Comparison of water drainage and nitrate leaching under three land use types in the North China Plain

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Contents

Purpose

Background

Review

Background:

Nitrate losses from agricultural activities mainly fertilizer applications, would substantially enrich nitrate in groundwater.
Land use affects groundwater resources through changes in recharge and by changing demands for water, and further affects groundwater quality.

Review :

•Different land use types might have different effects on groundwater N contamination in agricultural regions.

•land use types on the ground were poorly related to nitrate concentrations in the underlying water. (Lake et al. 2003; Liu et al. 2005)

•groundwater and contaminant sources would derive from land-use types, (Choi et al. 2007; Koh et al. 2010).

What is the situation in NCP?

Methodology

- **Purpose:** effects of different land use types on groundwater nitrate contamination in the North China Plain
  - Water drainage and nitrate leaching losses to groundwater from three land use types were quantified and compared during a 1-year study (2010.10—2011.09).

Three land use types

- **Vegetable fields, where leek was cultivated**
- **Winter wheat-summer maize field**
- **Woodland field, (poplars)**

- **Annual sunshine is 2832.7h, annual average precipitation is 617.2 mm**
- **with relatively consistent soil type and hydrogeological conditions**

Methodology

Traditional Irrigation Management in the NCP

Vegetable		Wheat-maize		woodland	
Date	Irrigation/mm	Date	Irrigation/mm	Date	Irrigation/mm
2010/10/9	45	2010/10/12	67.5	2010/10/16	75
2010/10/23	45	2010/11/24	67.5	2011/3/18	75
2010/11/7	45	2011/3/25	67.5	2011/5/7	75
2011/3/25	45	2011/5/4	67.5	2011/7/2	75
2011/4/3	45	2011/6/1	67.5		
2011/4/10	45	2011/7/20	67.5		
2011/4/17	45				
2011/4/24	45				
2011/4/30	45				
2011/5/21	45				
2011/6/4	45				
2011/6/18	45				
2011/7/2	45				
2011/7/23	45				
2011/8/21	45				
2011/9/7	45				

Methodology

Traditional Field Management in the NCP

Vegetable field

1st: organic manure application on 2010/10/3, 360 kgN·ha^{-1}

2nd: soybean cake On 2011/3/15, 900 kgN·ha^{-1}

3rd and 4th: compound fertilizer 2011/5/21, 2011/8/20 195 kgN·ha^{-1}, 195 kgN·ha^{-1}

Wheat-Maize field

Wheat:
1st: sown 2010/10/7 compound fertilizer 150 kgN·ha^{-1}
2nd: turning green stage, Urea 150 kgN·ha^{-1}
Maize:
Urea, 100 kgN ha^{-1}, Before sowing, at jointing stage, and heading stage

Woodland field

Urea was applied on May 16th 2011, equivalent about nitrogen 140 kgN·ha^{-1}

Methodology

What are monitored?

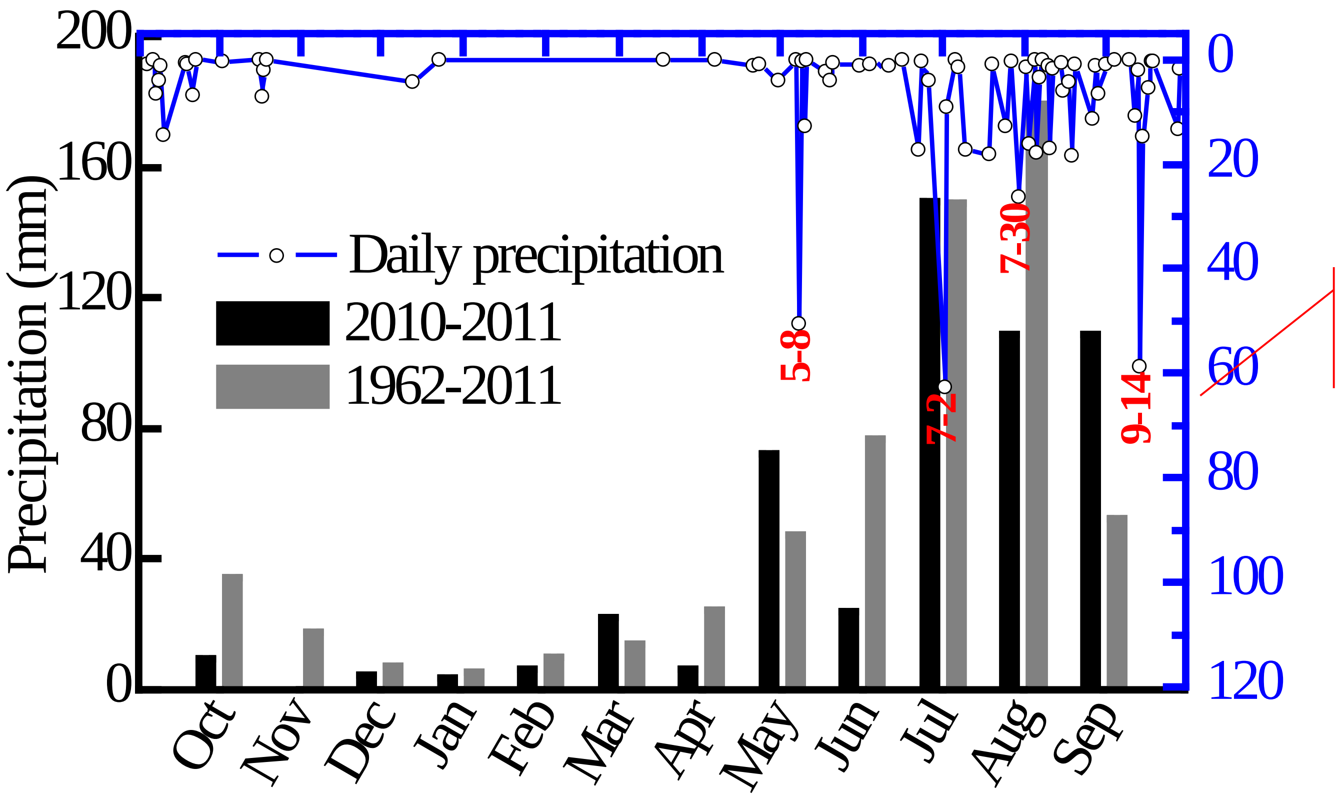
- Soil moisture
- Nitrate con. of soil solution at depth 2.0m
- Nitrate contents in the 2.0m soil profile
- Weather data including precipitation
- Irrigation water and Nitrate con.

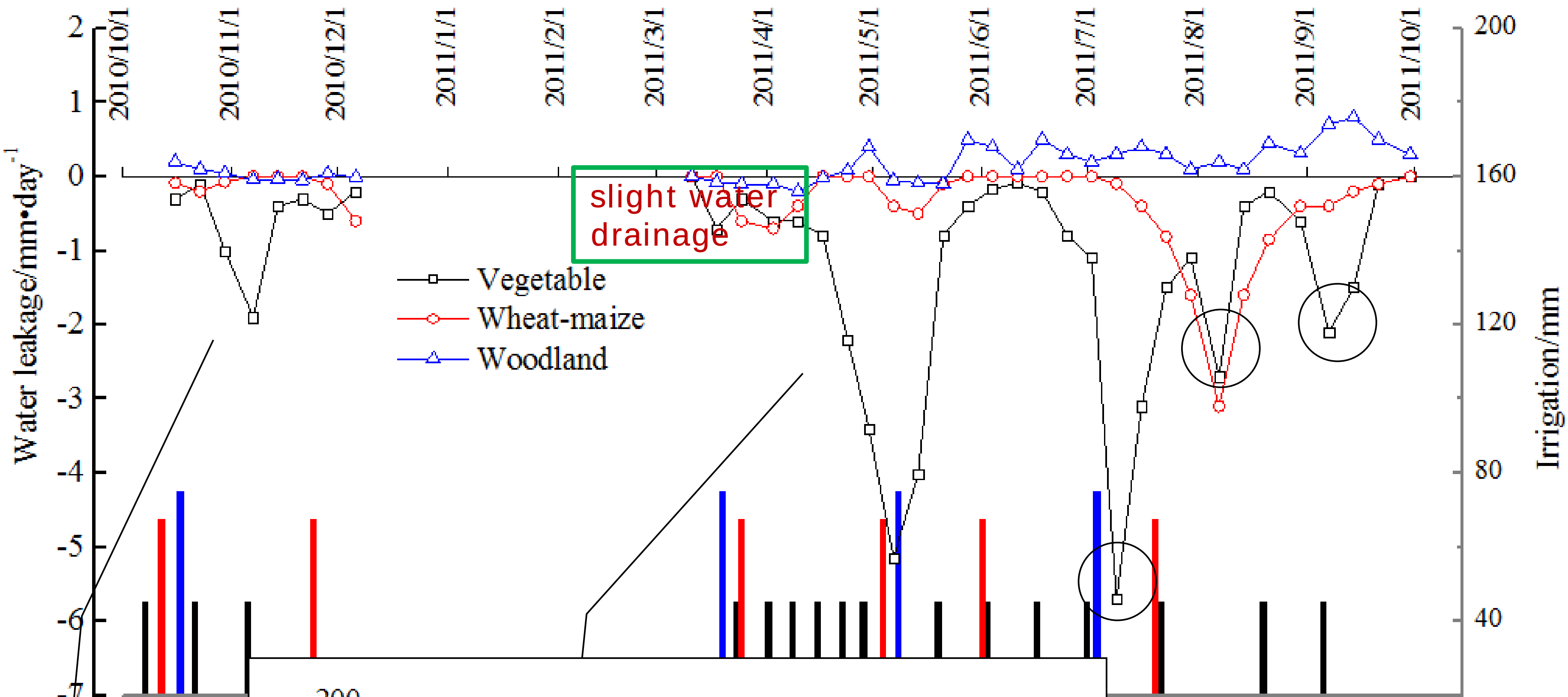
What are obtained?

- Water drainage amounts
- Nitrate leaching amounts
  - By Darcy's Law
  - SWCC(VG model)
- Nitrate distribution
- Daily and monthly Pre.

Results

Precipitation





obvious
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Dec.

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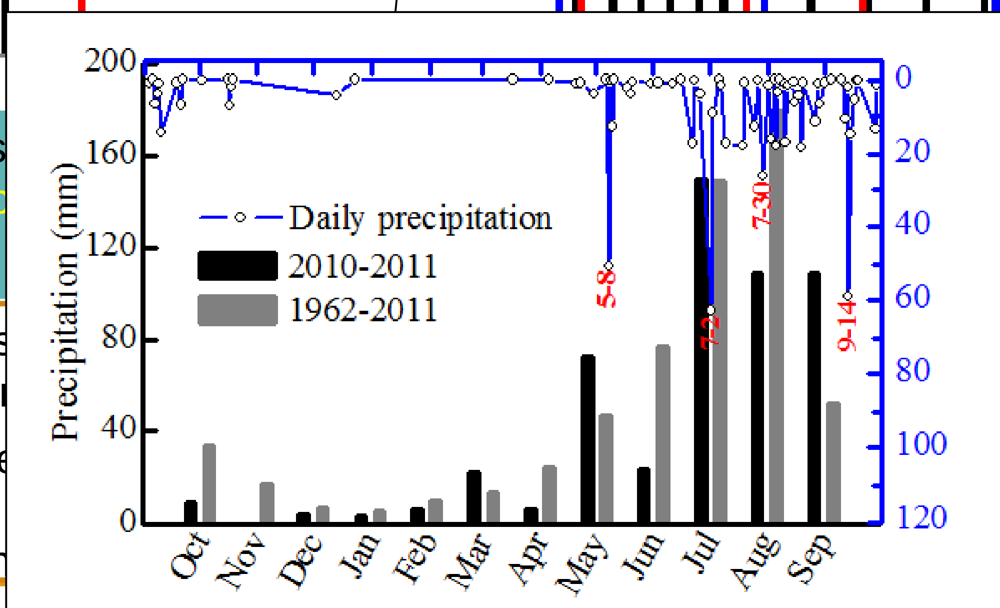
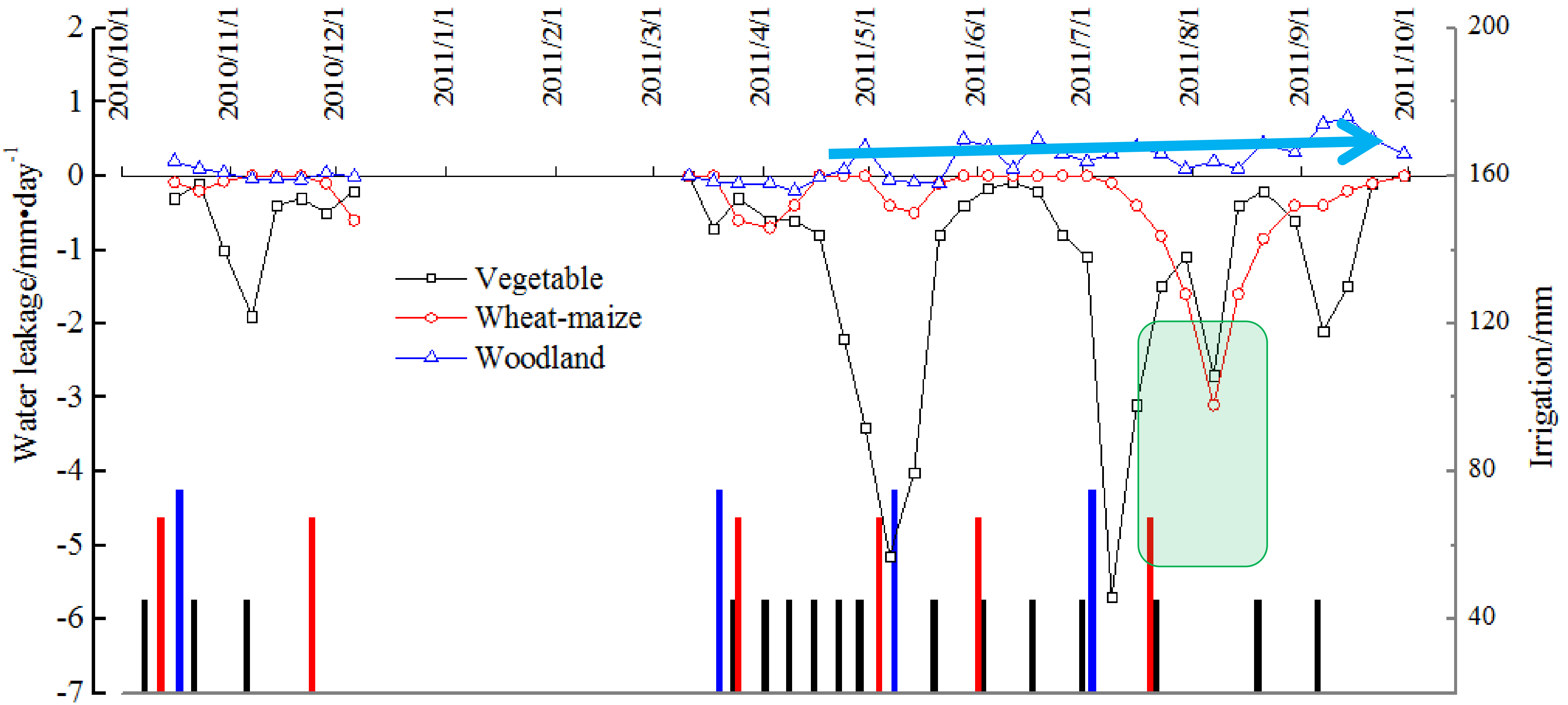


Three peaks in July, August, and September

Frequent Rainfall is the trigger.
Accompanied with high water content in the soil



Relatively heavier water drainage also occurred in wheat-maize field for irrigation and rainfall

Since late May in 2011, there had been an upward water flow trend to a certain degree.

Less irrigation and natural rainfalls couldn't provided sufficient water for poplar growth

Results

Water Balance

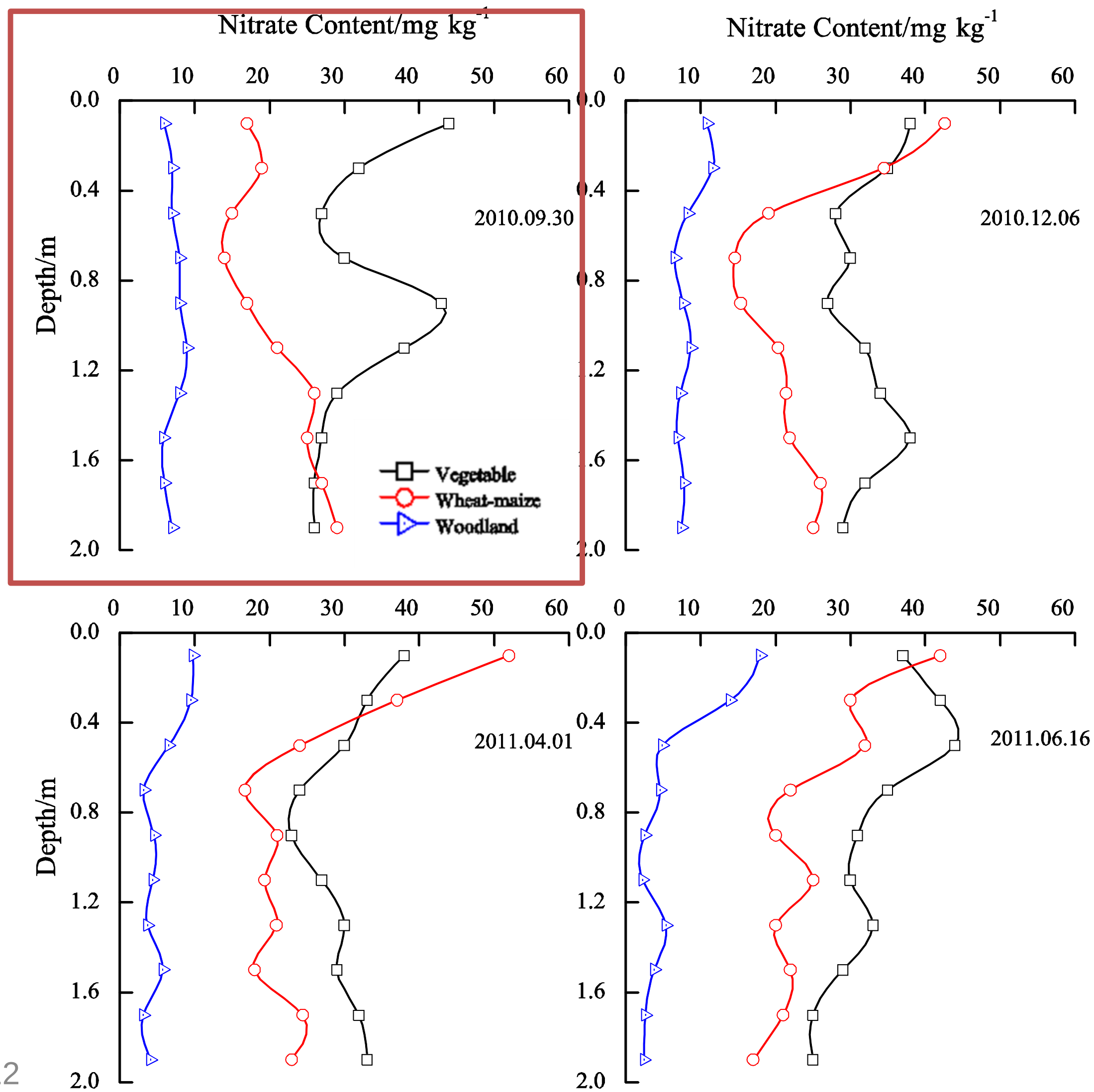
Items	*Wheat-maize field*	*Vegetable field(Leek)*	*Woodland field (Poplar)*
P (mm)	515.3	515.3	515.3
I (mm)	405	720	300
Q(T) (mm))	-93.54	-315.07	+36.3
Drainage rate (%)	10.16	25.51	--

The vegetable field:

- ✓About 25.51% of total water input leached;
- ✓3.36 times of that in the wheat-maize field.

Results

Soil Nitrate Content Distribution



beginning of the experiment

Vegetable:

1. Highest, with a peak at 1.0m;
2. N applied in Sep. not absorbed be washed down.

wheat-maize:

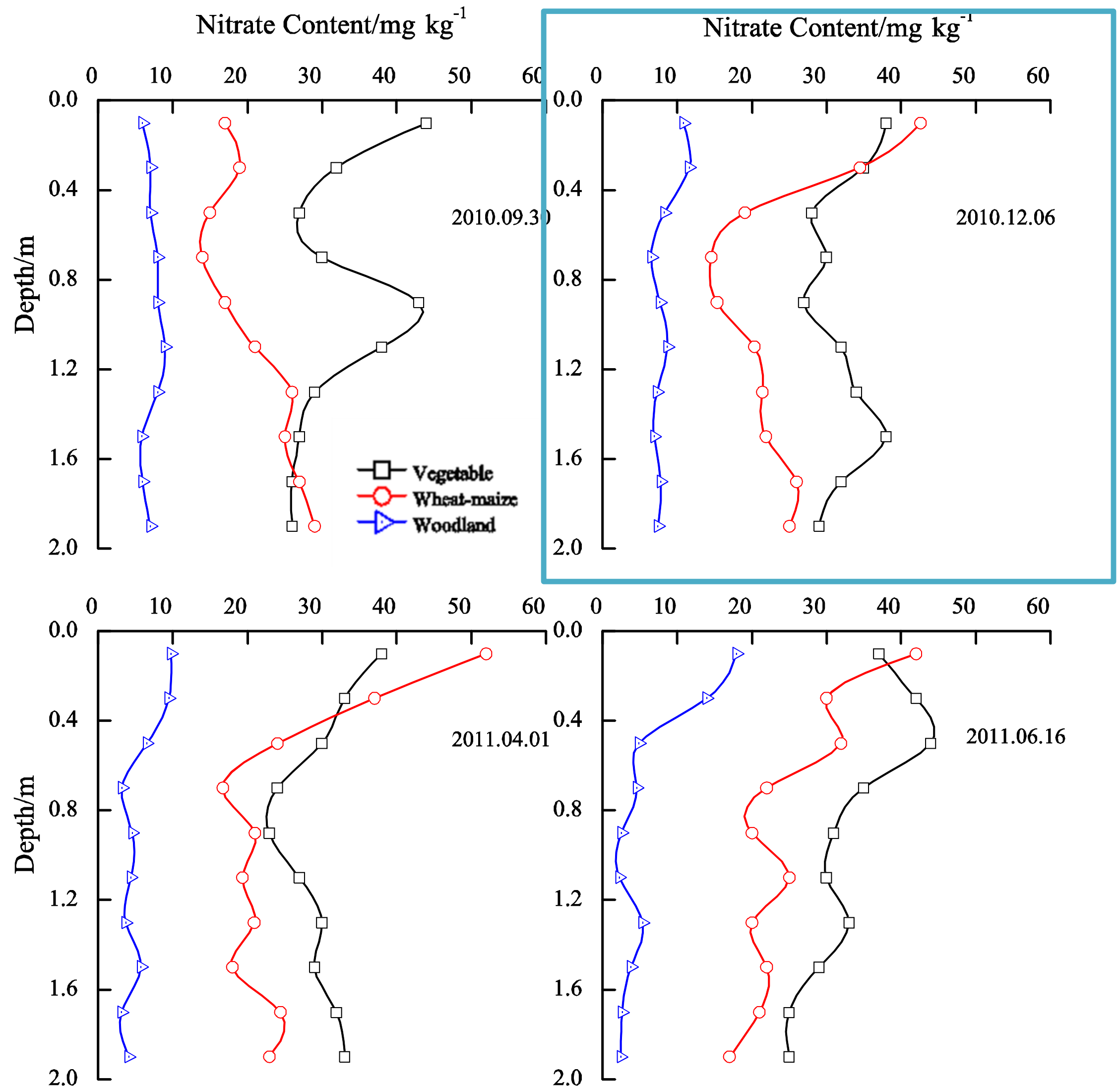
1. Gathered in the lower part of the profile
2. Season of ripening and harvesting of maize

No fertilizer applied, residual moved down

Woodland:

Almost no nitrogen had moved down for not enough nitrogen input.

Results



In Dec.

wheat-maize:

1. high nitrate content at 0-40cm depth, decreasing with depth.
2. Compound fertilizer in Oct. but less rainfall in winter.

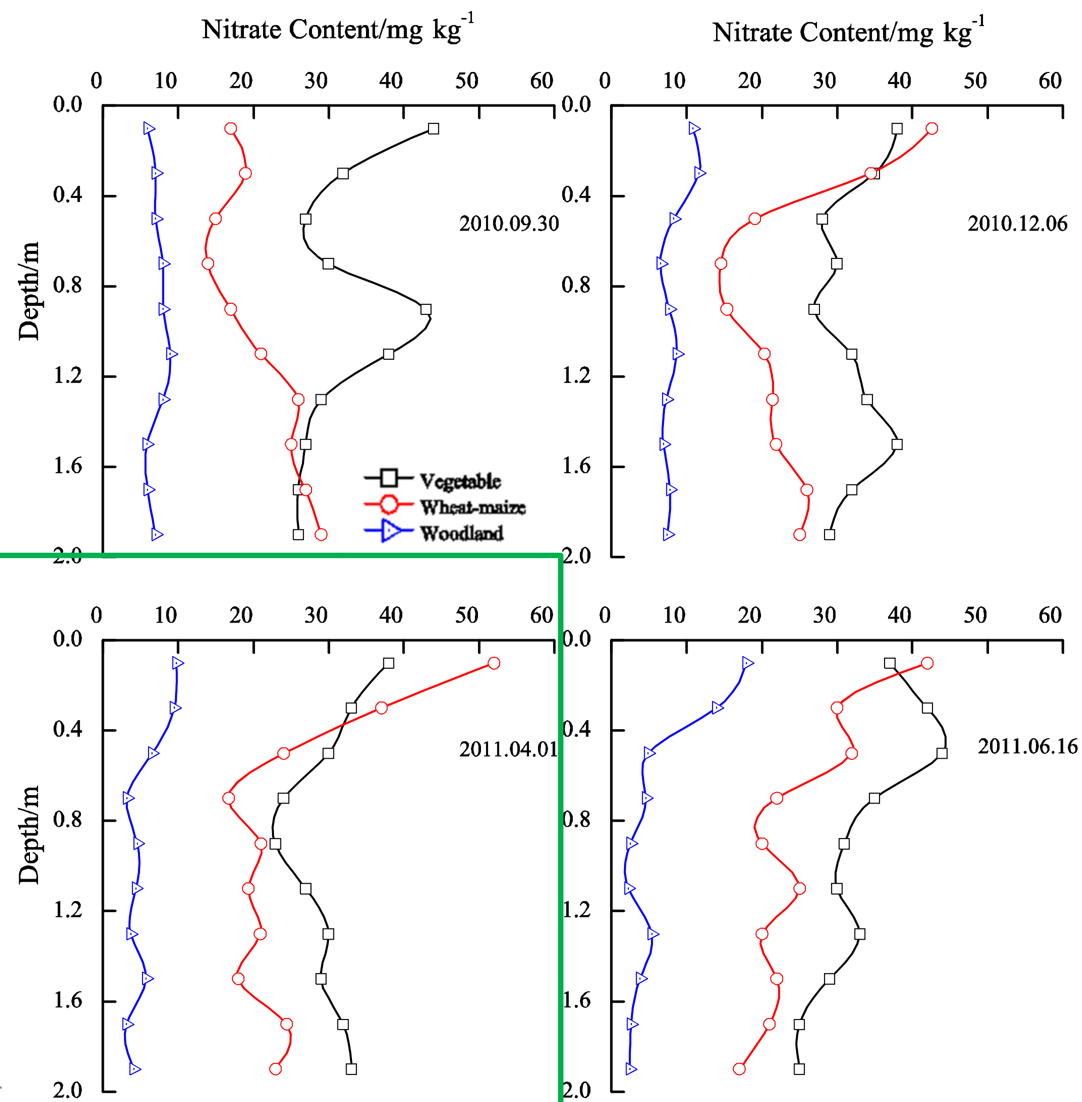
Vegetable:

1. at a high level
2. High organic manure application

Woodland:

No obvious change.

Results



In Apr.

Similar to Dec.

wheat-maize: Urea

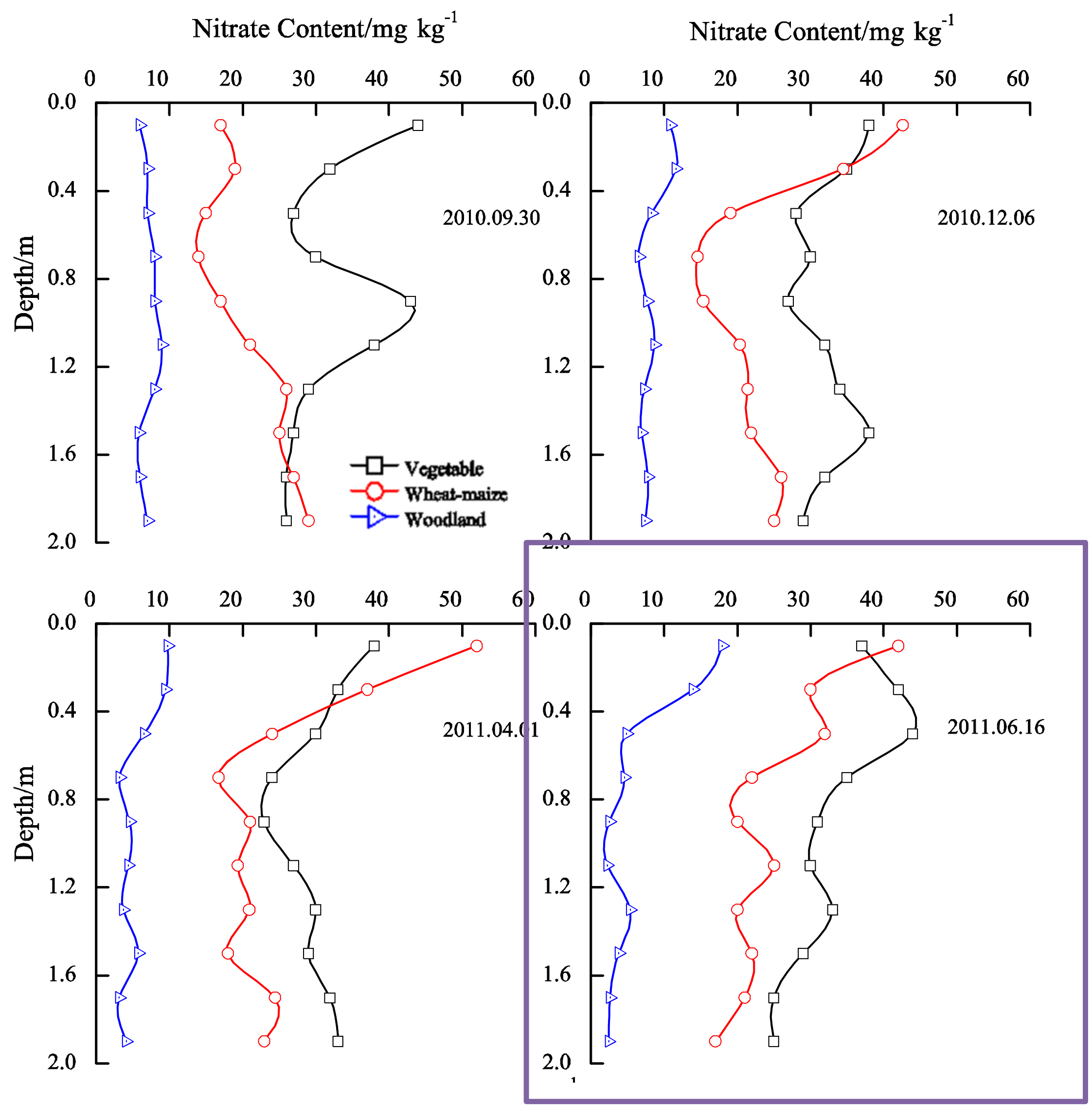
high at 0-40cm for the Urea input, and the remaining nitrate last season

Vegetable: Soybean cake

0.4-2.0m,higher than wheat-maize

much longer time for soybean cake to release N than Urea

Results

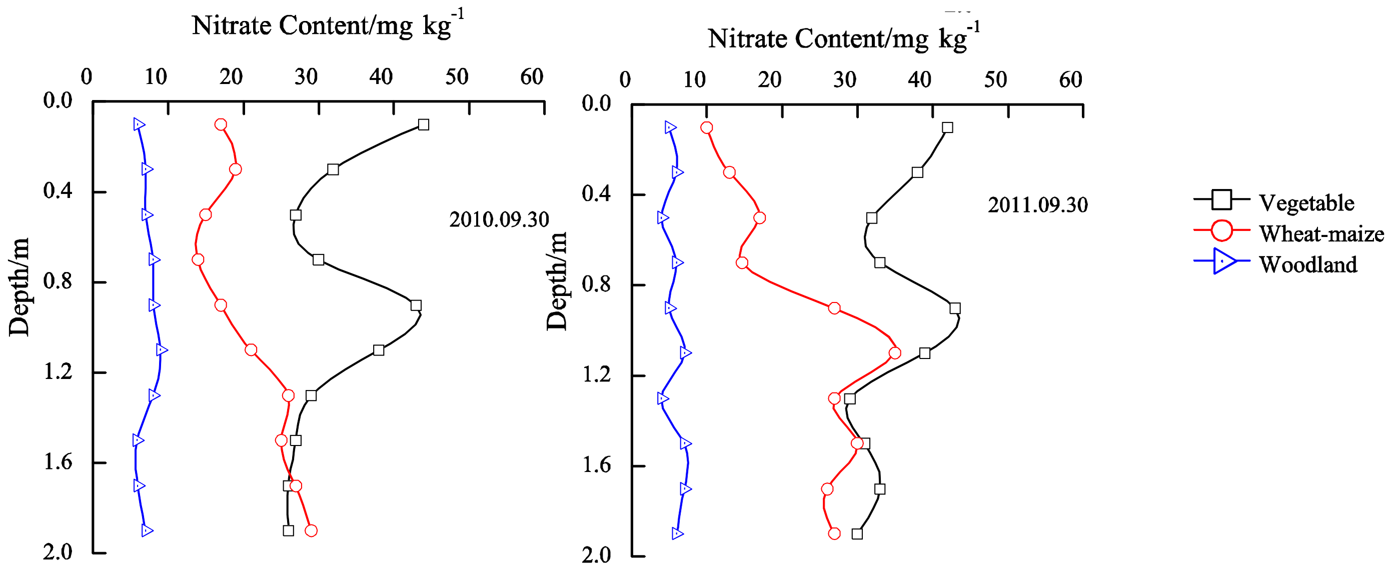


In Middle Jun.

compared to vegetable, N content in wheat-maize :
Generally lower

Woodland:
Higher in the surface layer for the fertilization event

Results

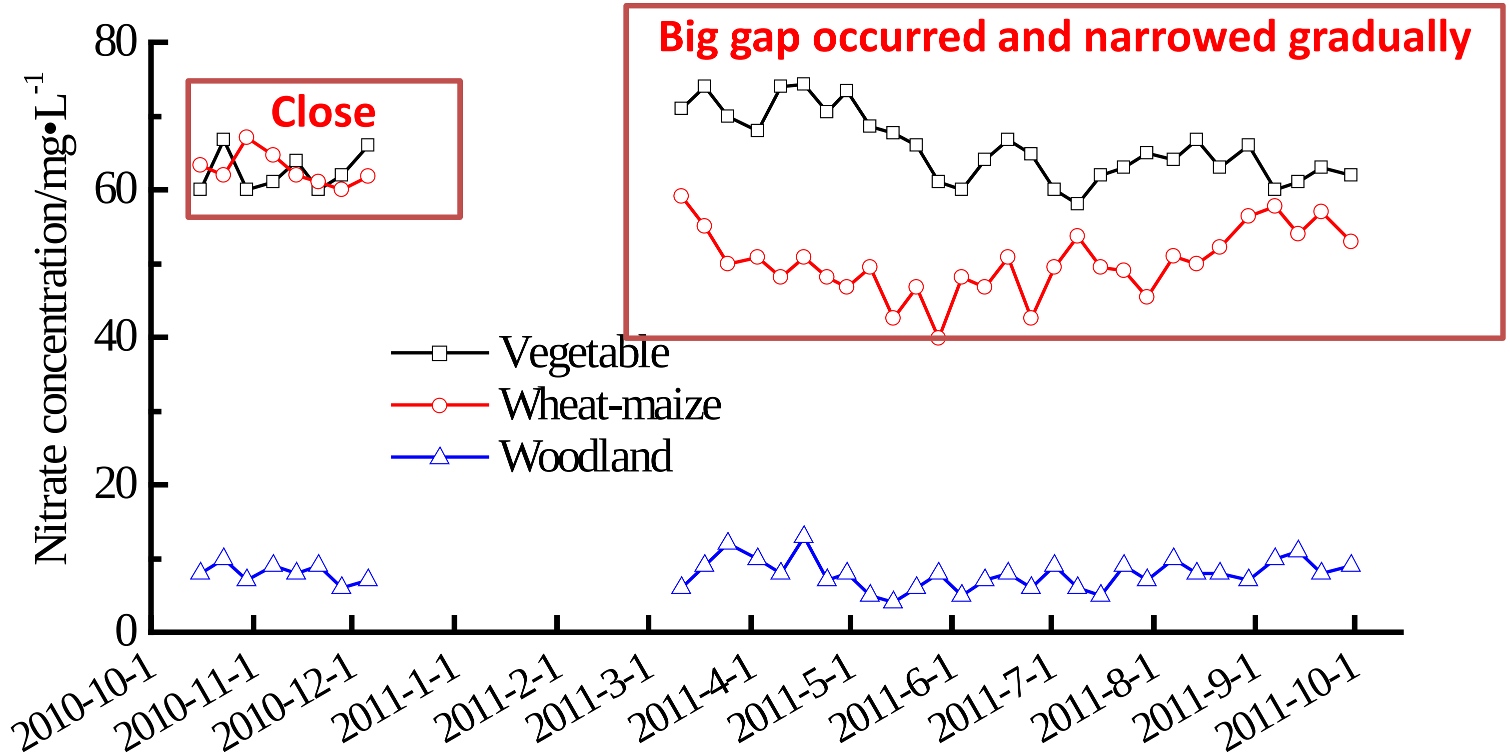


Compared to Sep., 2010
soil nitrate contents in Sep., 2011 didn't change much.

After one year, the nitrate was at a stable level in three land use types

Results

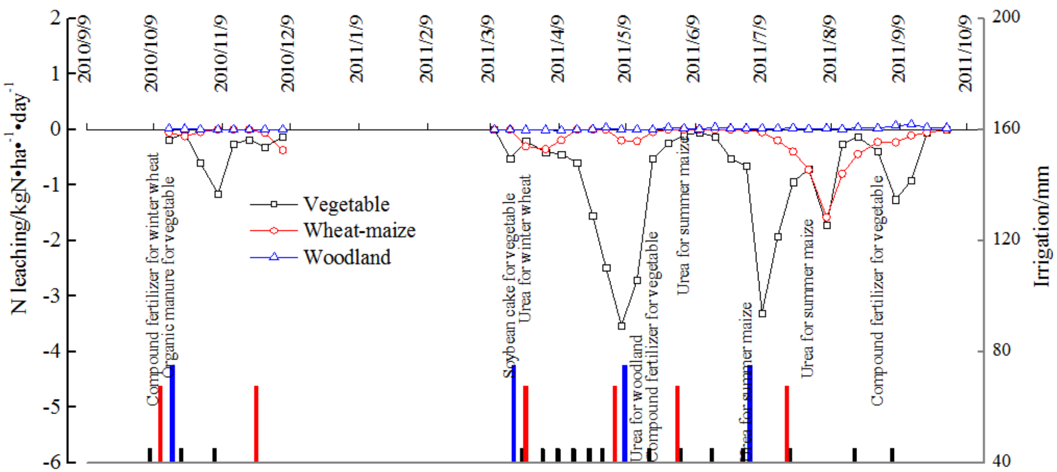
Nitrate Con. in soil solutions(2.0m)



- ✓With more water drainage, more nitrate had lost in the vegetable field.
- ✓But higher nitrogen input had made up for the loss and keep con. at a higher level.
- ✓Relatively stable N con. made N leaching only related to water drainage amounts.

Discussion

Nitrate leaching amounts



Items	*Wheat-maize feild*	*Vegetable field*	*Woodland field*
Fertilization (KgN·ha^{-1})	600	1650	140
Irrigation (KgN·ha^{-1})	23.19	39.19	12.82
Precipitation (KgN·ha^{-1})	8.93	8.93	8.93
N leaching (KgN·ha^{-1})	-47.51	-204.51	--
N leaching rate(%)	7.52	12.04	--

Discussion

- Balances of N content in the soils were achieved, though significant N leaching occurred in both the vegetable and the wheat-maize fields. **It's the experience of the famers in this region.**

- management practices like applying proper fertilizer rate would substantially reduce N leaching, but reductions on grain yield should be prevented.

- Irrigation events aggregated water drainage in vegetable fields. Also, water application to crop needs should be prompted.

- Woodland in this area would protect the groundwater from nitrate pollution. Losses in income might not be accepted.

Discussion

- To assess the relative impact of land use change on water and nitrate leaching to groundwater is also an application of SWAT.

- Our experiments and results might be a validation for results of the modeling method, which is relatively complicated in deriving parameters and data collection.

Conclusion

- The total water drainage amount of the vegetable field was 2.36 times higher than that of the wheat-maize field

- Reversely, an upward moving trend of water in the soil was observed in the woodland for less water input.

- Soil N contents kept stable in the three fields. Considering the losses from leaching, practices that adjust water application to crop needs and improved fertilizer management should be promoted.

- Effects on groundwater contamination:

  Vegetable> maize-wheat >woodland

Thank you for the attention!