Addressing agricultural nitrogen losses in a changing climate

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1. Changing precipitation patterns and plant-soil N cycling

Background and objectives

- Changes in the pattern and intensity of rainfall are expected with climate change. In the Central U.S., climate projections suggest (Fig. 1):
  - Seasonality shifts, more in spring, less in summer
  - Fewer, more intense events
  - More consecutive dry days
  - More extreme events (droughts, floods)
- Precipitation strongly influences all processes in the plant-soil N cycle, including the predominant loss pathways of excess N in agricultural systems
- Our objectives :
  - Review potential effects of changing precipitation patterns on agricultural N cycling and losses
  - Establish a framework for mitigating potential negative effects

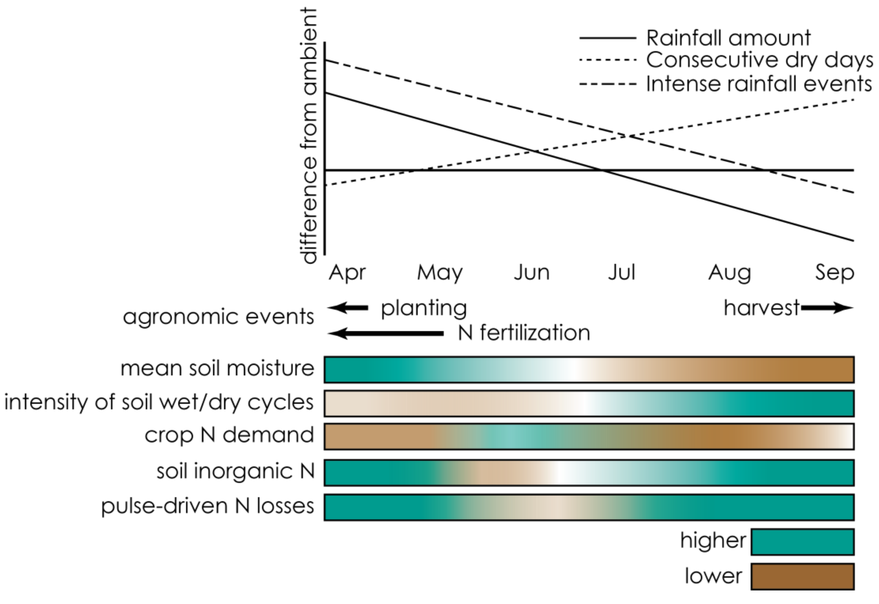

Fig. 1. Summary of climate projections[1–5] for changes in rainfall patterns in the Central U.S. coupled with hypotheses of how climate change-driven alterations in precipitation patterns will affect N cycling and N losses in rainfed, annual agroecosystems.

2. Exacerbating N losses in annual agricultural systems

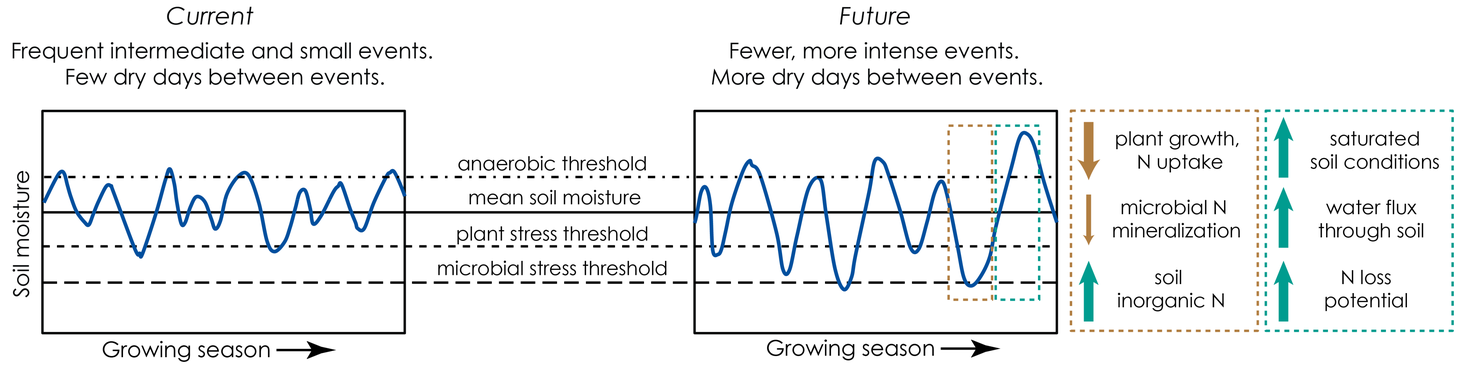

Fig. 2. Conceptual diagram of the response of plant-soil N cycling to changes in soil moisture dynamics resulting from fewer, but more intense rain events expected in the future. Based on figure from Knapp et al. (2008).

Effect	Potential mechanism	Uncertainty	Empirical evidence
Increased N leaching potential following summer droughts	Higher residual soil inorganic N due to decreased plant N uptake	low	6–12
Increased N leaching potential with greater/ more intense rainfall	Larger water flux through soil carries nitrate below the root zone	low	13–15
Greater N_2O emissions during increased spring precipitation	Longer periods of saturated soil conditions could increase N_2O emissions	medium	16
Reduced N turnover during more intense soil drying	Diffusion of microbial enzymes and substrates limited in dry soils	medium	17–20
Larger N_2O pulses with fewer, but more intense rainfall events	More intense wet/dry cycles may increase N_2O from both nitrification and denitrification	high	21–22

Summary message

Changes in the pattern and intensity of precipitation will likely exacerbate N losses in agroecosystems and concentrate losses in fewer, larger pulses (Fig. 2, Table 1), although the magnitude and pathways of losses will depend on many factors.

3. Tightening agroecosystem N cycling in a changing climate

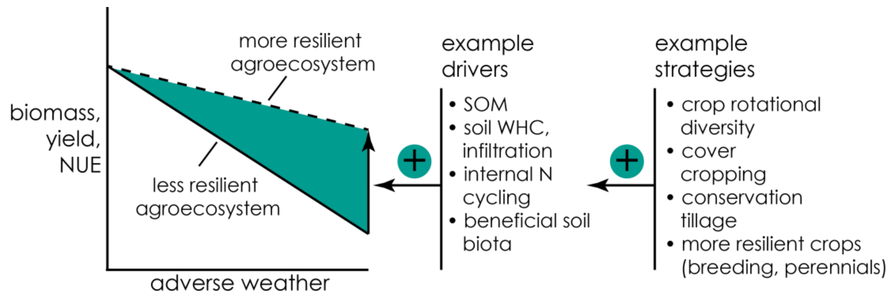

Fig. 3. Conceptual diagram showing relationship between adverse weather and interconnected effects on crop biomass production, yields, and nitrogen use efficiency (NUE) in more or less "resilient" agroecosystems, and management strategies that increase drivers of resilience.

Guiding principles

- Addressing fertilizer N use efficiency via conventional approaches is necessary but not sufficient
- Increasing agroecosystem resilience to extreme events will increase N retention
- Preparing for more pulse-driven N losses is essential

Acknowledgments and key references

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