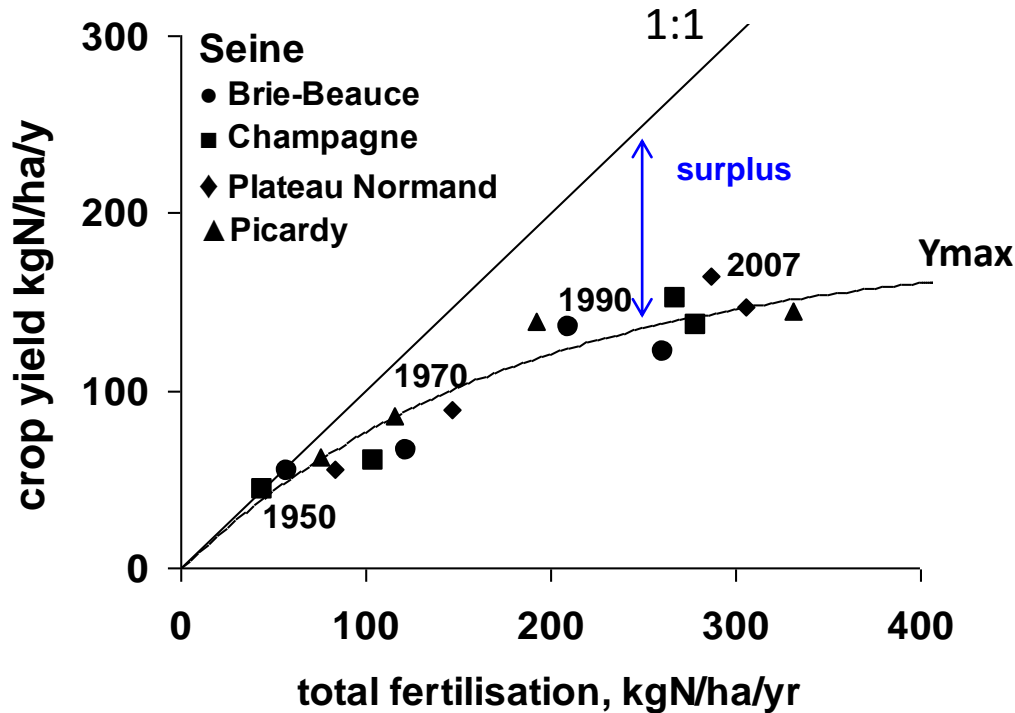
Crop production vs total fertilization relationship

$$\text{Crop prod} = Y_{\text{max}} \left[\frac{\text{fert}}{\text{fert} + Y_{\text{max}}} \right]$$

Integrated over
the whole crop
rotation cycle

↑
Total fertilization

↑
Max yield



Billen et al. (Phil Trans Roy Soc B)

Total fertilization

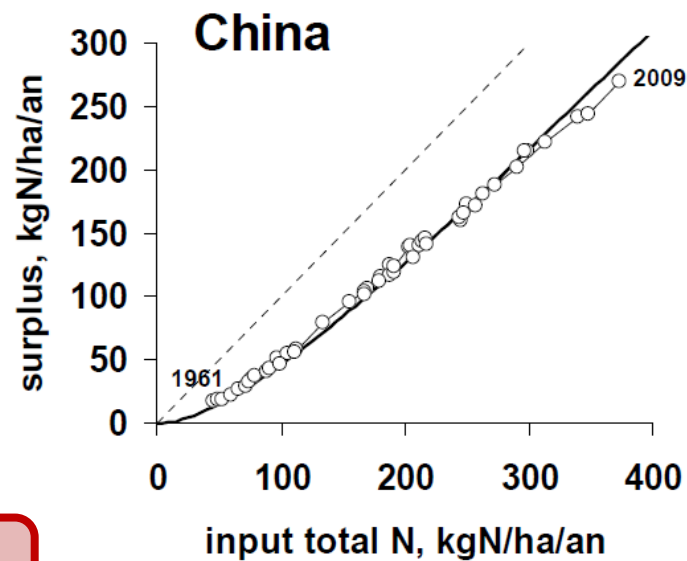
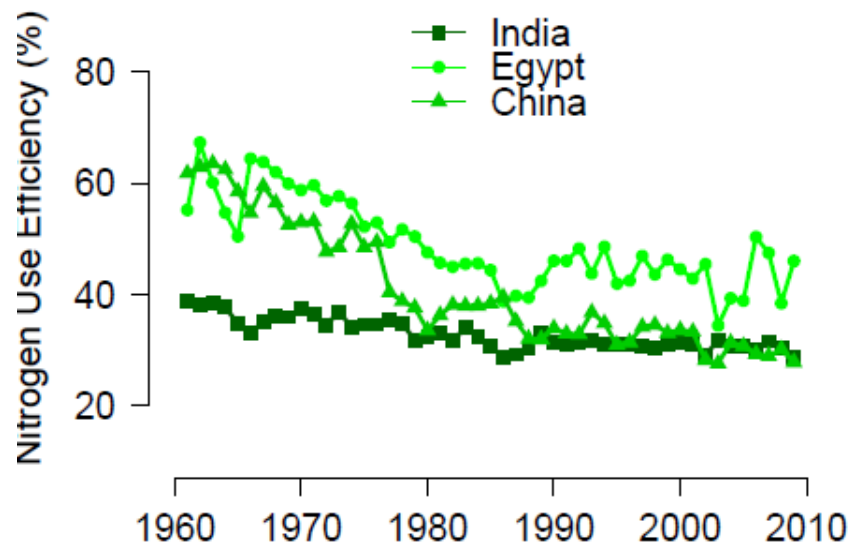
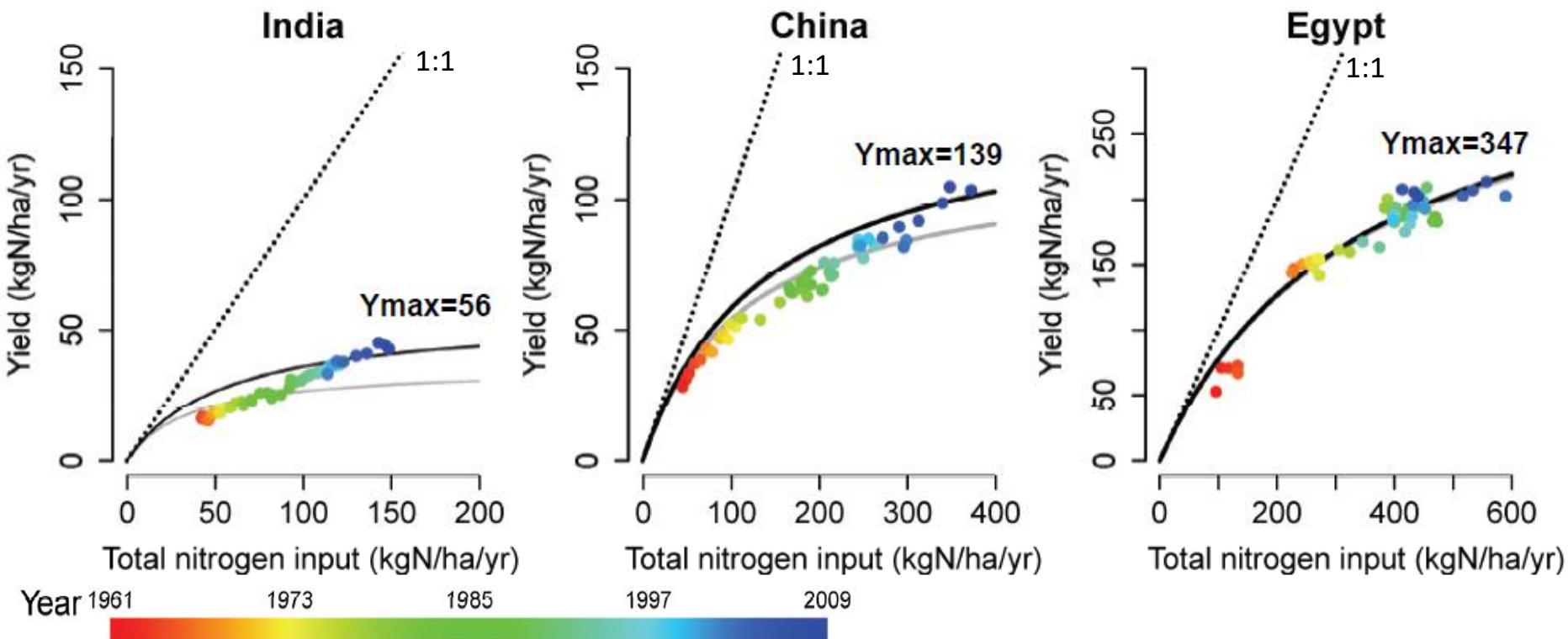
- Synthetic fertilizer
- Crop N fixation
- Manure
- Atmospheric deposition



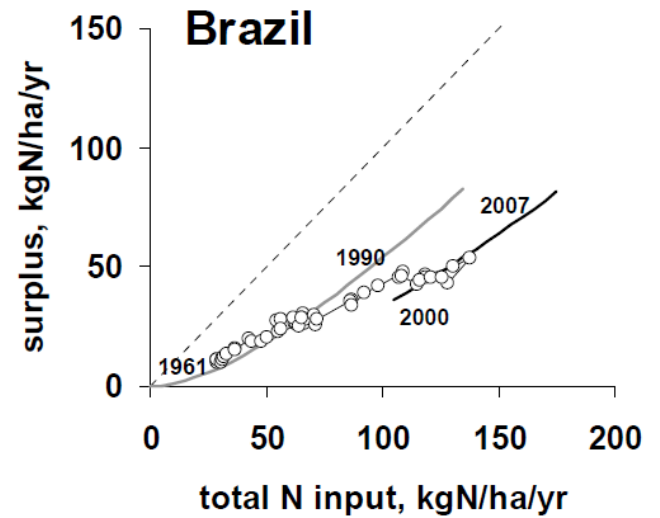
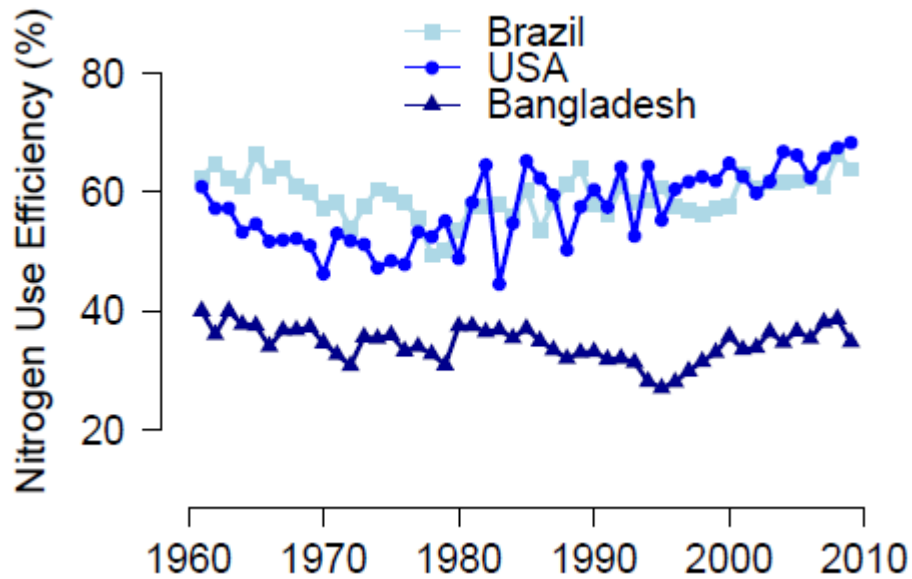
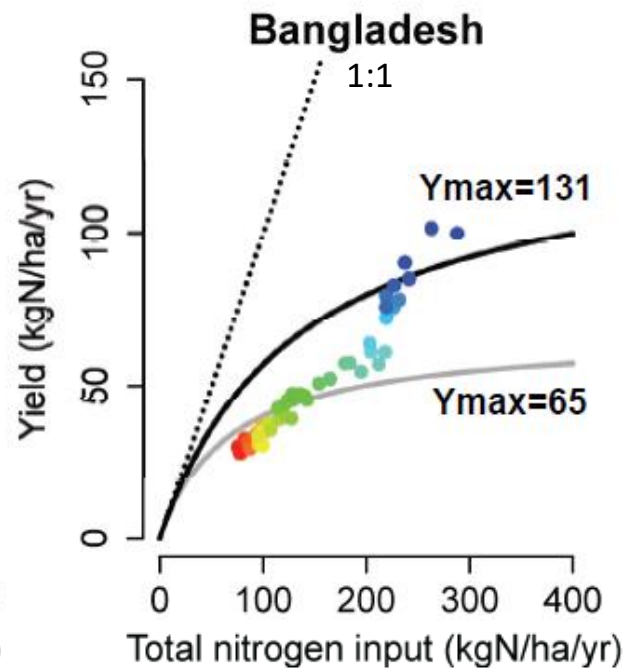
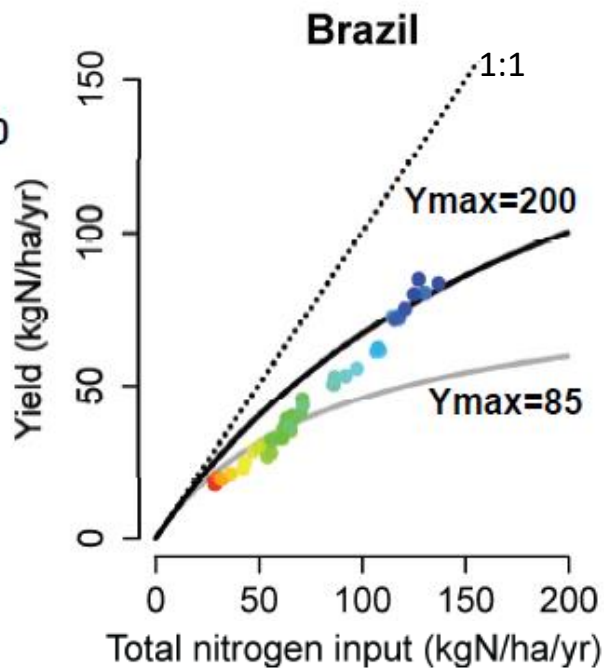
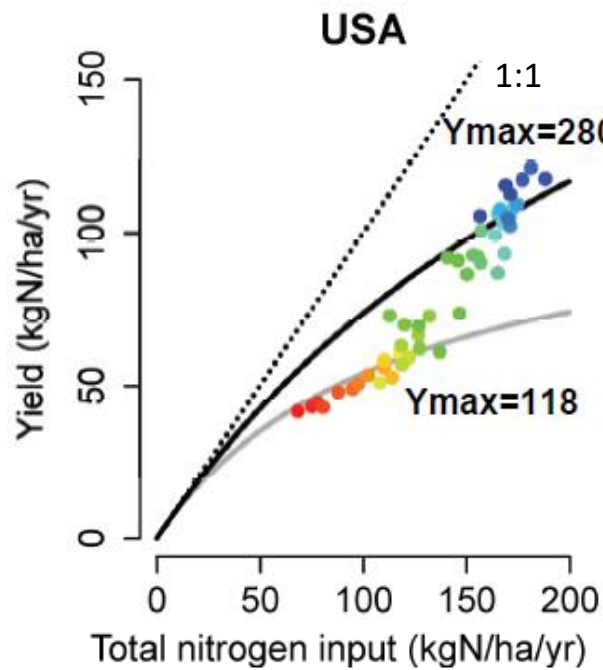
Outputs: kgN/ha

Surpluses: kgN/ha

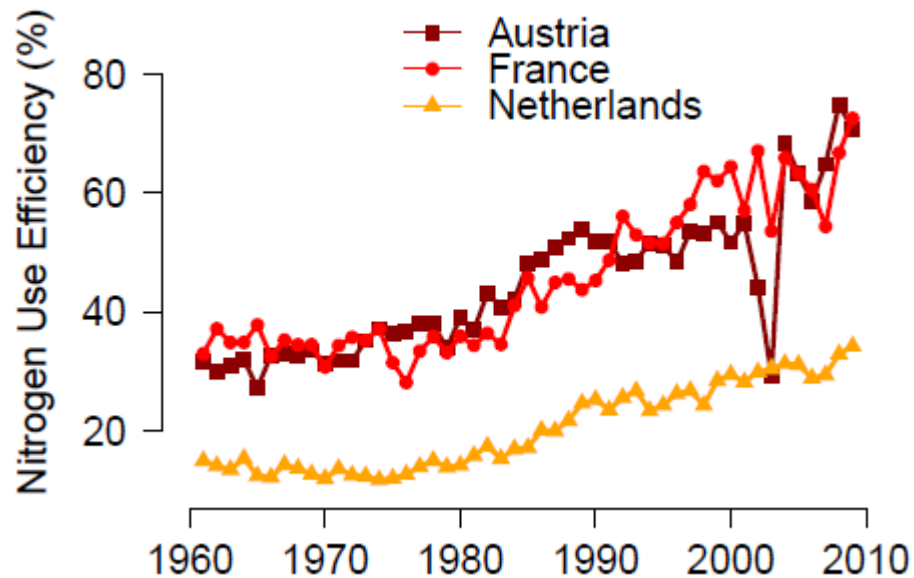
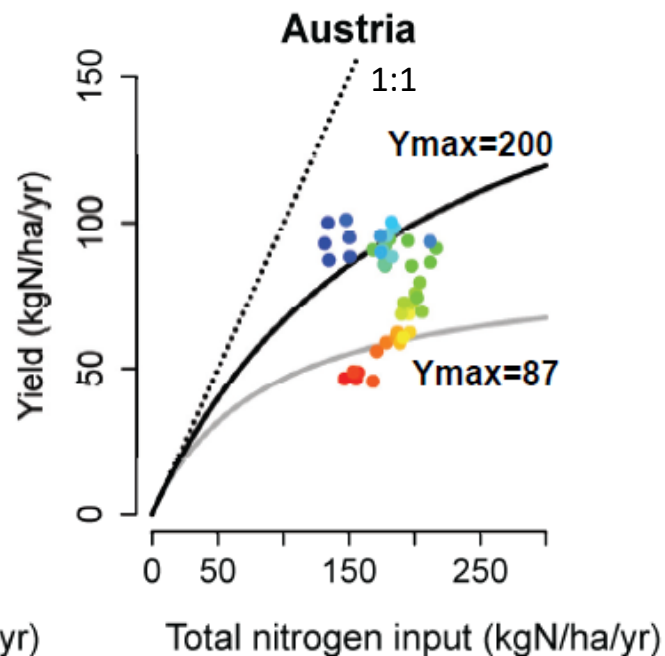
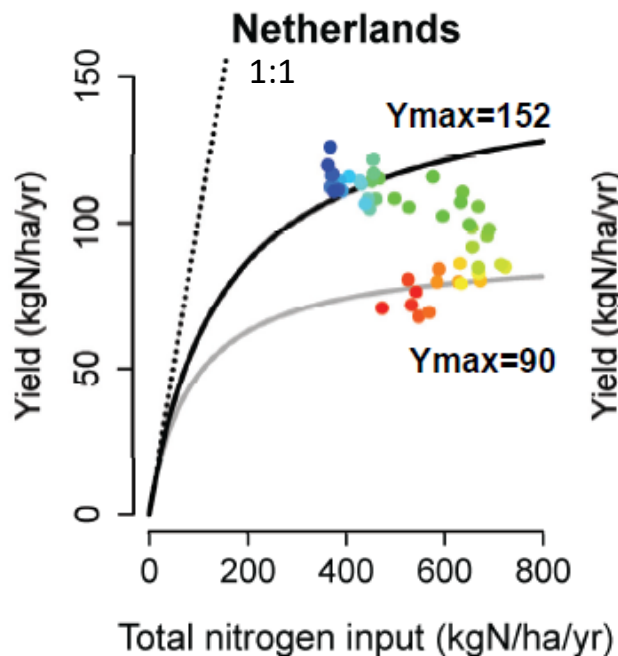
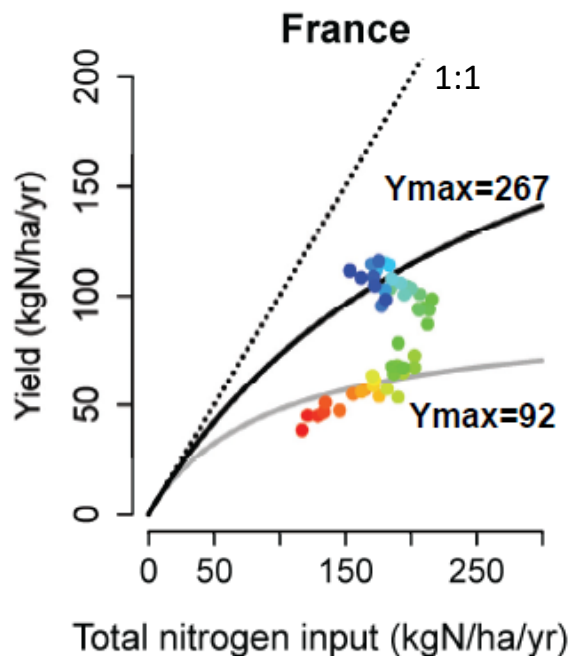
N.U.E. = Nitrogen exported from field in crop products / Nitrogen fertilization



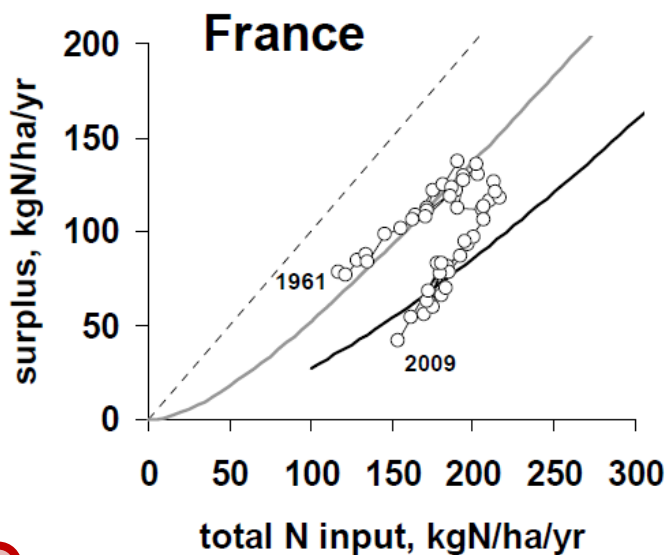
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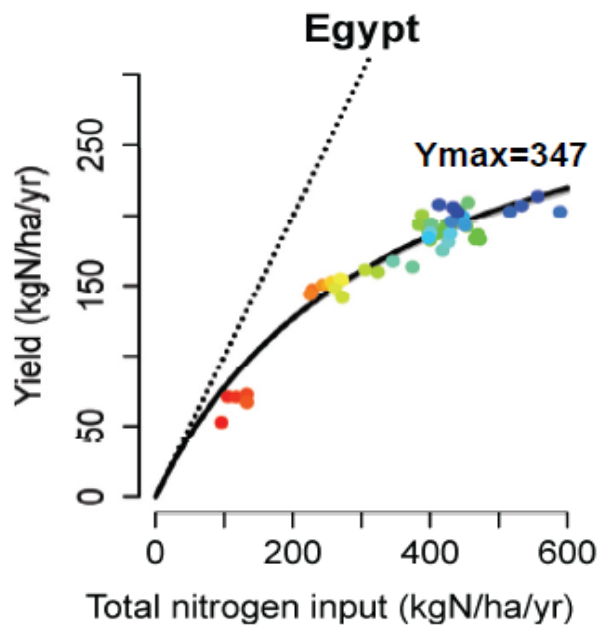


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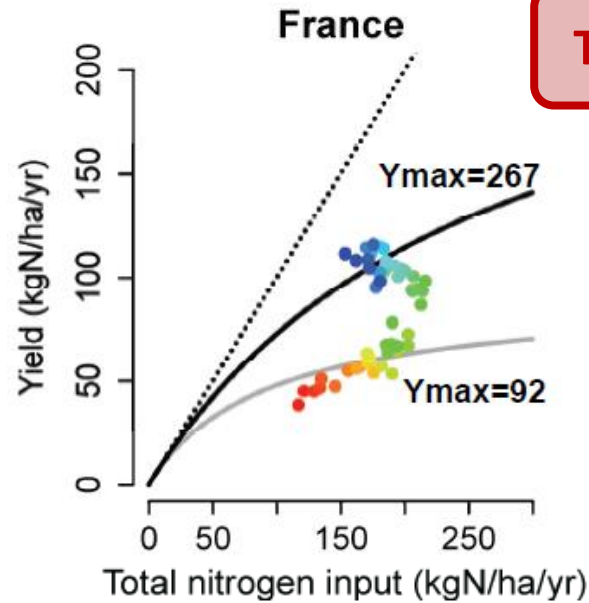


Type III

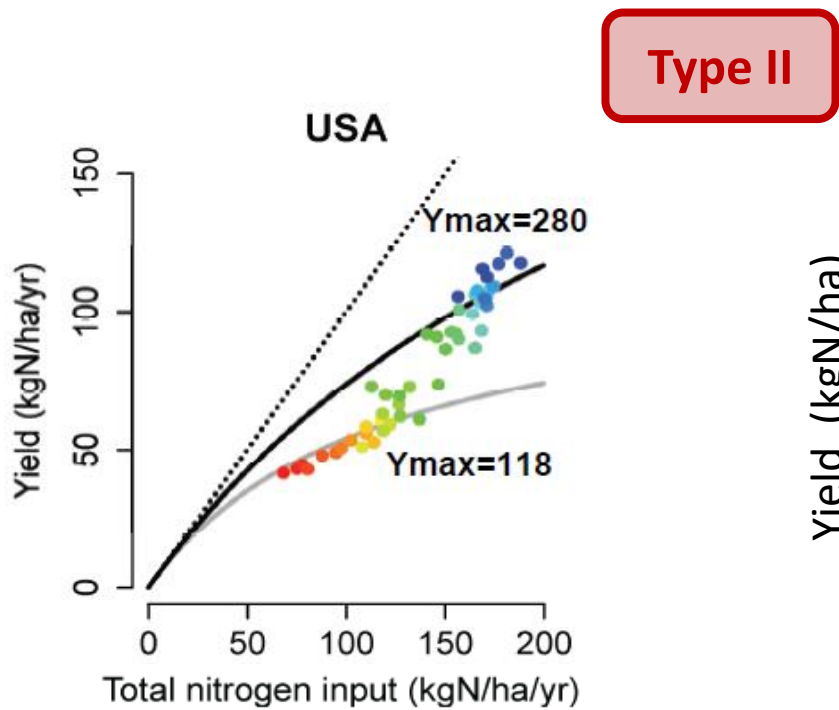




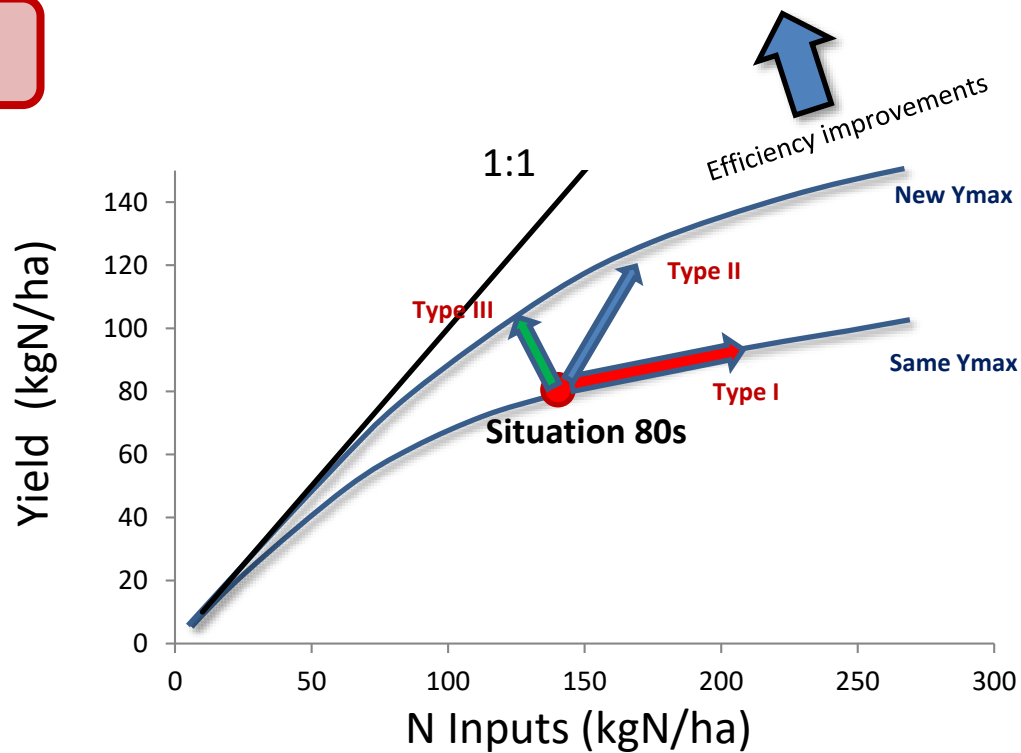
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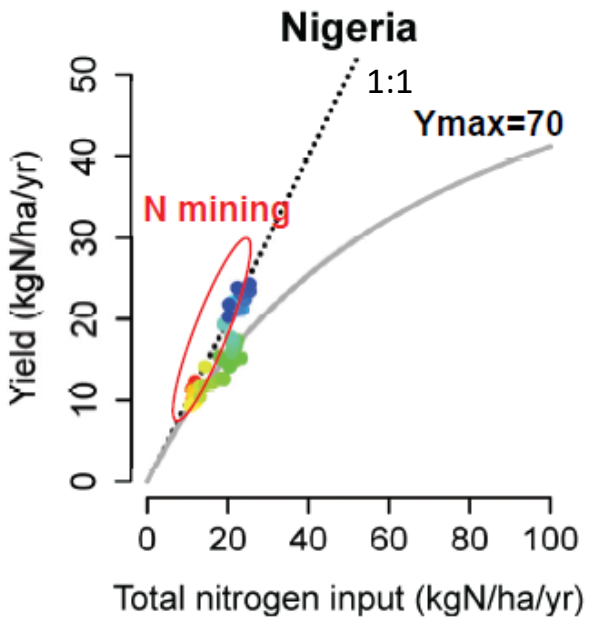
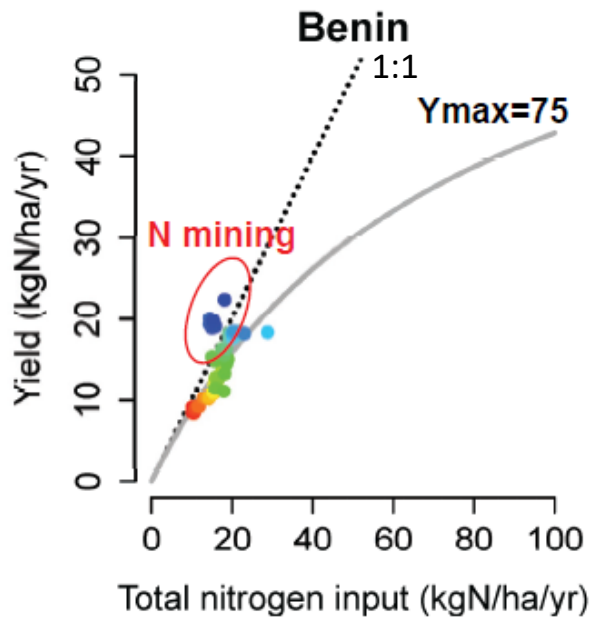
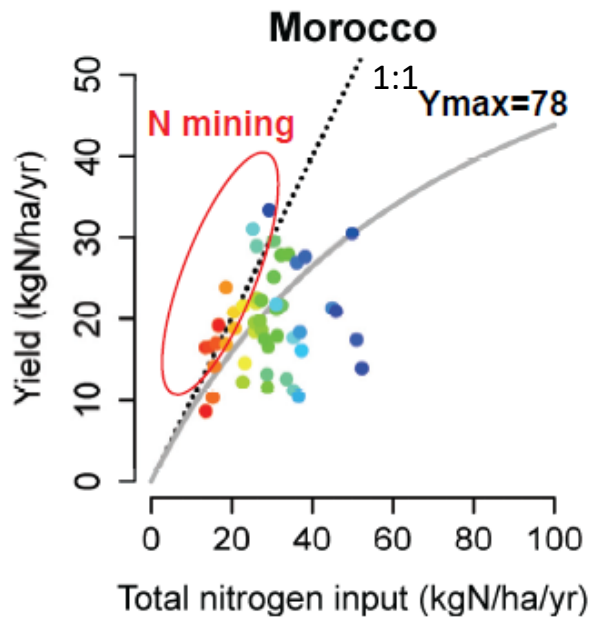


Type III



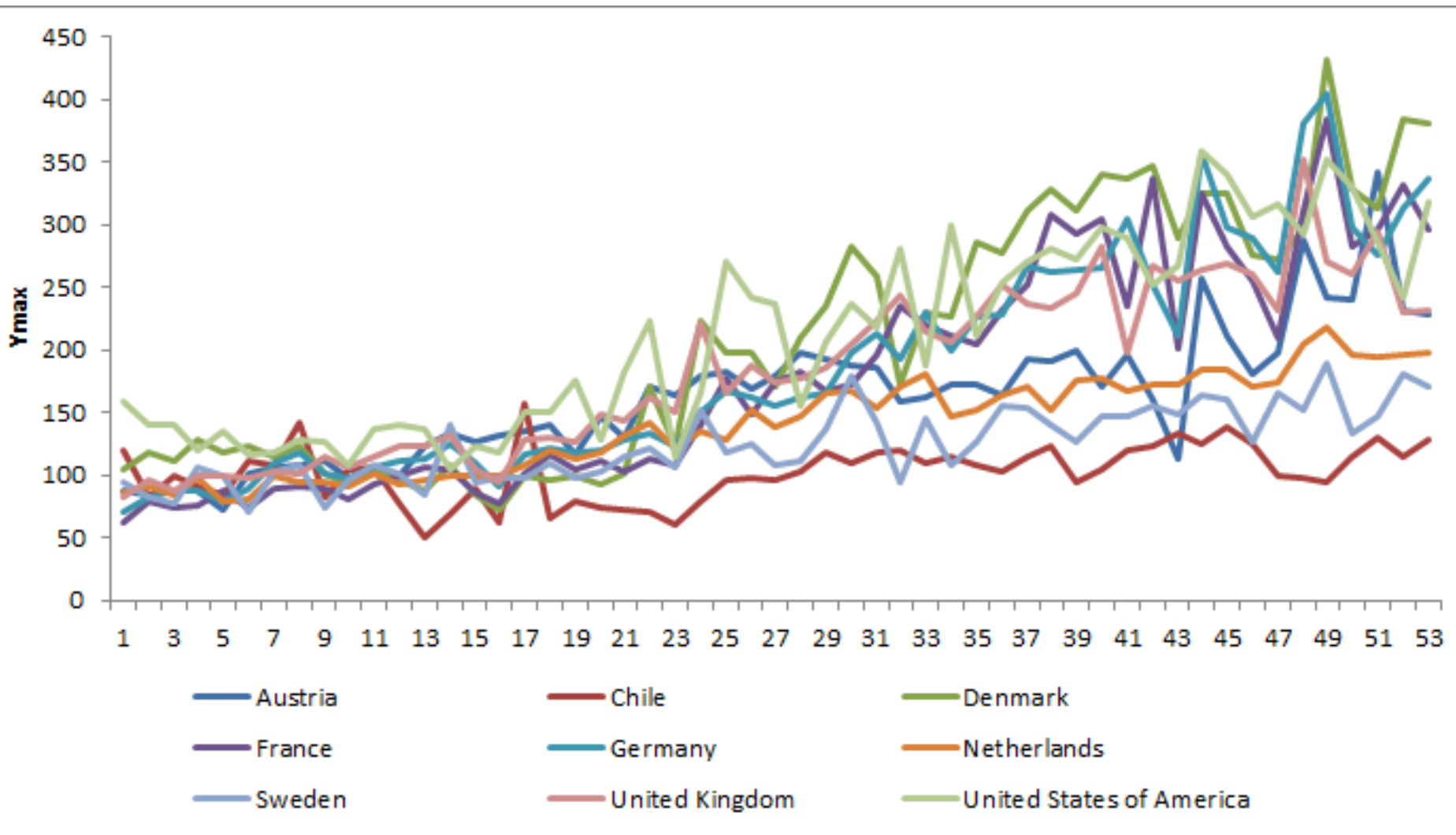
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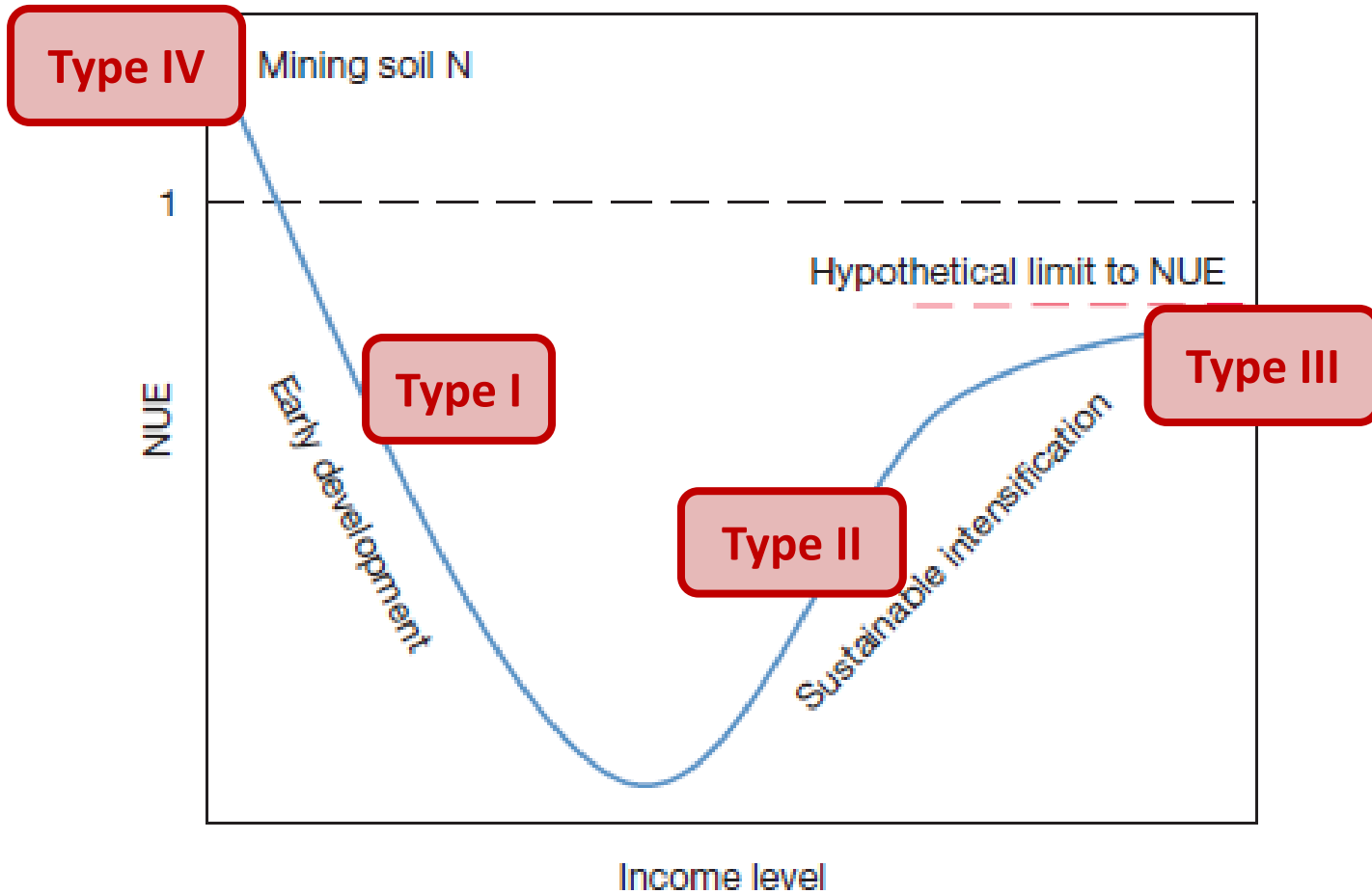




Type IV

Evolution of Ymax





Ymax for SSPs

Property	2050 level				
	SSP1	SSP2	SSP3	SSP4	SSP5
Keyword	Sustainability	Middle of the road	Fragmentation	Inequality	Conventional development
Technological development	Rapid	Medium	Slow	Slow	Rapid
Progress towards development goals	Good	Some	Failure to achieve goals	Highly unequal	Market-driven
Resource intensity	Low	Medium	Very low	Highly unequal	Conventional development
Population (10^6 inhabitants)	8531	9243	10038	9213	8629
GDP/capita (2005 US\$, market exchange rate)	24563	17877	12024	17500	32449
Global greenhouse gas emissions (GtC-eq yr ⁻¹)	15.6	19.8	21.5	18.0	27.9
Global mean temperature increase relative to 1860 (°C)	2.1	2.3	2.3	2.2	2.5
Crop production (Mton d.m. ^a)	4749	5111	5069	4855	5215
Area arable and permanent crops (Mha)	1522	1735	1846	1732	1720
N Production (Tg N yr ⁻¹)	120	132	137	126	148
Y_{max} calculation ($F_{Y_{max}}$, equation S2)	$\frac{Y}{(1-NUE)}$	equation S1	Same as previous year	wealth dependent	equation S1

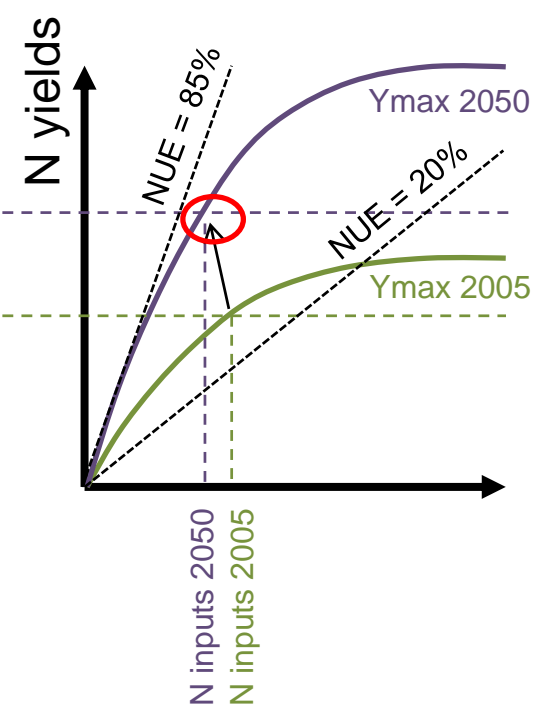
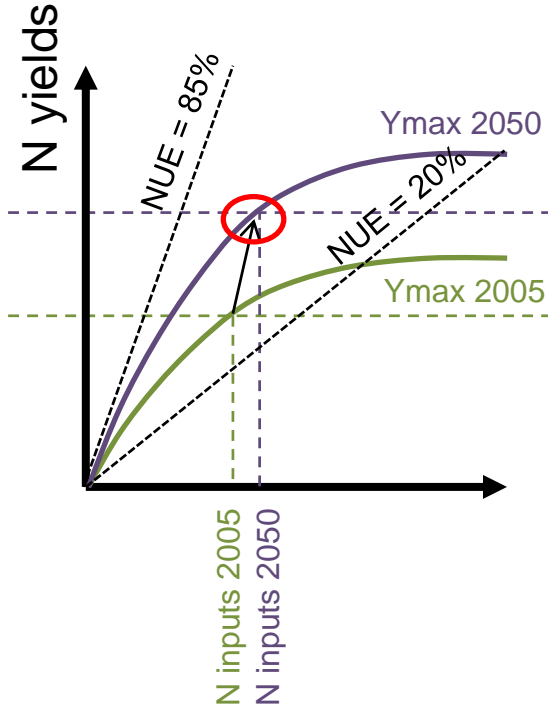
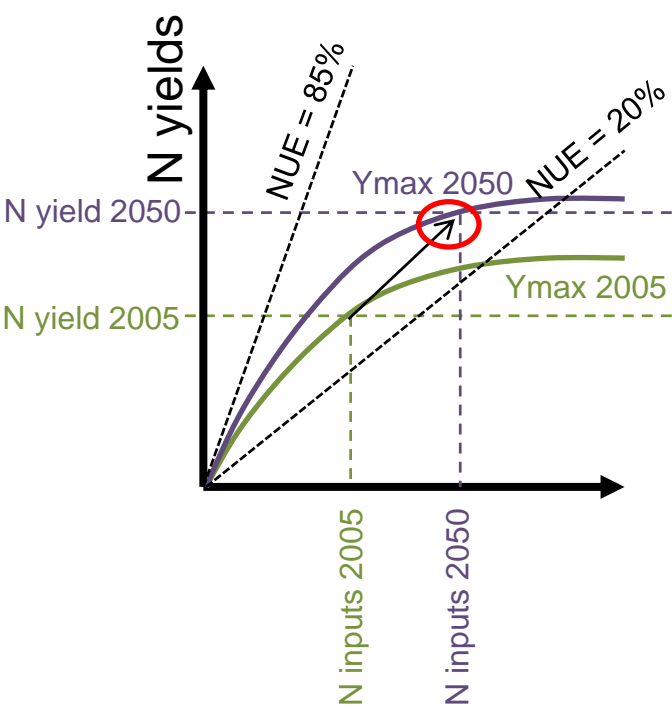
^a d.m. = Dry matter.



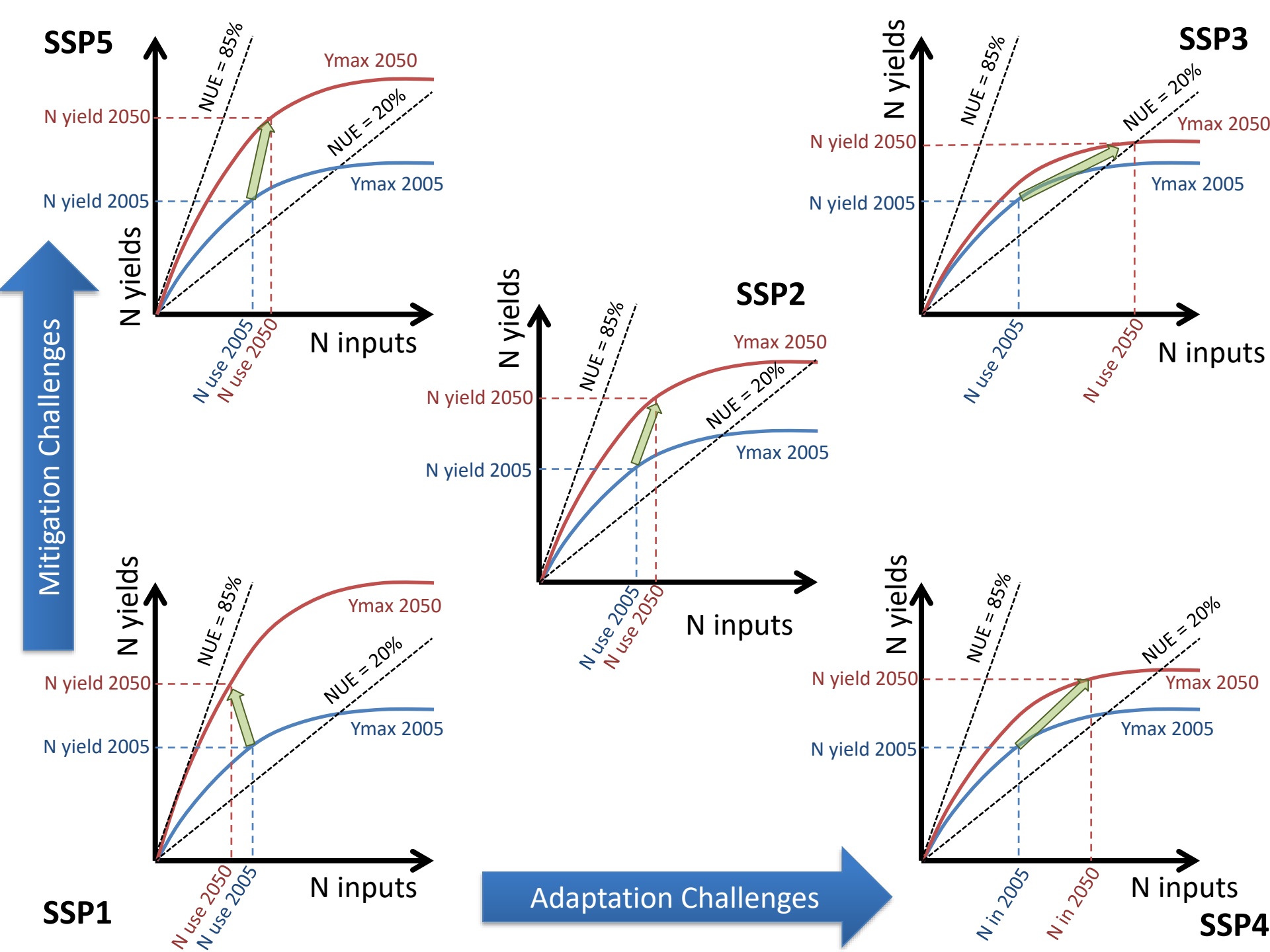
GDP dependent

Inspired in Zhang et al. 2015 proposals

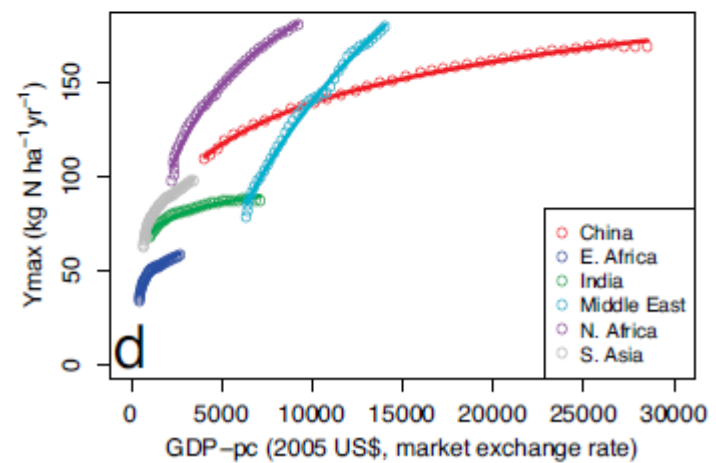
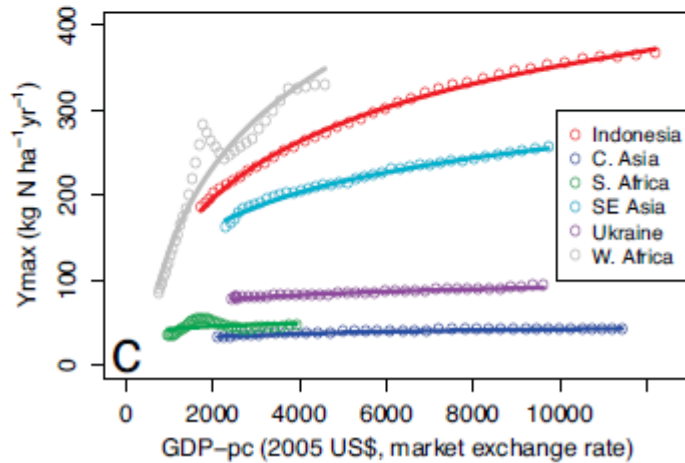
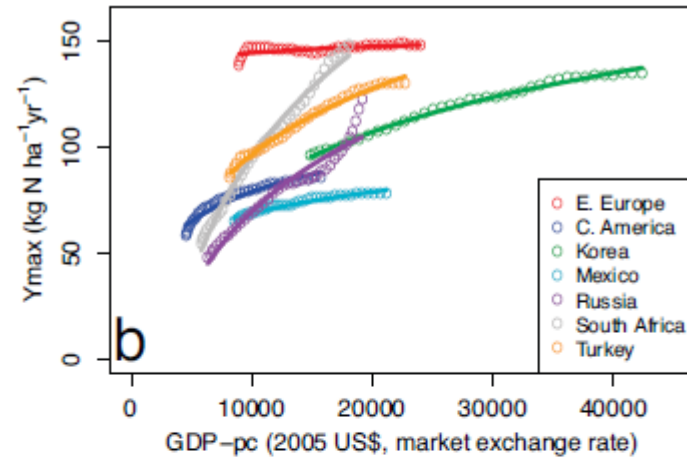
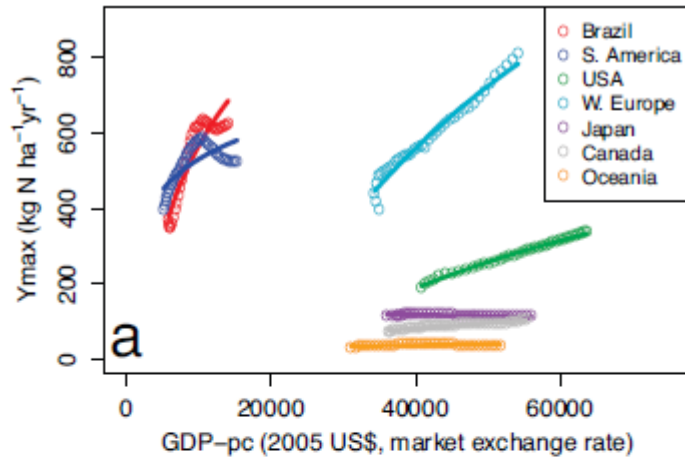
Mogollón et al., 2018 (ERL)



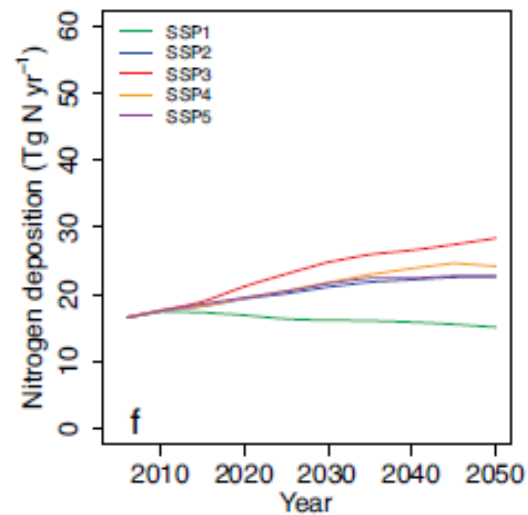
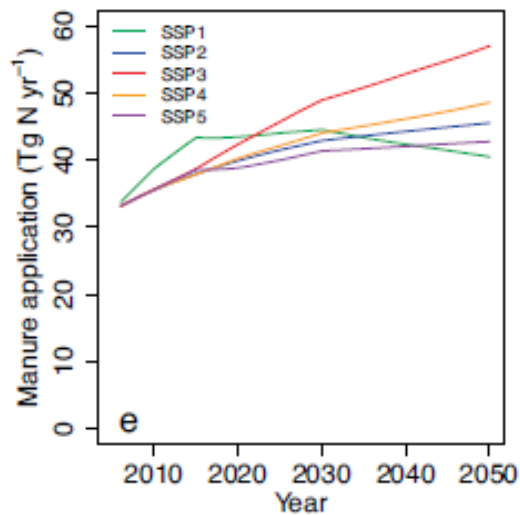
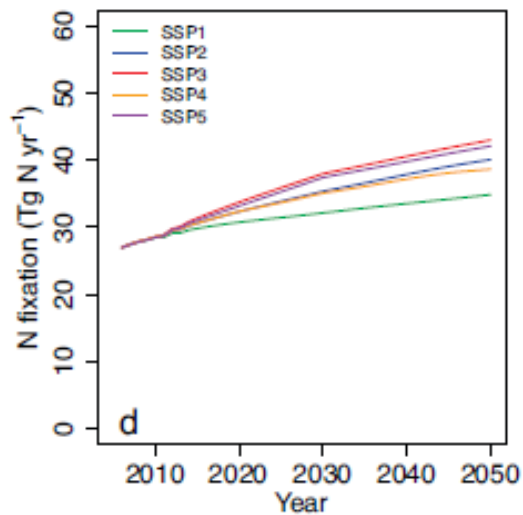
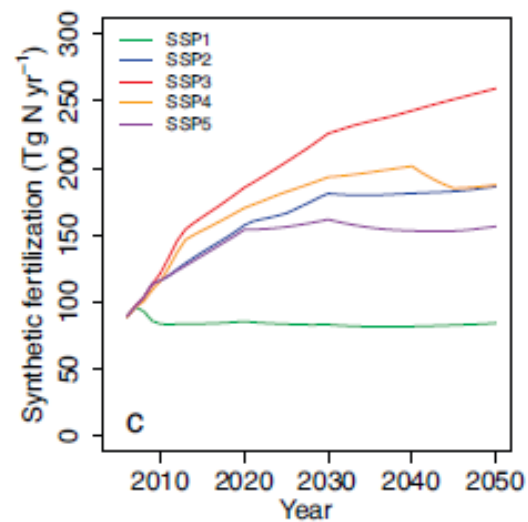
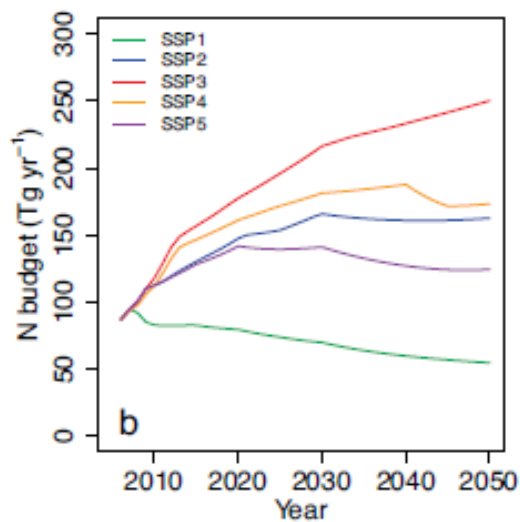
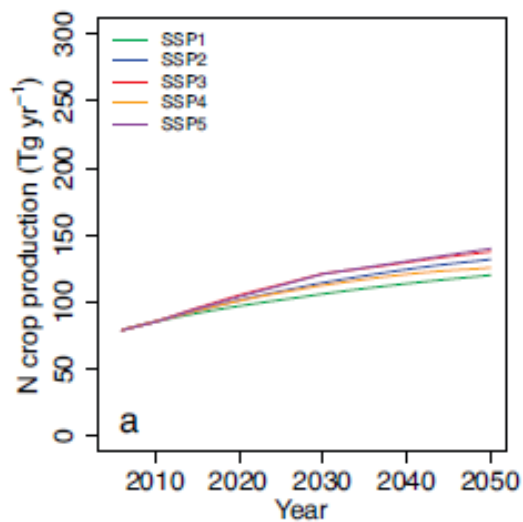
Effects of Improving Ymax



Ymax for SSPs



Some results



References

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- Lassaletta, L., Billen, G., Grizzetti, B., Anglade, J., Garnier, J., 2014. 50 year trends in nitrogen use efficiency of world cropping systems: the relationship between yield and nitrogen input to cropland. *Environmental Research Letters* 9, 105011.
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- Zhang, X., Davidson, E.A., Mauzerall, D.L., Searchinger, T.D., Dumas, P., Shen, Y., 2015. Managing nitrogen for sustainable development. *Nature*