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Nitrogen budgets in croplands of three counties with different land-use changes over the past decades

Jianbin ZHOU, Xueqiang ZHU, Shimiao WANG, Jingbo GAO, Zhujun CHEN

jbzhou@nwsuaf.edu.cn

College of Natural Resources and Environment / Key Laboratory of Plant Nutrition and the Agri-environment in Northwest China, MOA ,

Northwest A&F University, Yangling, Shaanxi, China

西北农林科技大学
NORTHWEST A&F UNIVERSITY

Outlines

1. Background
2. Study methods
3. Results
4. Conclusions

1. Background

Agricultural miracle in China since 1978:

feeding our huge population with only ~9% of global arable land.

Expensive costs:

High inputs of chemicals and other resources, e.g., consumption more than 30% of N fertilizers in the world.

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Fig 1. Changes of different agricultural products in China since 1978

Land use change in China: cereals to horticultural crops.

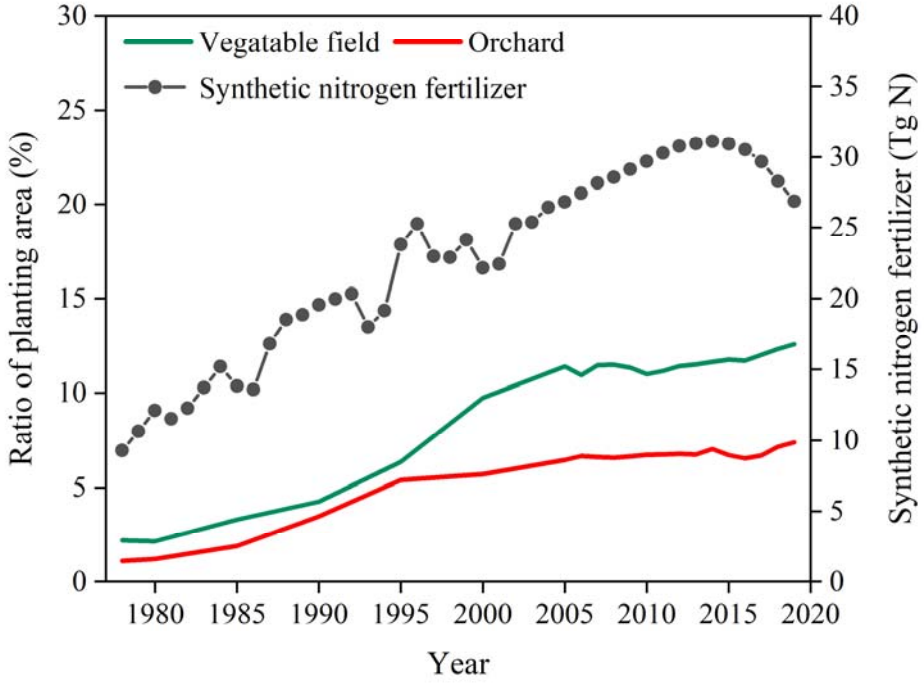
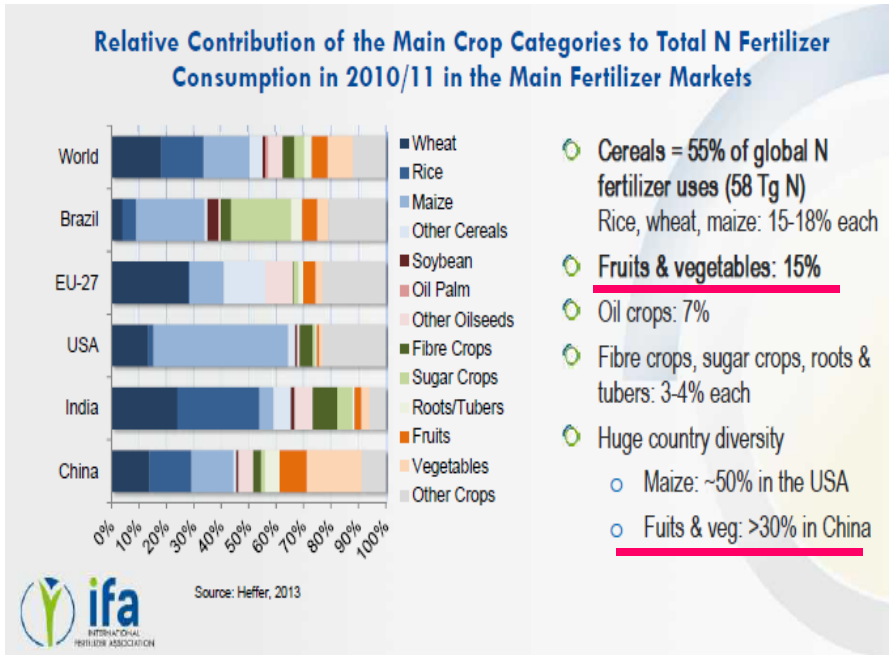


Fig 2. Percentages of vegetable crops and orchard, and use of N fertilizers in China since 1978

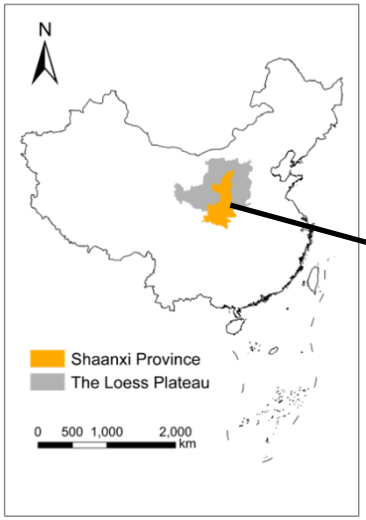


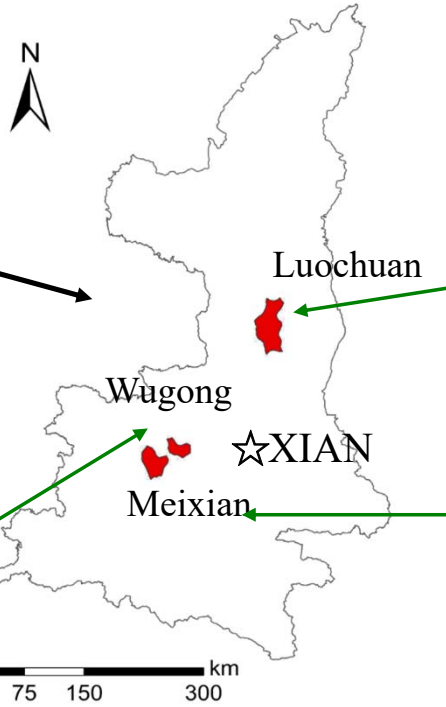
Heffer P. 7th International Nitrogen Initiative Conference, 4-8 Dec 2016, Melbourne

Understanding the long-term effects of this change on N budgets in croplands at the county scale is very important for managing N in agricultural systems.

2. Study sites & methods

Three counties with different land use changes on the Loess Plateau





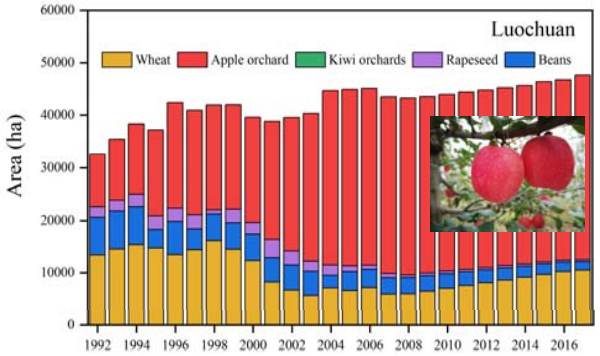
Cereal to apple orchard (Dryland farming)

Cereal (irrigated)

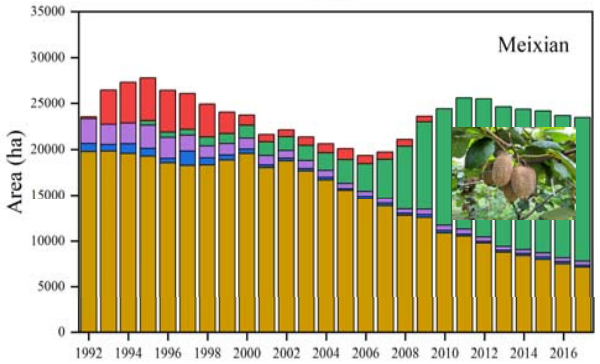
Cereal to kiwifruit orchard (irrigated)

Land use changes of the three counties

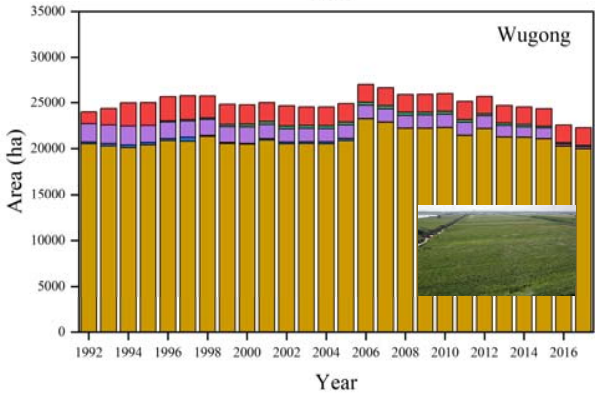
Luochuan



Meixian



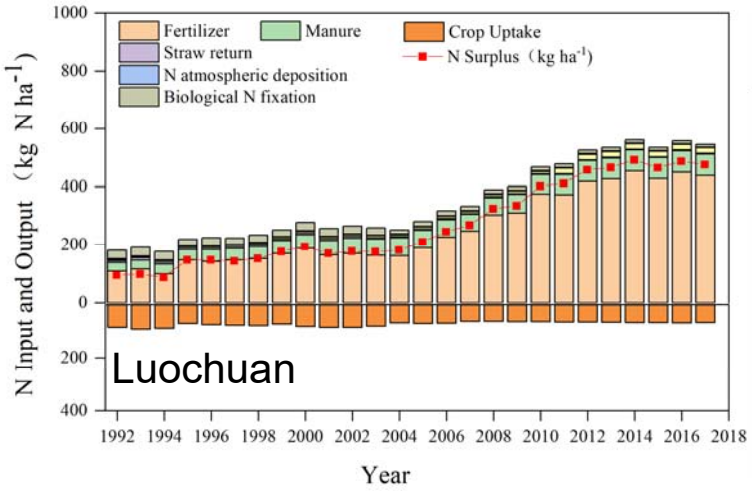
Wugong

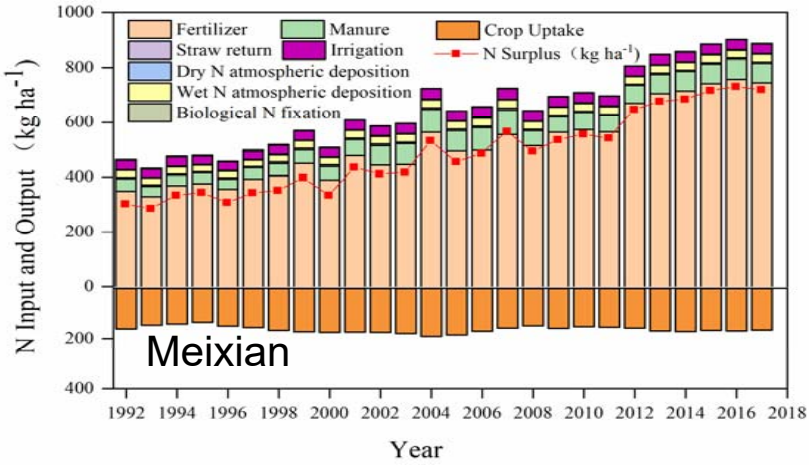


- **N budgets:**
  - **N inputs** = synthetic fertilizers + manures+ atmospheric deposition + biological fixation+ straw return
  - **N outputs** = harvested by crops + pruning of fruit trees.
  - **N surplus** = N inputs – N outputs
- **Determined the nitrate in soil profiles**

3. Results

3.1 N budgets in croplands of the county scale:





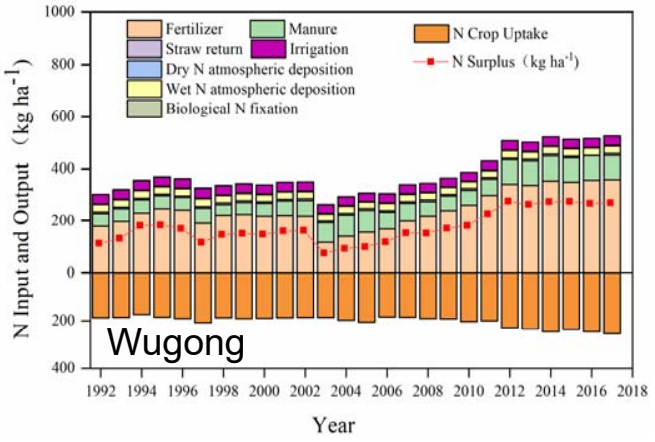


Fig 4. N budgets in croplands of three counties from 1992 to 2018

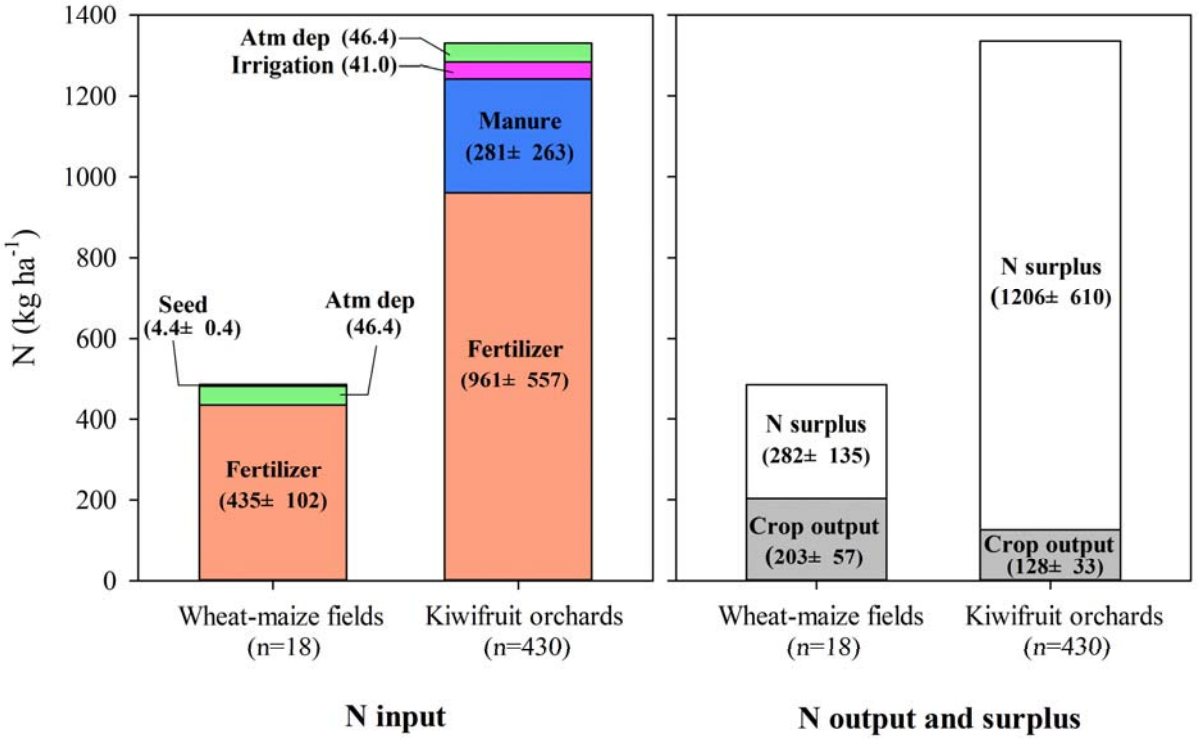
Wang Shimiao, unpublished

N surplus (kgN/ha)

>600 >  >400 >>  ~200

Results

N budgets at the field scale in *Meixian*:



N surplus (kgN/ha):

Kiwi-orchards = 4.2 × cereal lands

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Figure 5 N budgets in kiwifruit orchards and cereal land of *Meixian*

3.2 Nitrogen use efficiency

NUE =

N outputs / N inputs

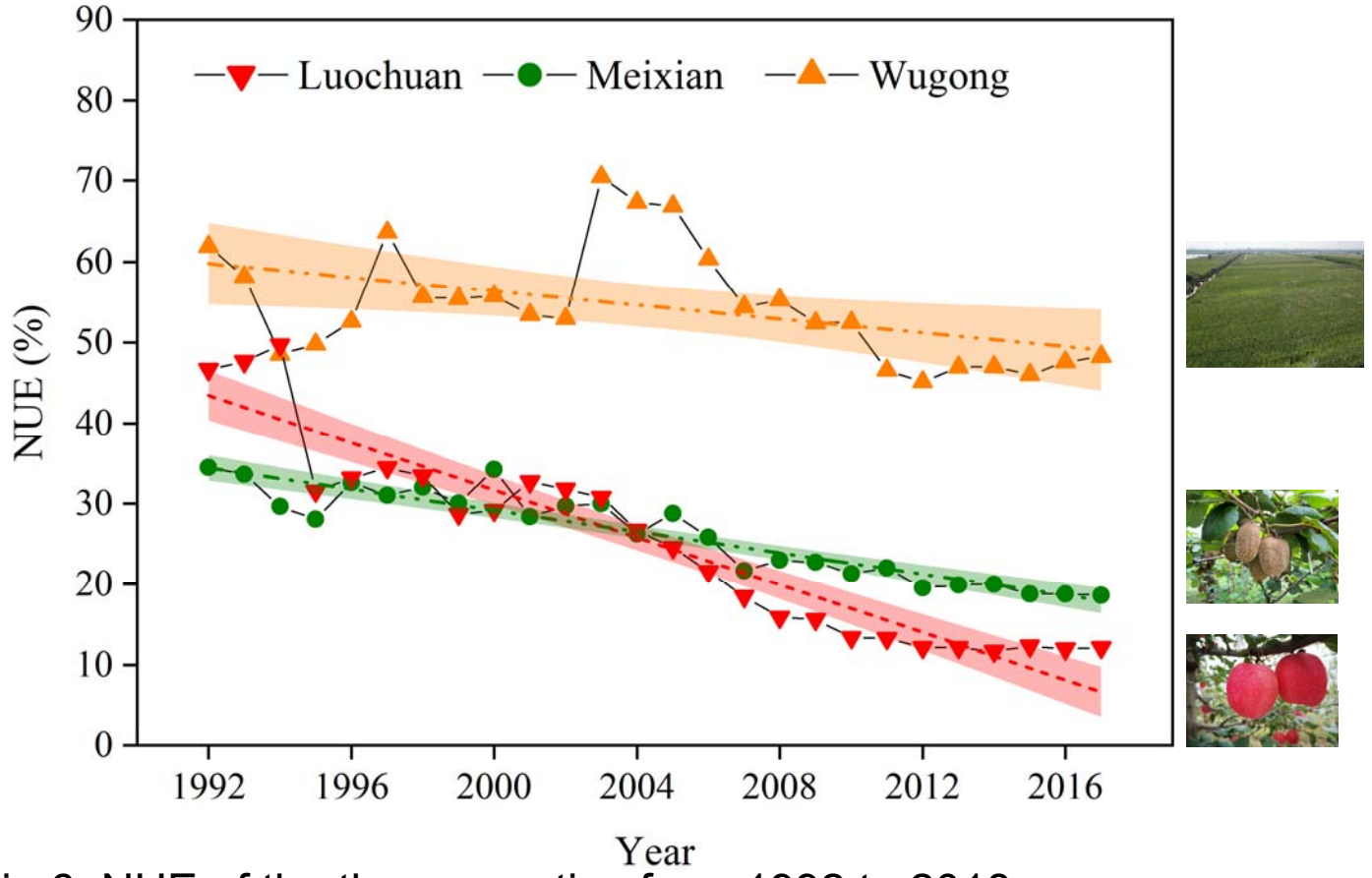
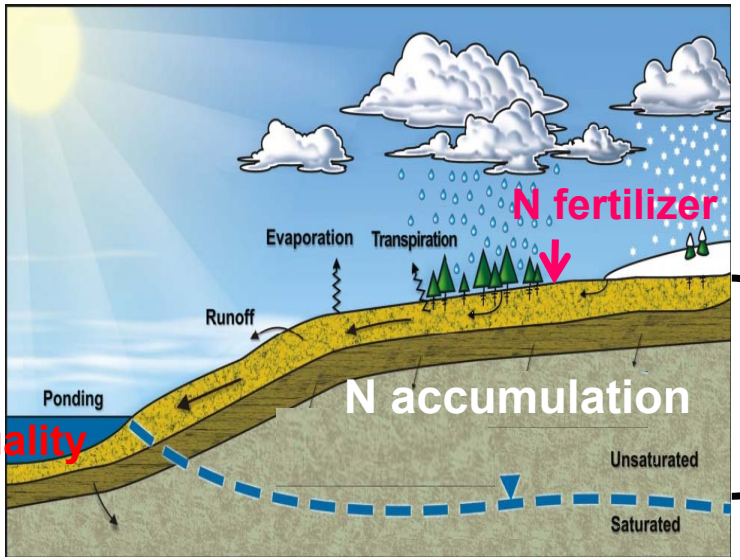


Fig 6. NUE of the three counties from 1992 to 2018

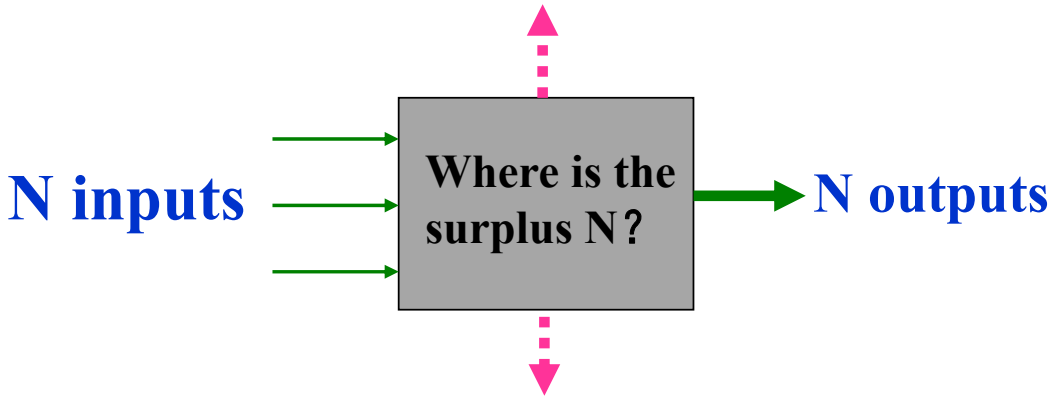
3.3 where is the surplus N?

- Uptake by plant
- accumulation in vadose zone
- Loss to atmosphere and aquifer



Water quality

vadose zone



- Loss to aquifer?
- Accumulation in vadose zone

Results

The soils in the Loess Plateau have very deep vadose zone.

◆**Deep borehole method**

Two types: irrigated *vs* dryland

Cereal to apple orchard (Dryland farming)

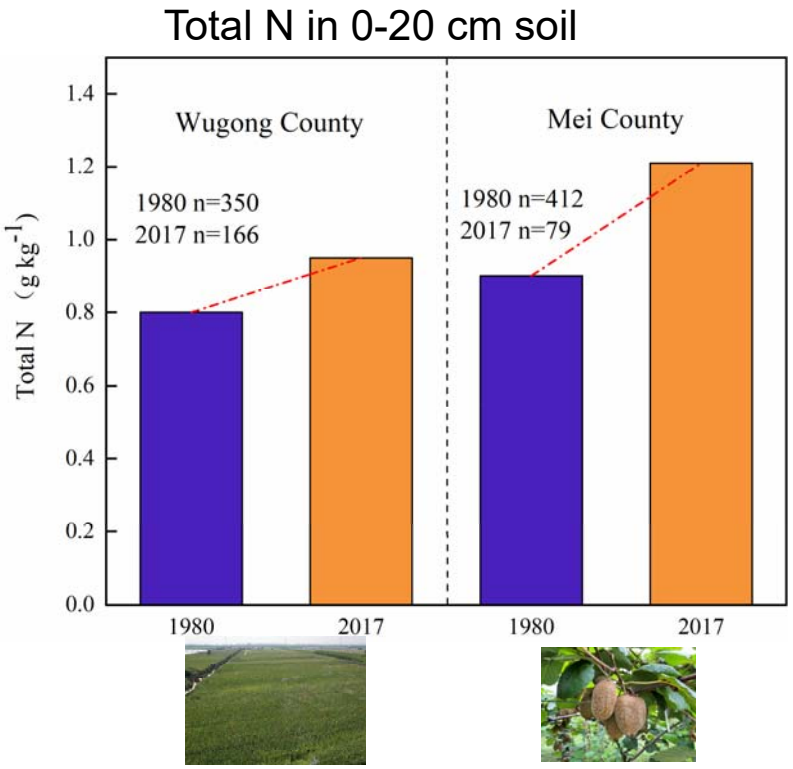
Cereal (irrigated)

Cereal to kiwifruit orchard (irrigated)

Results

(1)Fates of surplus N in *Meixian* and *Wugong* Counties

(Irrigated ~300 mm + rainfall ~630 mm)



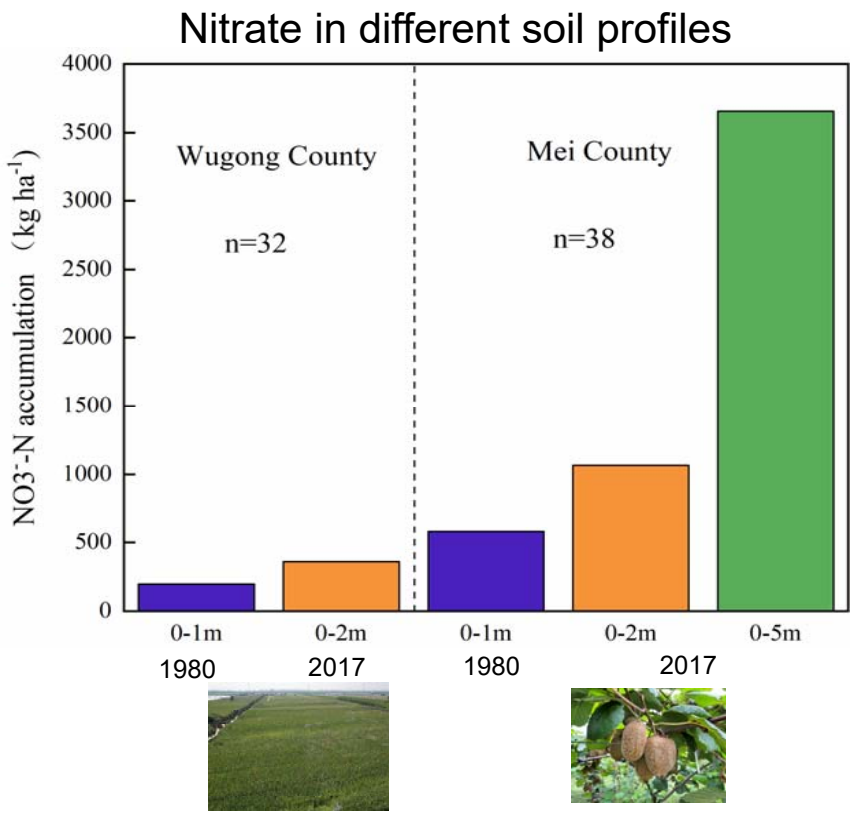
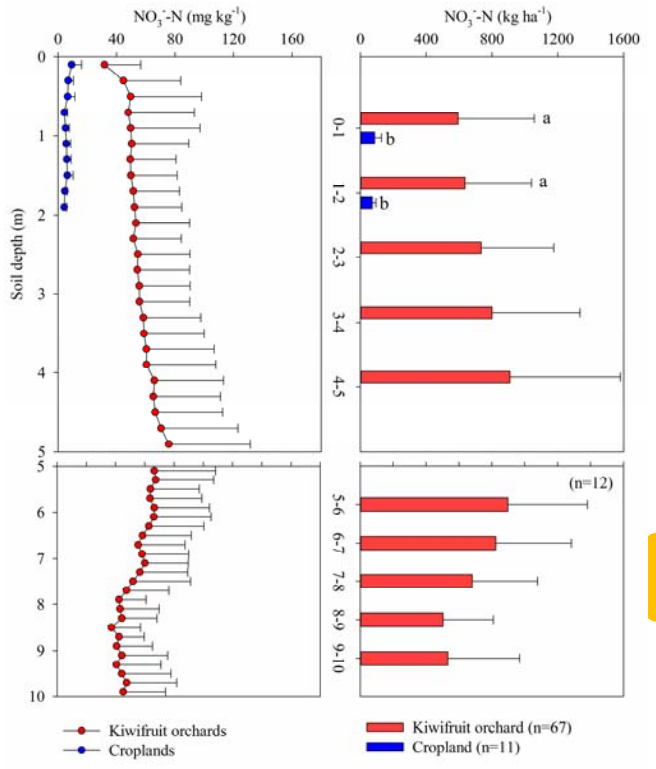


Fig7 Changes of total N and nitrate in soil profiles of *Wugong* and *Meixian* between 1980s and 2017

High nitrate accumulation in soil profiles (0-10m)



∑= 7113 kgN/ha

Fig. 8 Concentration and accumulation of NO_3^--N in 0-10 m soil profiles in cereal land and kiwi-orchards in *Meixian*

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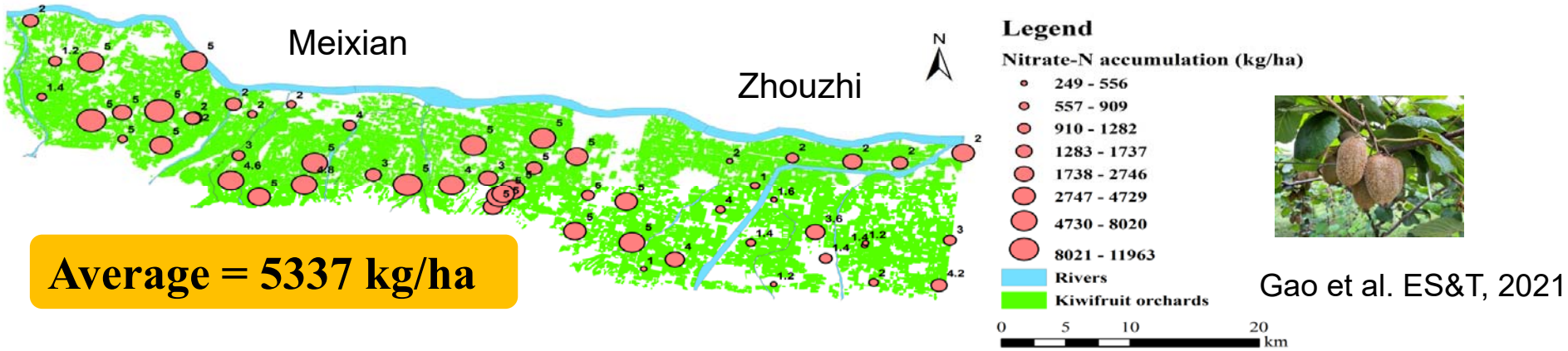
Nitrate accumulation in soil profiles of kiwifruit belt (0-5m, n=57)



Average = 5337 kg/ha

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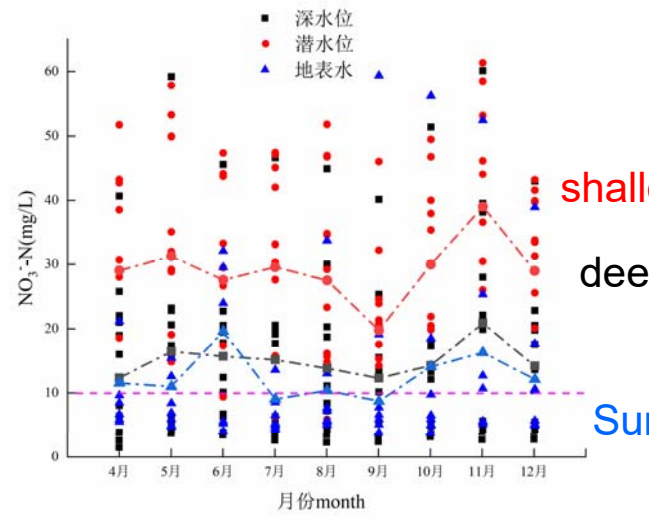
Fig 9 Nitrate accumulation in soil profiles of kiwifruit belt (0-5 m)



shallow groundwater

deep groundwater

Surface water

Fig 10 Nitrate in surface and groundwater of kiwifruit belt (mgN/L)

Total N loss to aquifer?

(2)Fates of surplus N in *Luochuan* County

(Dryland farming, rainfall ~600 mm)

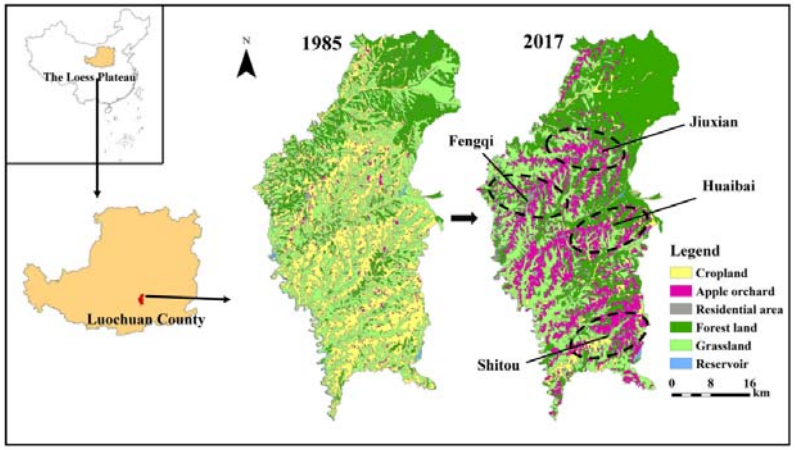


Fig 11 Land use change in 1985 and 2017 and soil sampling sites at Luochuan County

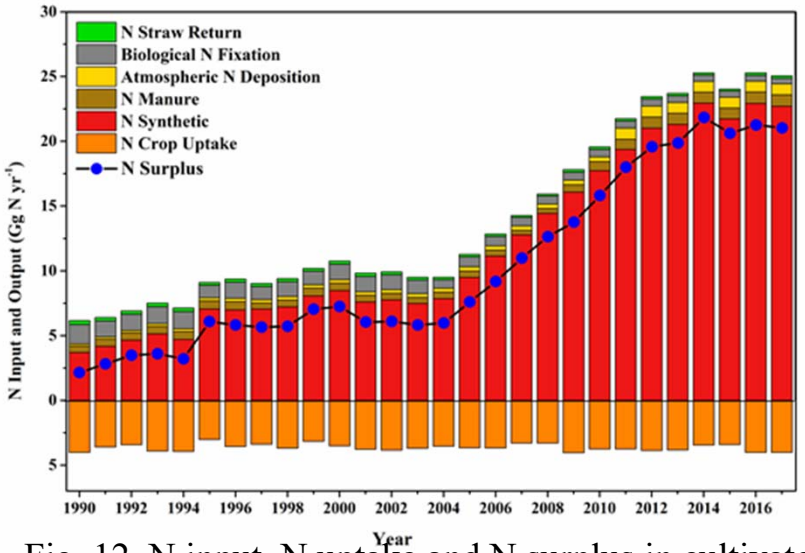


Fig. 12. N input, N uptake and N surplus in cultivated land in Luochuan County from 1990 to 2017. (Unit: Gg=10^9 g).

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The evapotranspiration is higher than rainfall, results in water deficit in deeper soil profiles of the old apple orchards

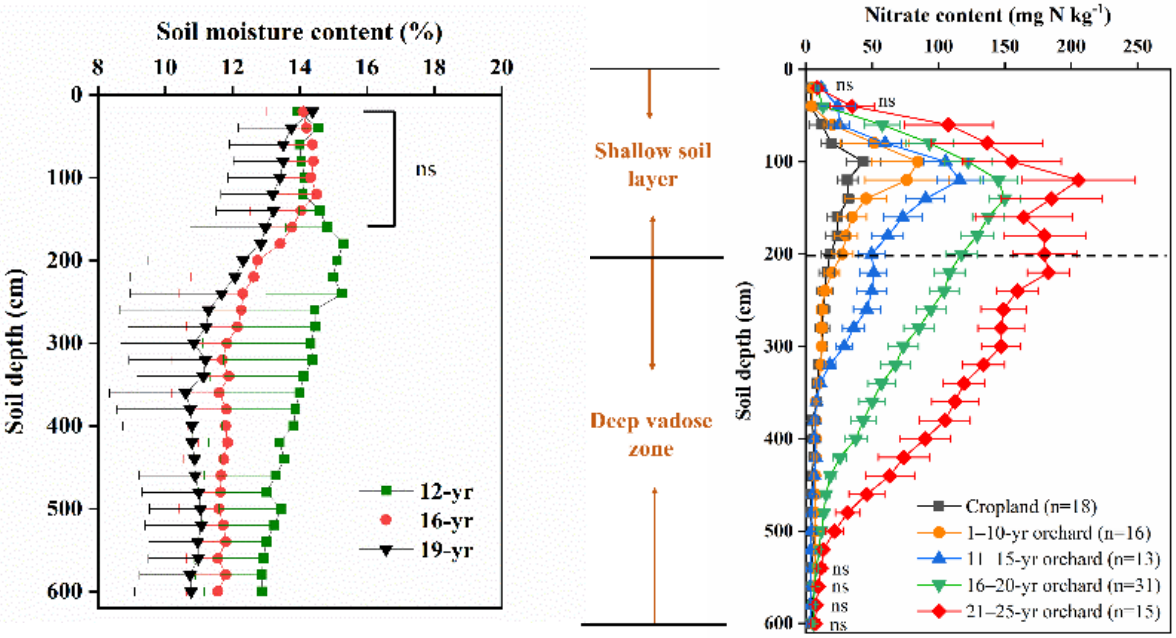

Fig. 13. Soil moisture and nitrate contents in the soil profiles of cereal lands and apple orchards of different stand ages in Luochuan County

Nitrate accumulation in vadose zone is the main fate of surplus N (~ 2/3 of surplus N)

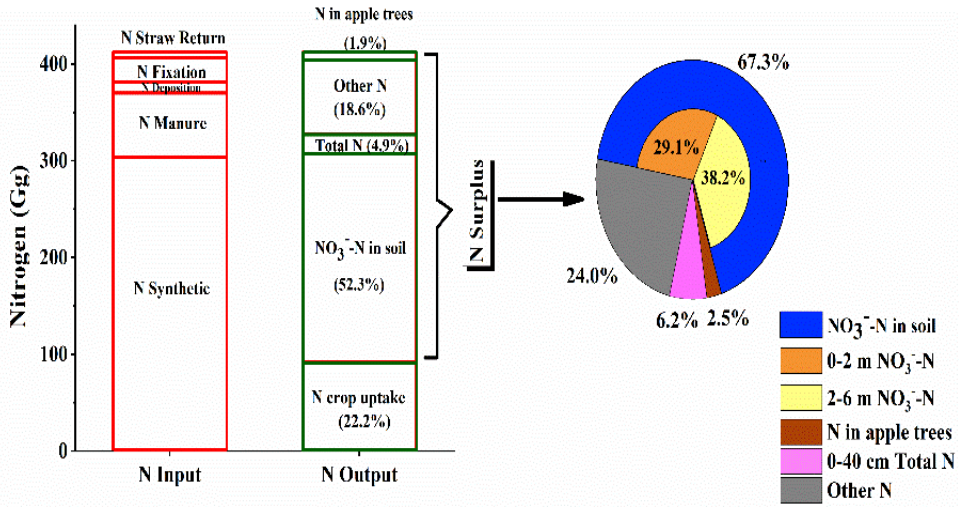

Fig. 14. Percentages (%) of the net soil nitrate storage, total N surplus and total N crop uptake out of total N input during the past 28 years in Luochuan County. Note: 0–2 m NO_3^--N means nitrate accumulated in the 0–2 m soil layers; 2–6 m NO_3^--N means nitrate accumulated in the 2–6 m soil layers. Total N indicates net increase of total N in the 0–40 cm soil layers. Other N means N losses through NH_3, N_2 and N_2O emissions. Unit: Gg = 10^9 g.

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4. Conclusions

◆Land use changes from cereal lands to orchards resulted in high N surplus (N hotspot!).

◆Nitrate accumulation in the vadose zone is the main fate of surplus N. (the missing N?)

◆Nitrogen accumulation in vadose zone is a big risk to the water quality at the intensive agricultural regions in China (Legacy N).

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Thanks + questions?

jbzhou@nwsuaf.edu.cn