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'SOLUTIONS TO IMPROVE NITROGEN USE EFFICIENCY FOR THE WORLD'

GHG emission and Nr release from staple food production in China and their mitigation potentials

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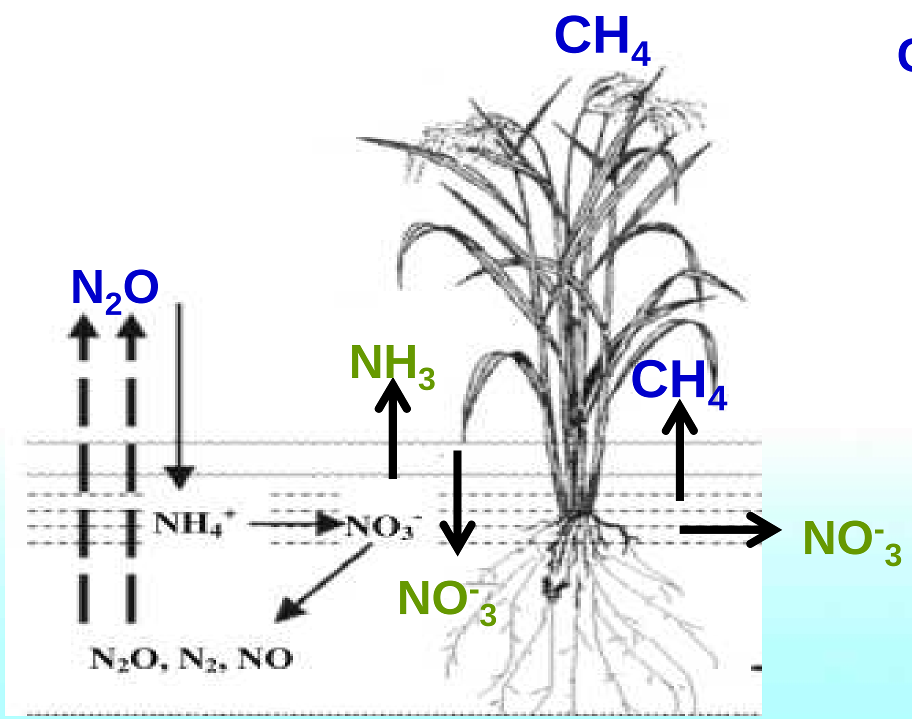
GHG and Nr release

Field cultivation

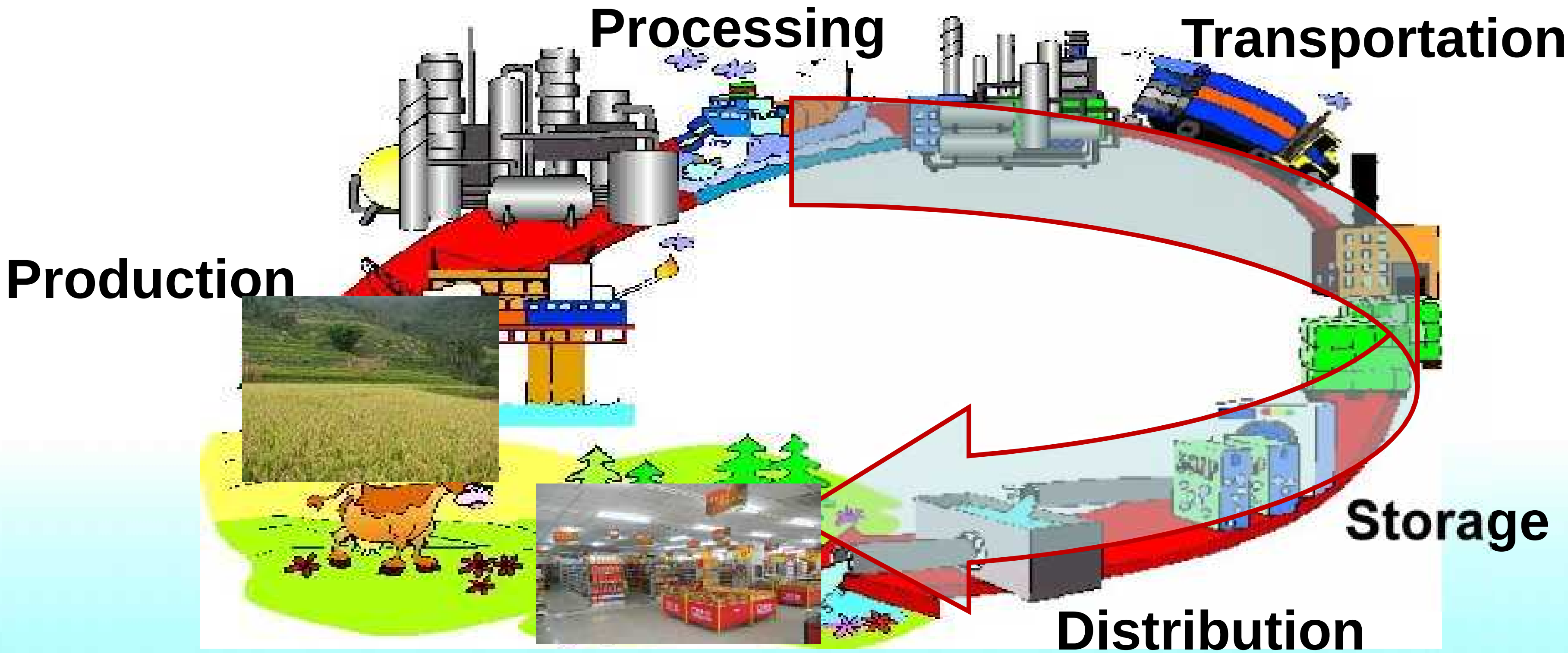


GHG (CH_4, N_2O, CO_2)

- Fertilizers
- Pesticide
- Processing
- Transportation
- …

Nr（NH_3， NO_3^-， N_2O, NO_X……)

Life cycle assessment (LCA)



Carbon footprint (CF) & Nr footprint (NrF)

CF and NrF

CO_2

Nr

Questions

1. How much of the mitigation potential?

2. How to realize the mitigation potential?

Methodology (LCA)

$$\text{Carbon footprint (kg } CO_2 \text{ eq kg}^{-1} \text{ grain)} = \left(\sum_{i=1}^{m} AI_{i\,CO_2} + \sum_{j=1}^{n} FC_{j\,CO_2} + \sum_{g=1}^{k} FP_{g\,CO_2} \right) / \text{yield}$$

$$\text{Nr footprint (g N kg}^{-1} \text{ grain)} = \left(\sum_{i=1}^{m} AI_{i\,Nr} + \sum_{j=1}^{n} FC_{j\,Nr} + \sum_{g=1}^{k} FP_{g\,Nr} \right) / \text{yield}$$

System boundary: AI production to food product being distributed to markets

AI: Agricultural inputs (fertilizers, pesticide…) **FC**: Field cultivation (fertilization, irrigation)

FP: Food production and distribution

GHG emission : CH_4, N_2O, CO_2, SOC change

Nr loss : NH_3, N_2O, NO_X, N leaching and runoff

Data compiling: statistical data, empirical model, IPCC emission factors….

Distribution of footprints

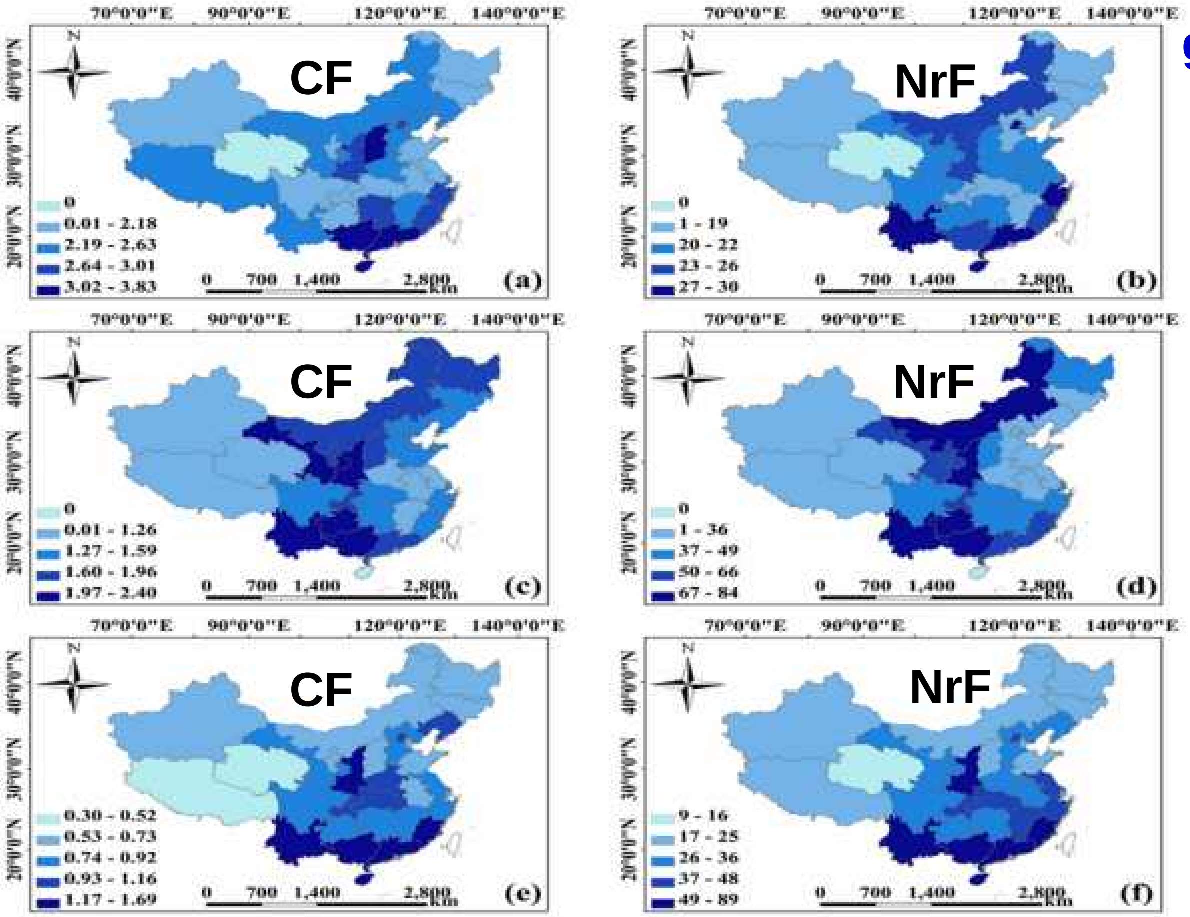
kg CO_2 kg^{-1} grain

g N kg^{-1} grain

Rice

Wheat

Corn

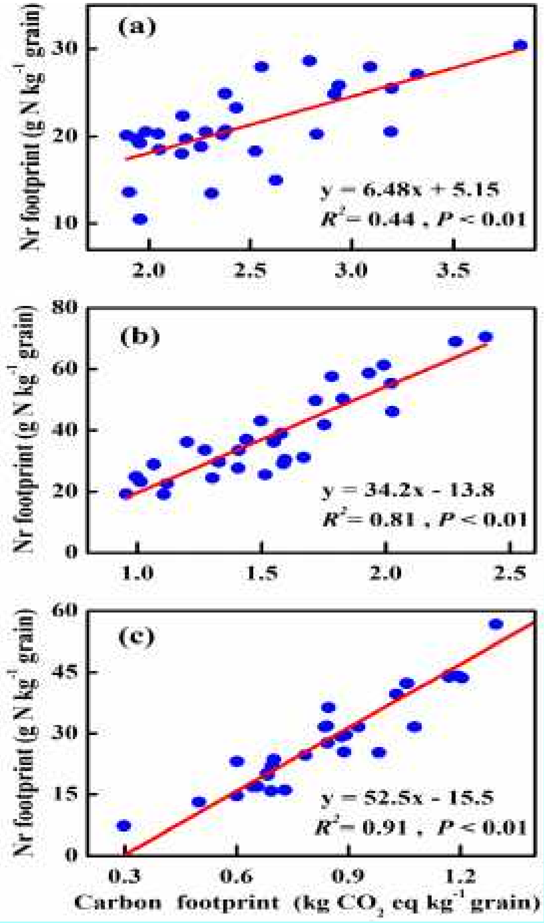


Relationship between footprints

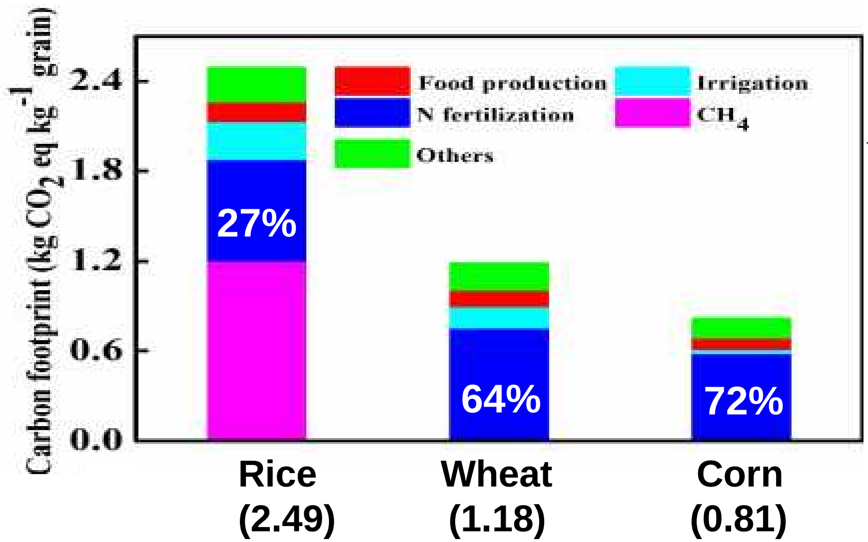
Rice

Wheat

Corn



Components of footprints

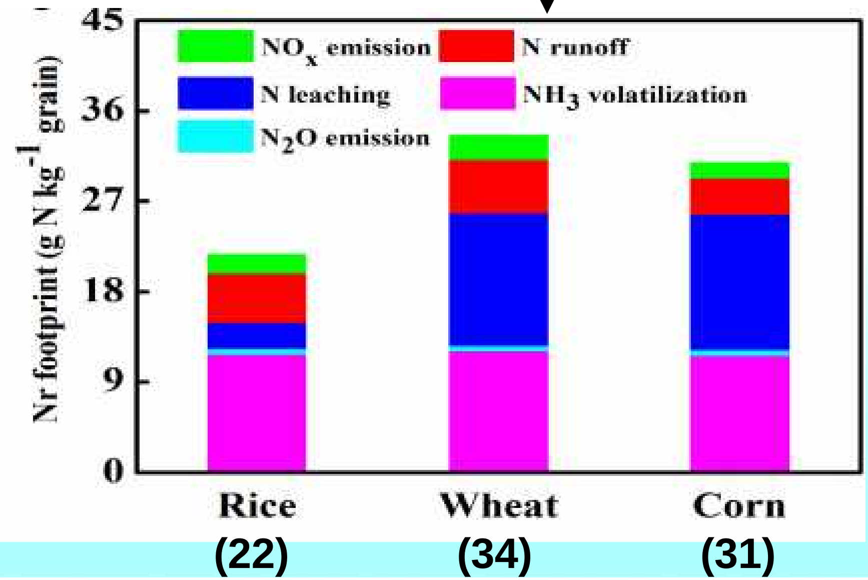


High Proportion

CO_2+N_2O

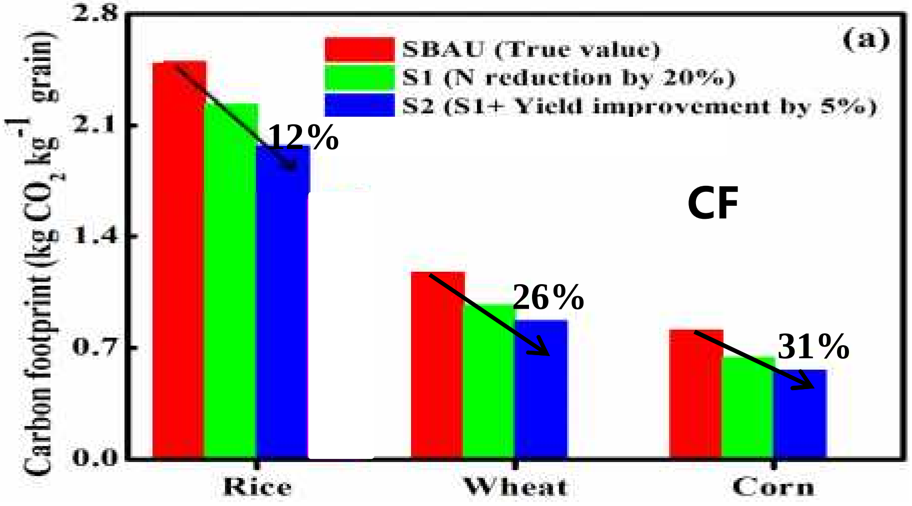
N (production) fertilization

Decide



Xia et al., 2016, Science of the Total Environment

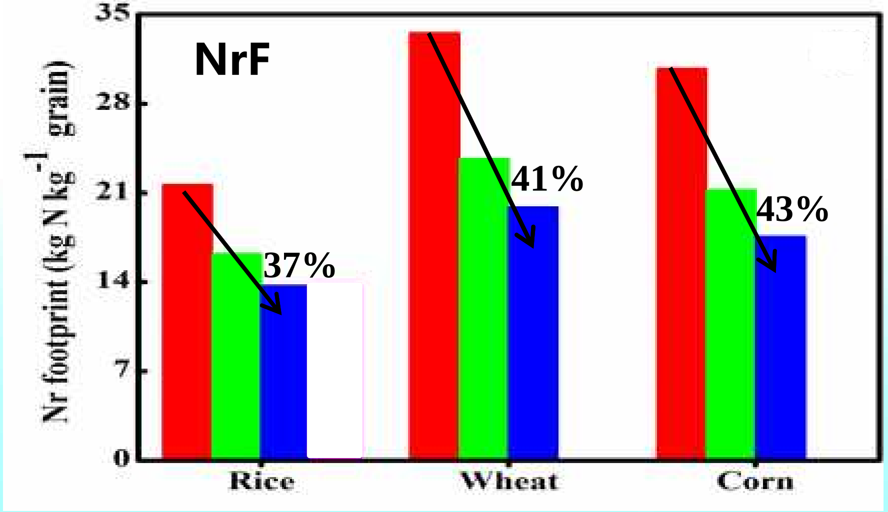
Mitigation potentials



SBAU (True value)

S1 (N reduction by 20%)

S2 (S1+Yield improvement by 5%)



How to realize?

S2: N reduction + yield improvement

↓

Knowledge-based N practices

↓

Nitrogen use efficiency (+)

Knowledge-based N practices

- **Enhanced efficiency N fertilizers**

  Controlled release N fertilizer (source)

  Nitrification inhibitor (source)

  Urease inhibitor (source)

- **Optimized N application**

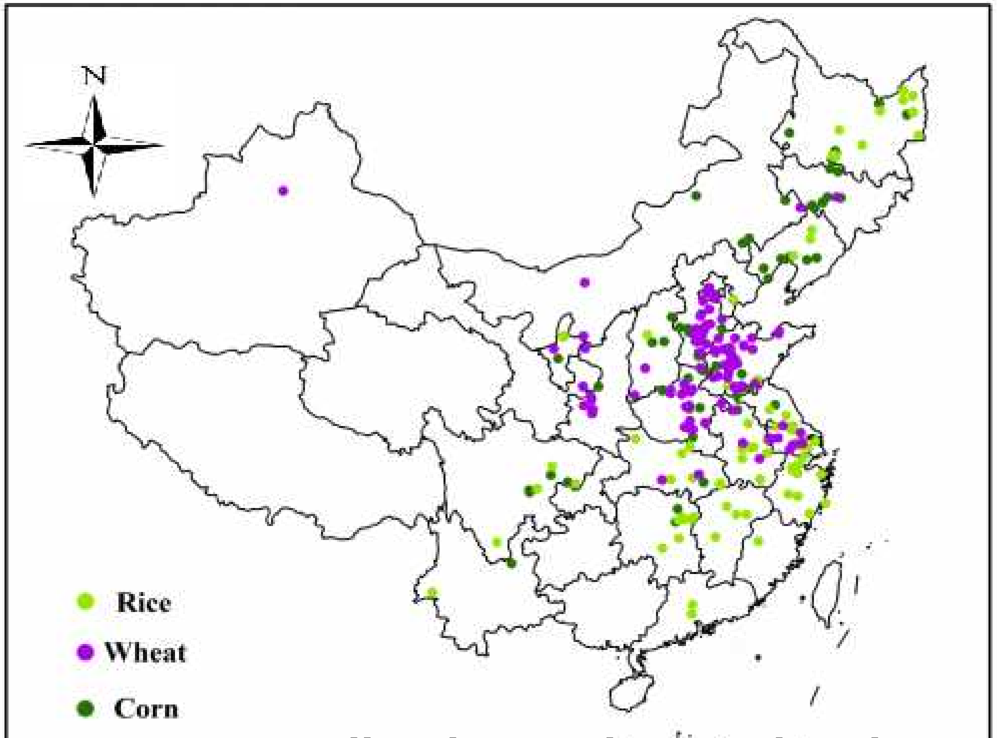
  Reducing basal fertilizer N ratio (time)

  Increasing N splitting frequency (time)

  Applying N deep placement (place)

  Reducing N rate based on soil N test (rate)

Meta-analysis



376 studies (1166 observations)

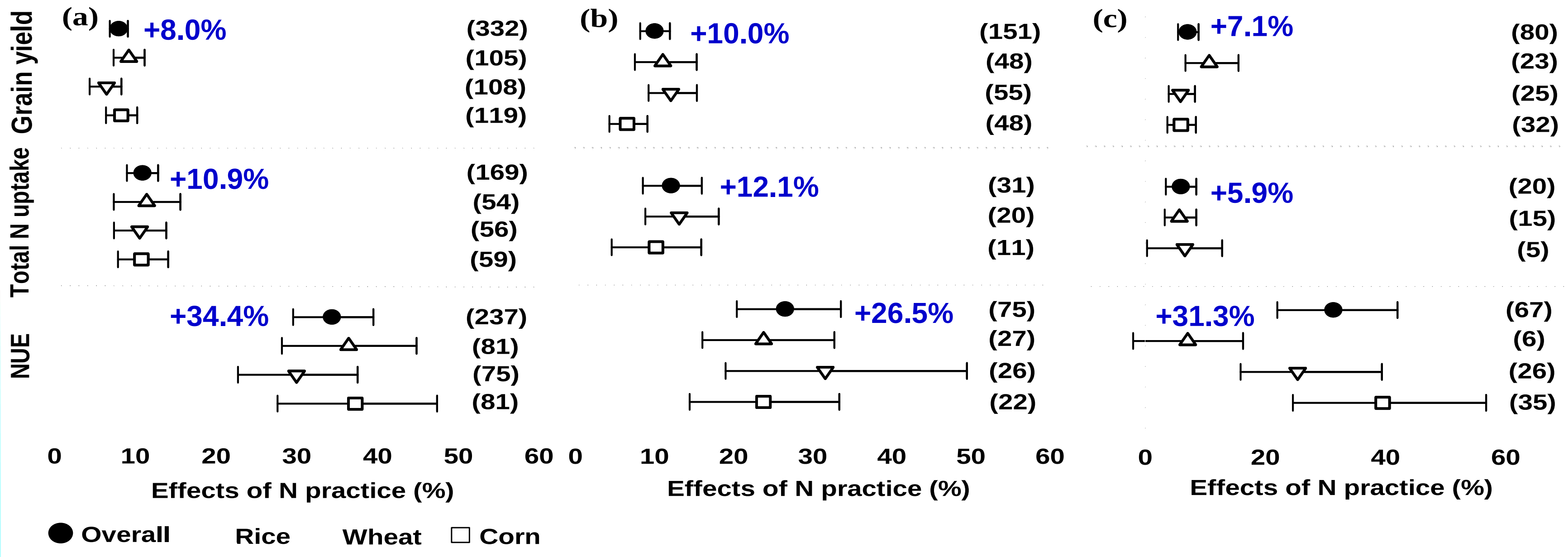
Xia et al., 2016, Global Change Biology

- Crop productivity
  - Grain yield
  - Plant N uptake
  - Grain NUE
- Various Nr loss
  - NH_3 emission
  - N_2O emission
  - N leaching
  - N runoff
- Economic indicators
  - Input cost
  - Yield profit
  - Net economic profit

Effects on crop productivity

Enhanced efficiency N fertilizers

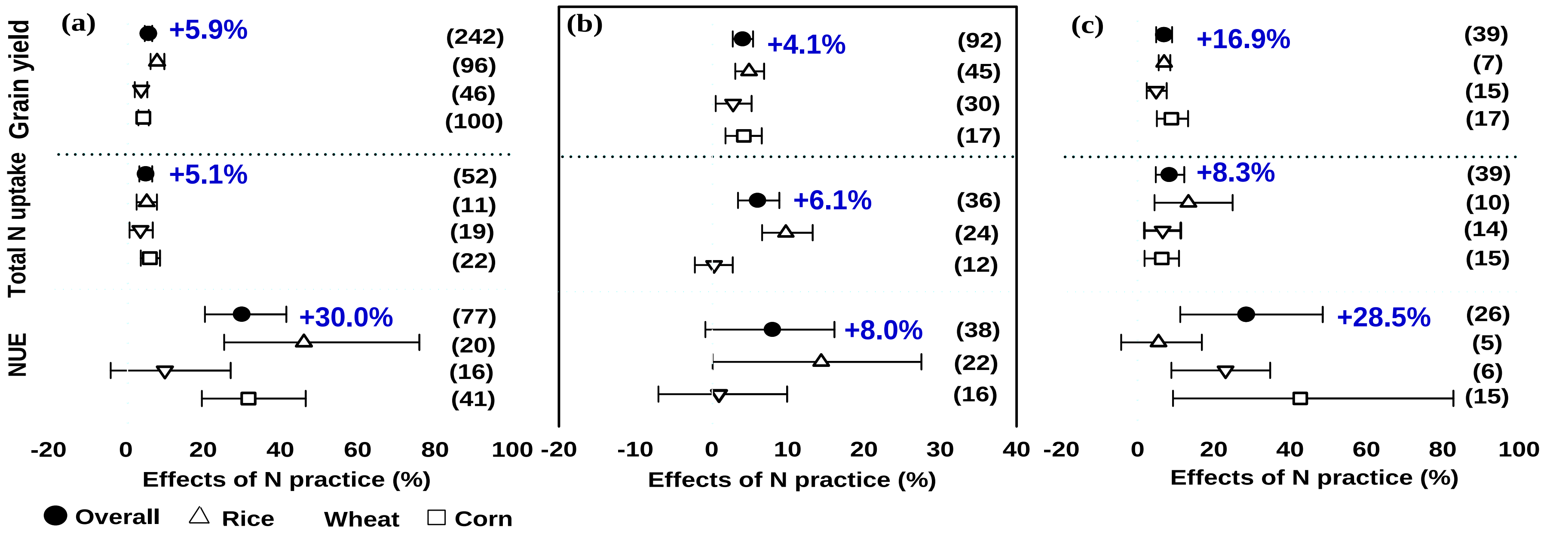
CRF application | NI application | UI application



Effects on crop productivity

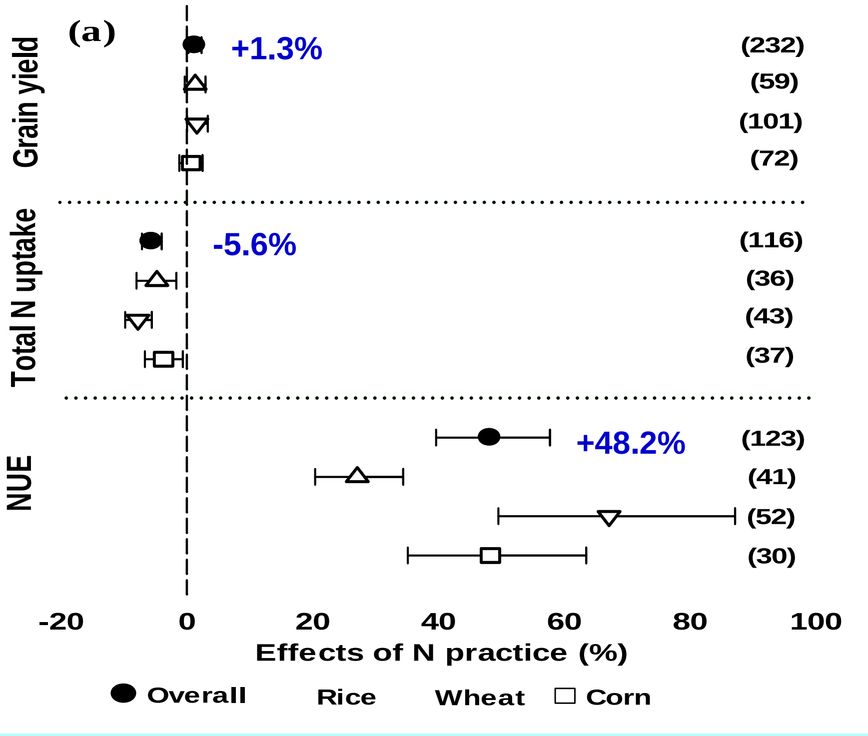
Optimizing N application methods

Increasing N splits | Reducing BF ratio | N deep placement



Effects on crop productivity

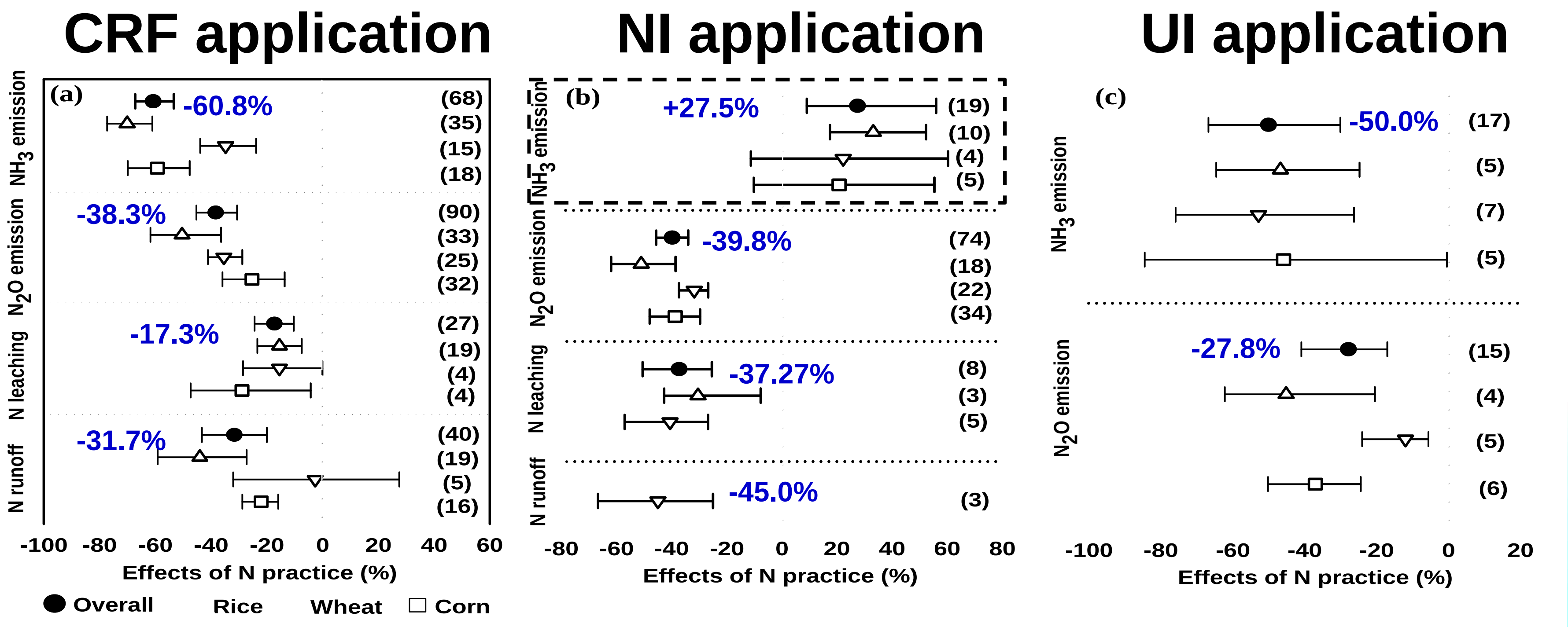
Reducing N application rate based on soil N test



Achieved on a national average N reduction of 28%

Effects on Nr loss

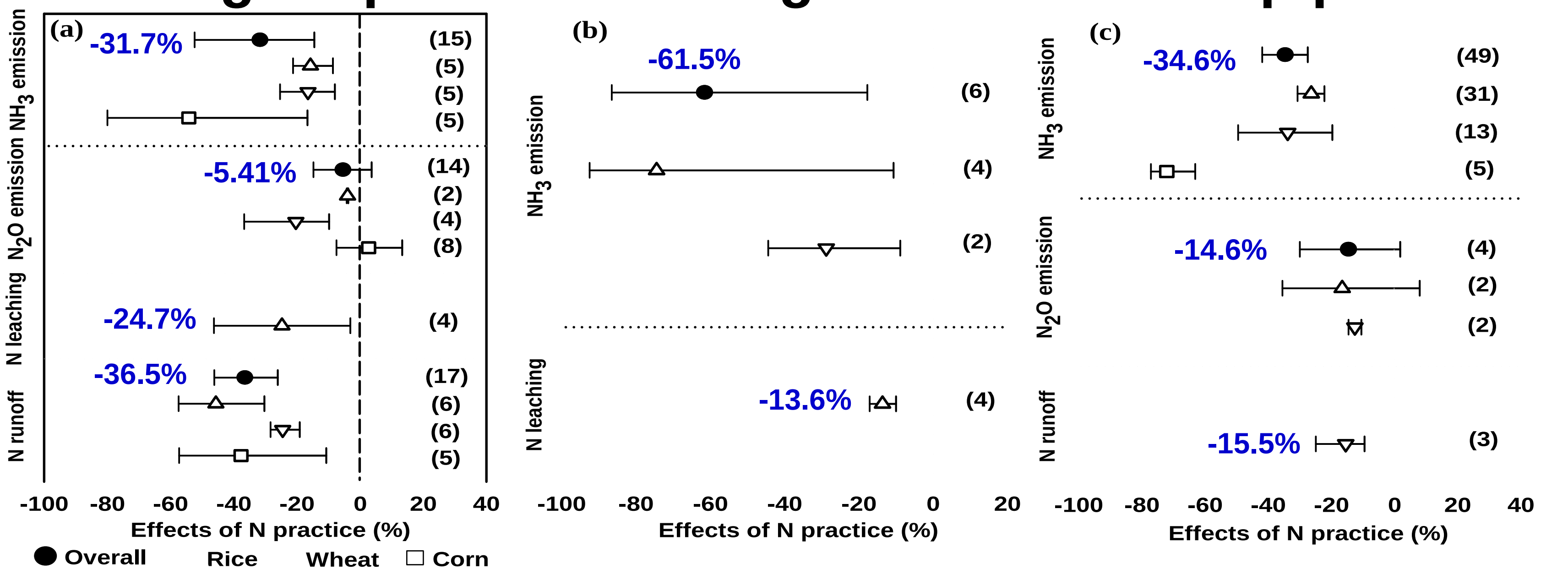
Enhanced efficiency N fertilizers



Effects on Nr loss

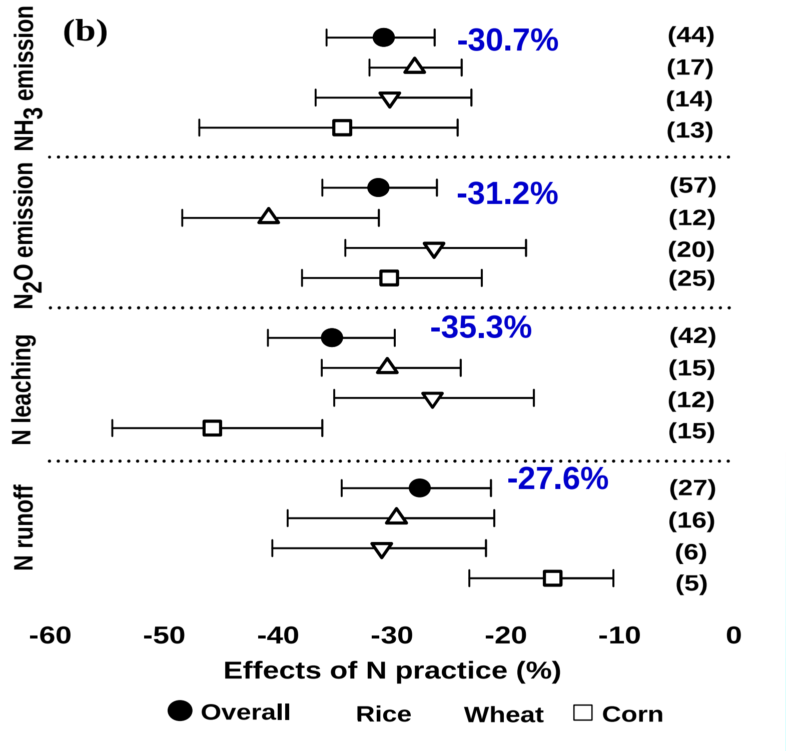
Optimizing N application methods

Increasing N splits / Reducing BF ratio / N deep placement



Effects on Nr loss

Reducing N application rate based on soil N test



Cost-benefit analysis

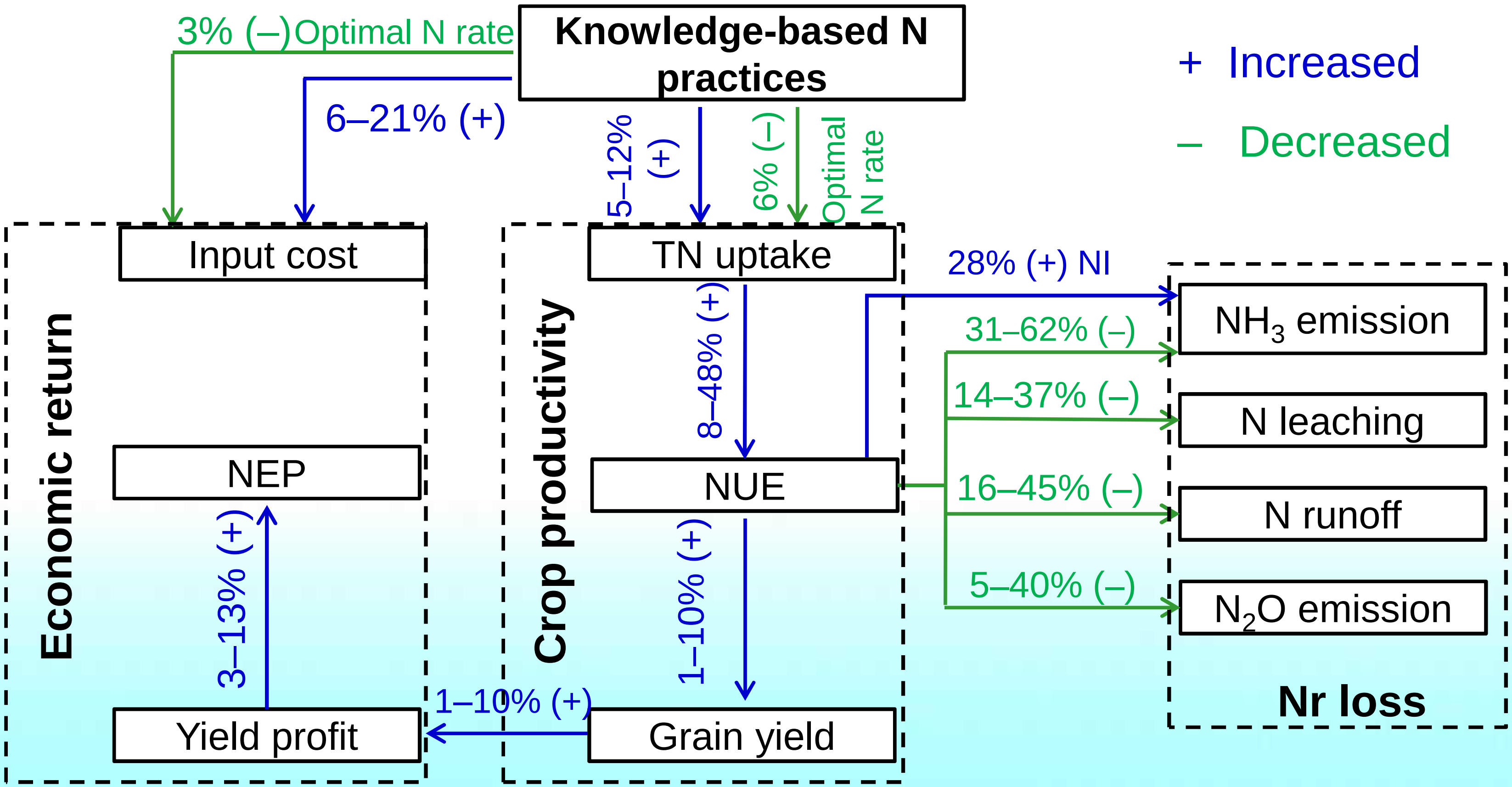
Knowledge-based N practices	Input cost[a],%		Yield profit[b],%		Net economic profit[c],%	
	mean	95% CI	mean	95% CI	mean	95% CI
CRF application	6.38	4.93-7.84	7.67	6.51-8.76	**7.78**	6.31-9.23
NI application	9.78	8.07-11.51	10.02	8.23-12.05	**12.64**	8.96-17.1
UI application	7.05	5.53-8.73	7.09	5.47-8.90	**5.85**	2.15-9.27
Increasing N splits	21.42	20.14-22.80	5.83	4.85-6.81	**3.58**	2.39-4.74
Reducing BF ratio	No change	No change	4.06	2.74-5.42	**5.03**	3.49-6.73
Applying N deep placement	8.21	7.51-8.97	6.64	4.67-8.91	**6.11**	3.81-8.57
Reducing N rate based on N test	-3.2	-(4.6–1.9)	1.25	0.25-2.31	**2.86**	1.44-4.46

[a]**Input cost** included the cost of agricultural materials (fertilizers, NI and UI), and labor cost associated with fertilizer application and conducting N management practices (e.g., increasing splitting frequency, deep placement and soil N test).

[b]**Yield profit** was the gross economic profit obtained from crop grains.

[c]**Net economic profit** calculated by subtracting the input cost from the yield profit.

Overall effects of N practices



Barriers

- Effects of these N practices varied among different crop species and soil properties.
- Many farms are still small scale, farmers' knowledge, environmental awareness still need to improve
- Farmers are risk-sensitive, and opportunity cost (time, labor, training/education costs) for implementing these N practices is very high.
- Fertilization mechanization.

Conclusions

- **Large mitigation potentials exist for staple food production in China, 12-31% for GHG emission and 37-43% for Nr loss.**

- **Knowledge-based N practices can facilitate the realization of these potentials, with more grains, lower Nr pollution and higher economic return.**

- **Barriers still exist.**


Thank you for your attention
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