中国农业科学院农业资源与农业区划研究所

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Effect of acidification on potassium availability in red soil

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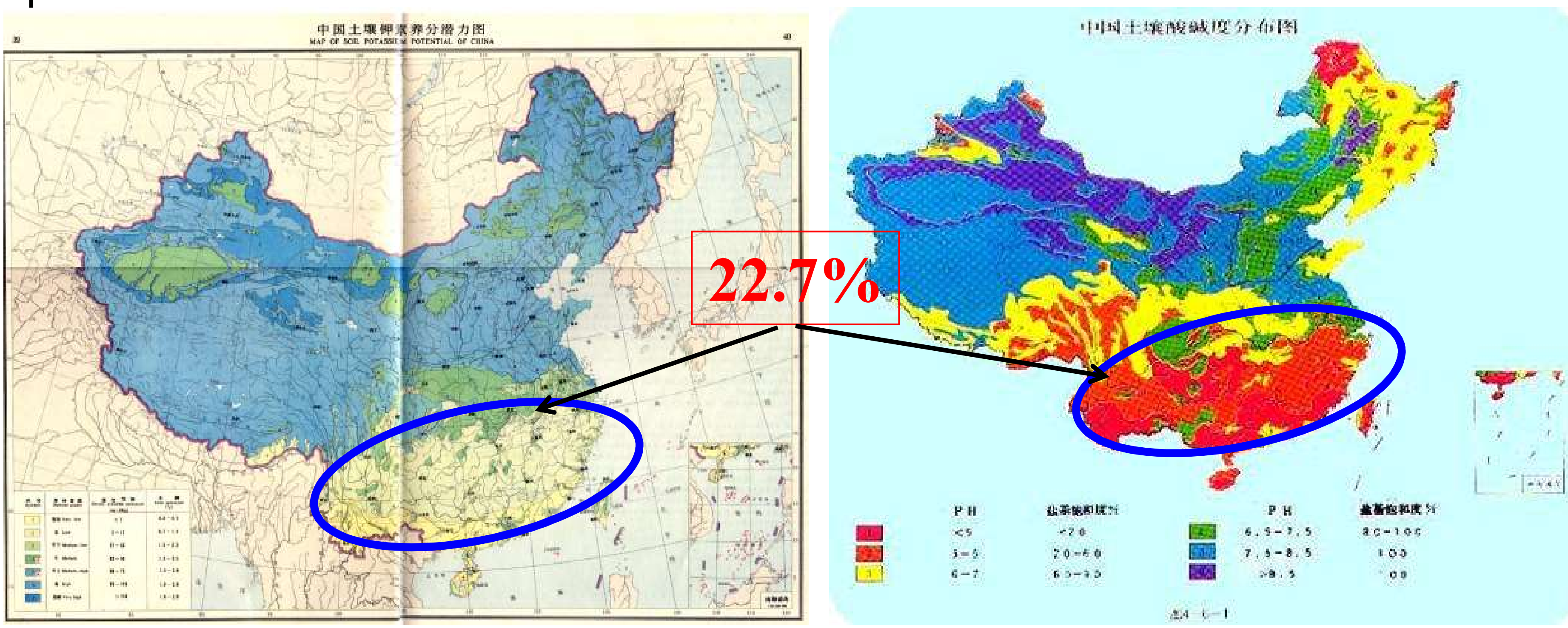
Outline

1. Background
2. Research contents
3. Main results
4. Main conclusion
5. Further research

1. Background

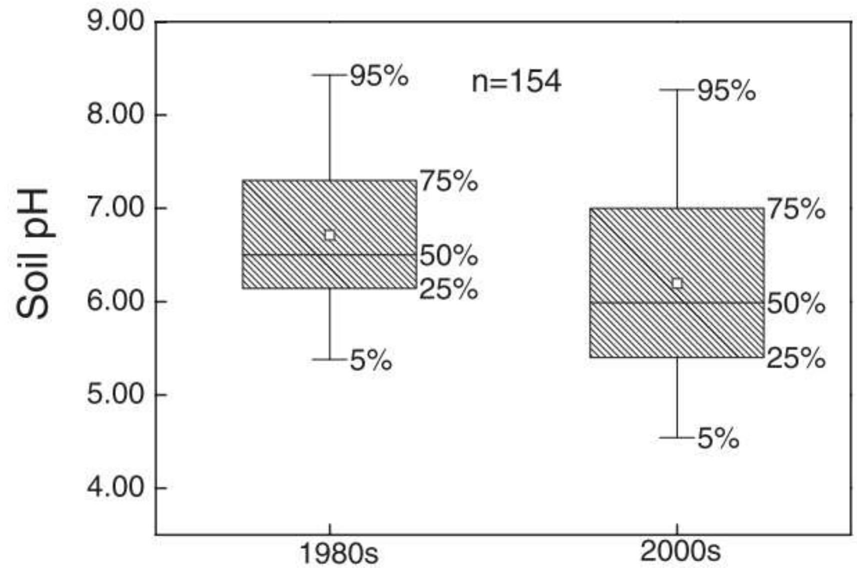
Distribution of soil potassium supply potential in China

Distribution of soil pH in China



Low soil K supply potential in South China

Soil severe acidification in this region could result the soil potassium more deficiency



(Guo et al., 2010)

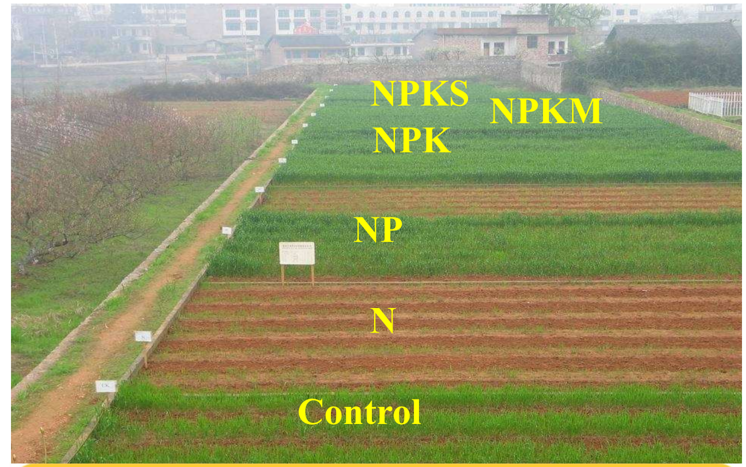
Most soil pH was lower 5.5 in red region (Xu et al., 2016)

To research how effectively improve potassium availability in red acidic soil become more and more improtant.

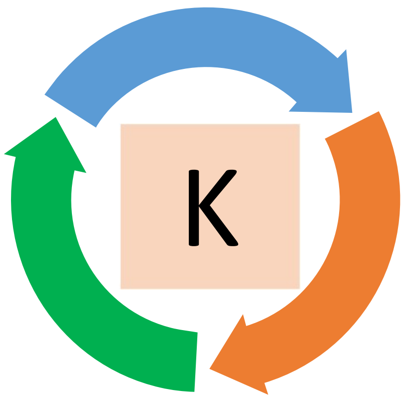
2. Research contents

Monitoring data of the Ministry of Agriculture and Rural Affairs

Relationship between soil K and pH

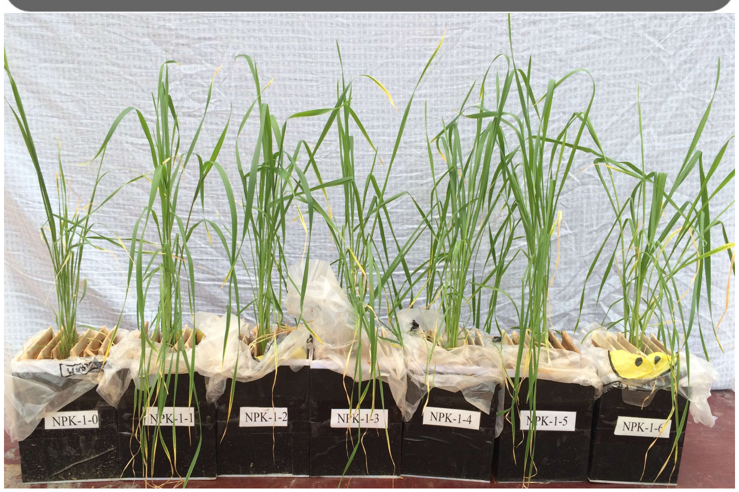


Long-term fertilization experiment



pH → aggregate K, K uptake

Lime → K uptake, rhizoshphere K



Pot + Incubation

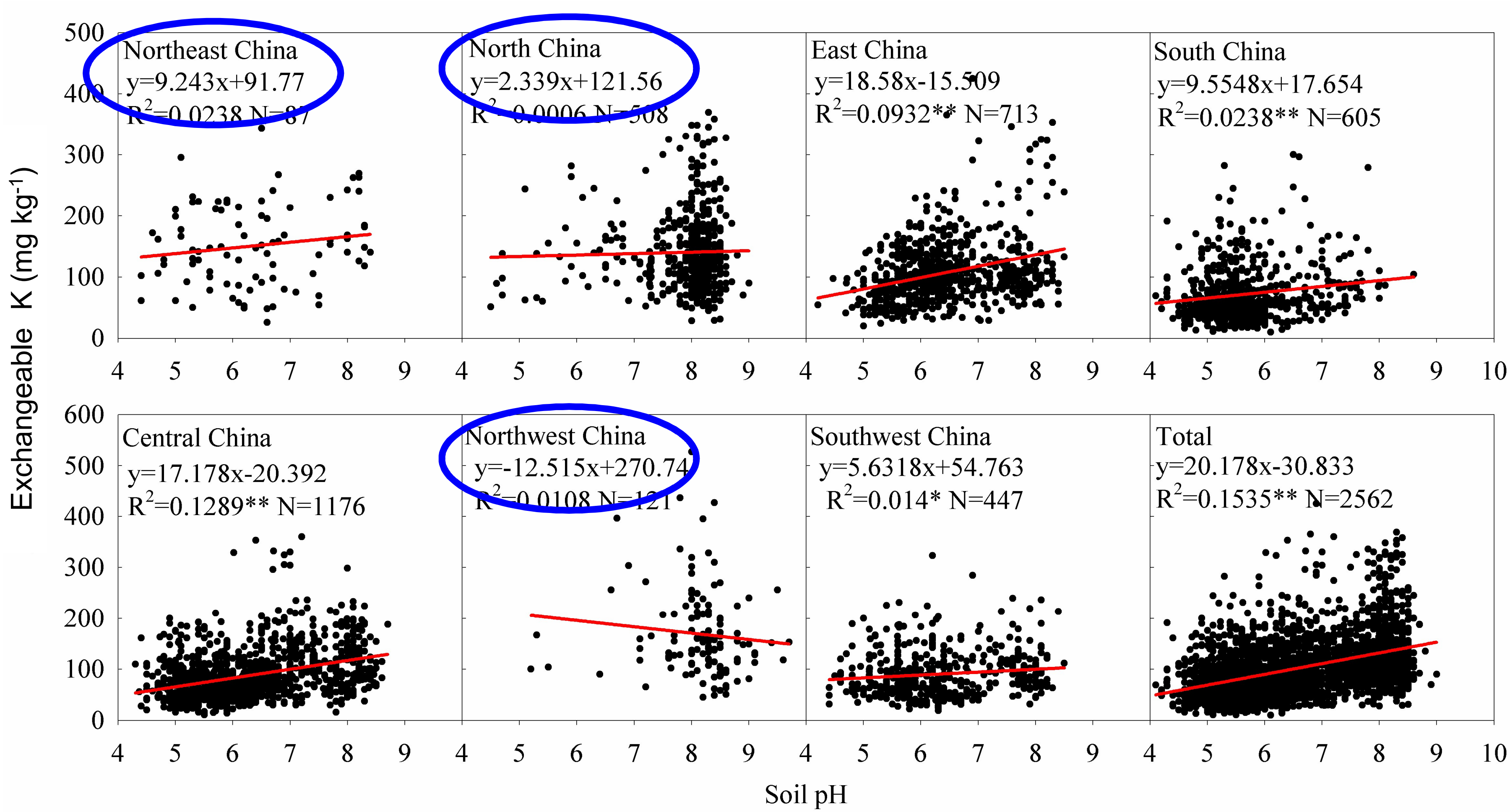
3. Main results

- Relationship between soil pH and K in main farmland of China;
- Response of soil and aggregate K to long-term fertilization in red acidic soil;
- Changes of soil aggregates-K under different pH levels in red acidic soil;
- The K availability in rhizosphere and non rhizosphere after lime added.

3.1 Relationship between soil pH and exchangeable K

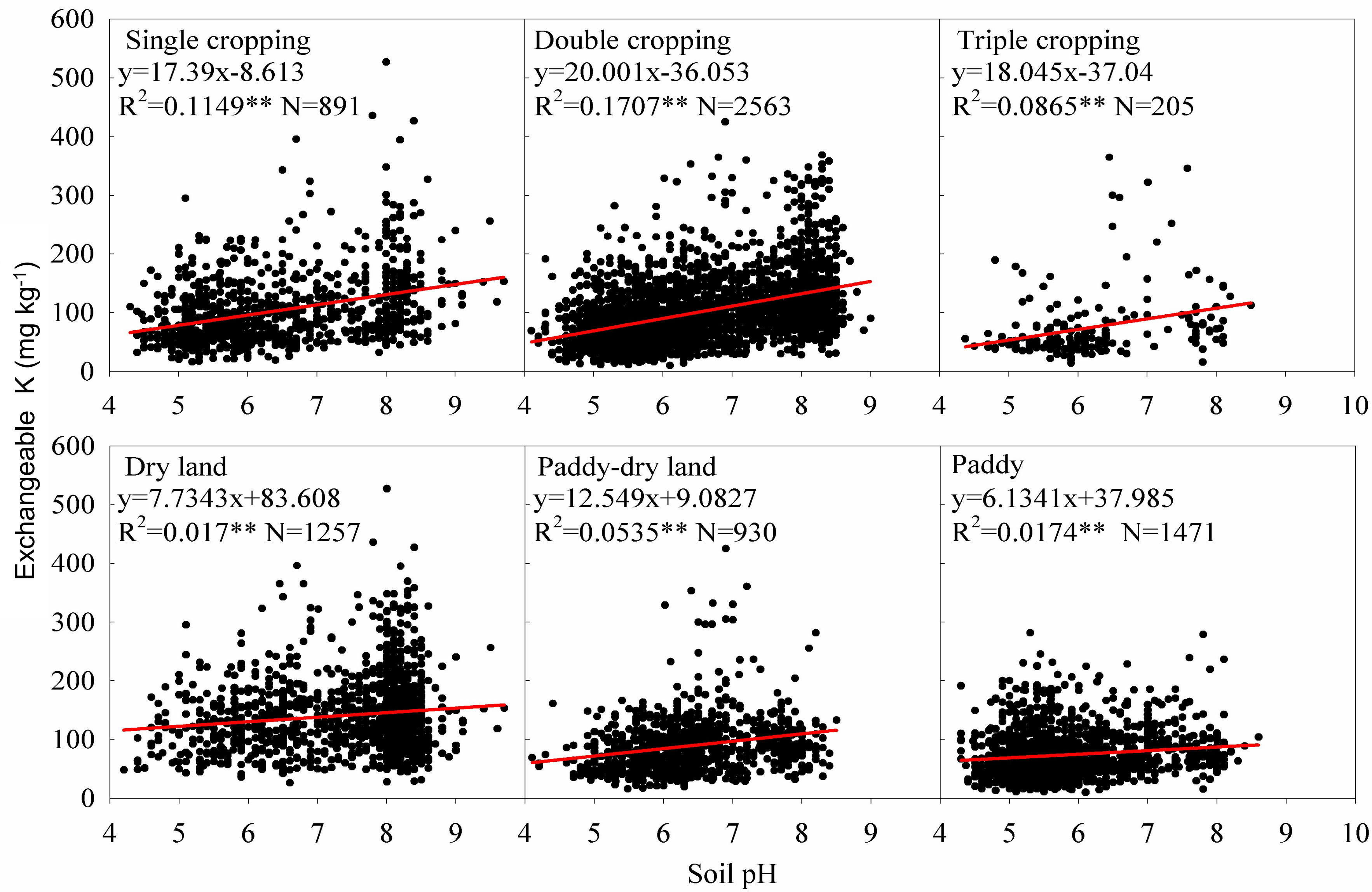
-------Different regions

The data was obtained from Ministry of Agriculture and Rural Affairs (850 sites)



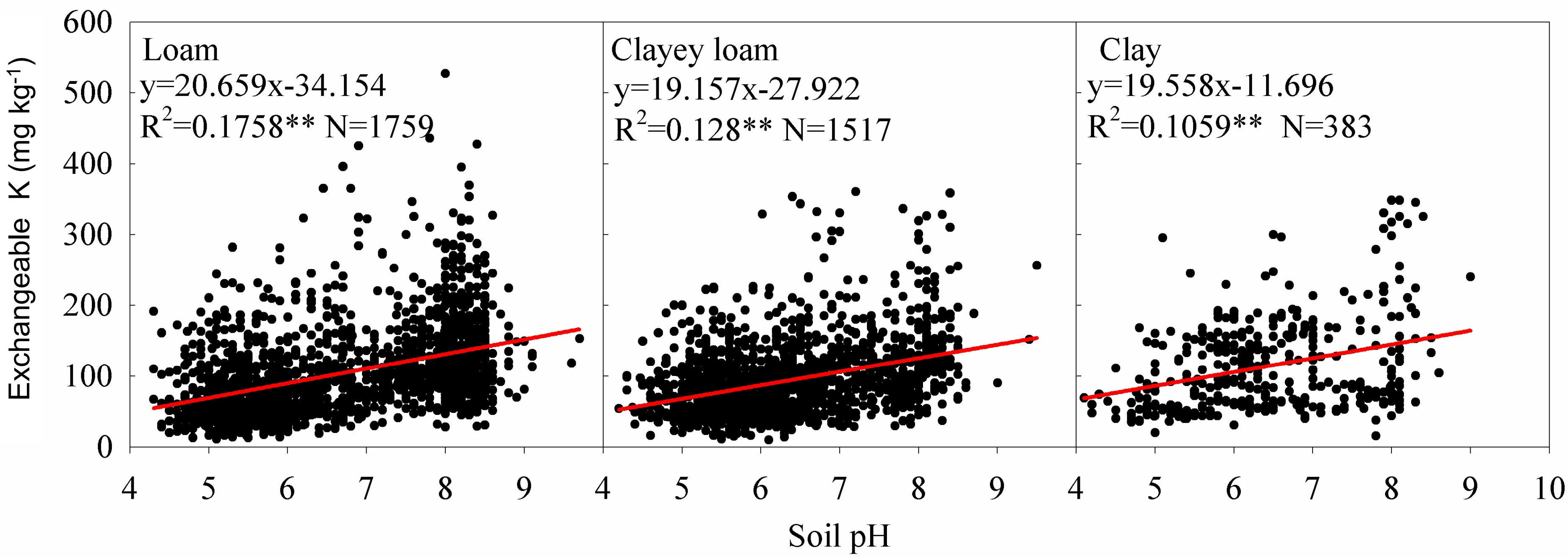
Except North China, soil pH and EK were significant positive correlated.

Different cropping systems and land use types



Soil pH and EK were significantly positive correlated under different cropping systems and land use types.

Different soil textures

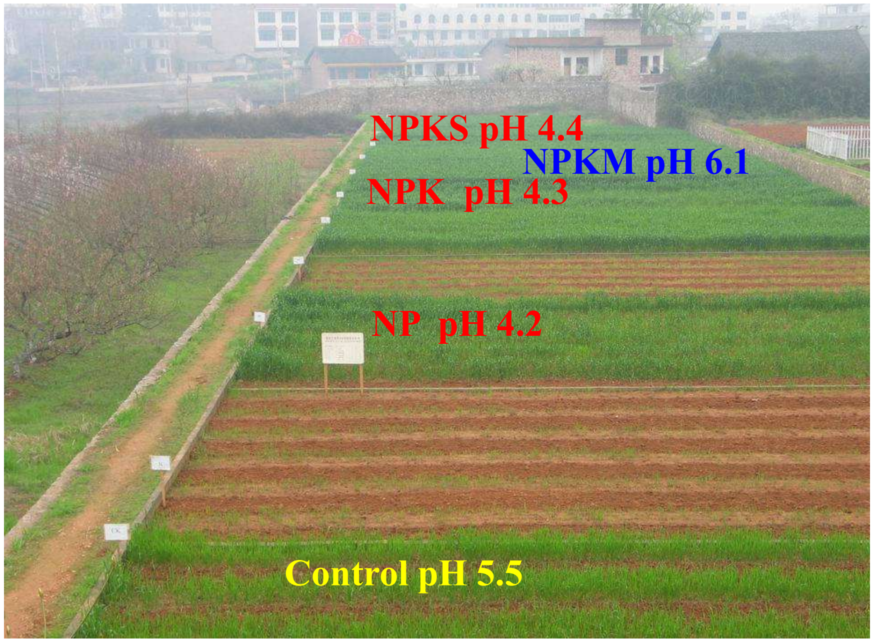


Soil pH and EK were significantly positive correlated under different soil textures.

Unpublished

3.2 Response of soil aggregate K to long-term fertilization under acidification

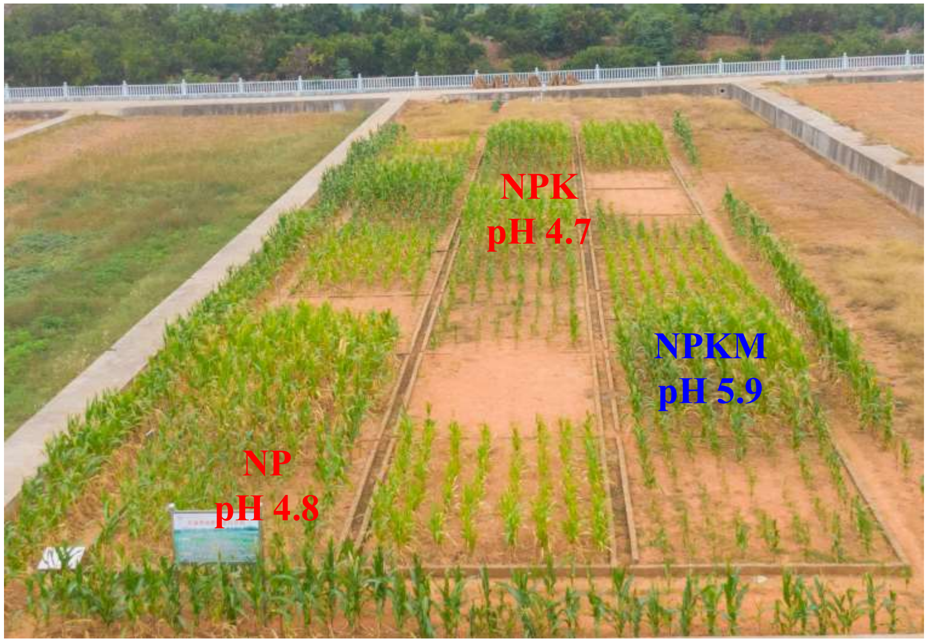
Qiyang (1990)



Wheat-maize

E:111.88°, N:26.75°

Jinxian (1986)

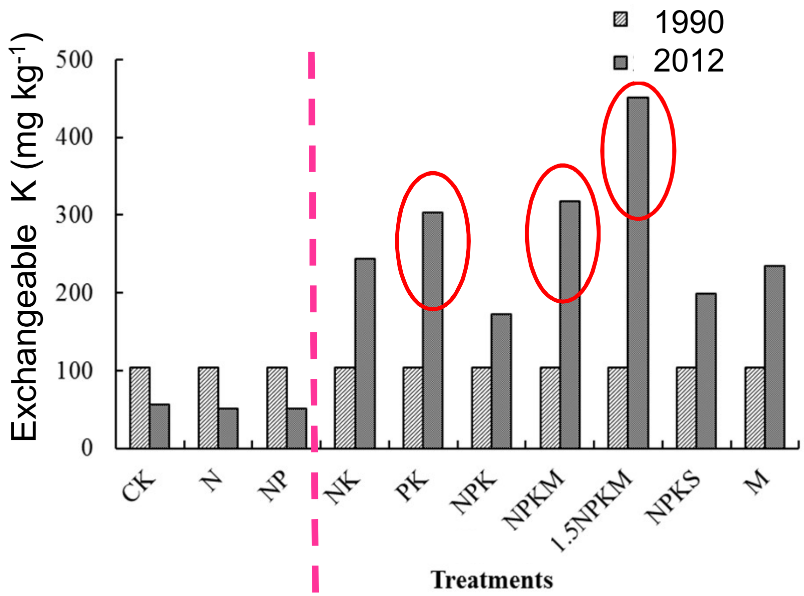


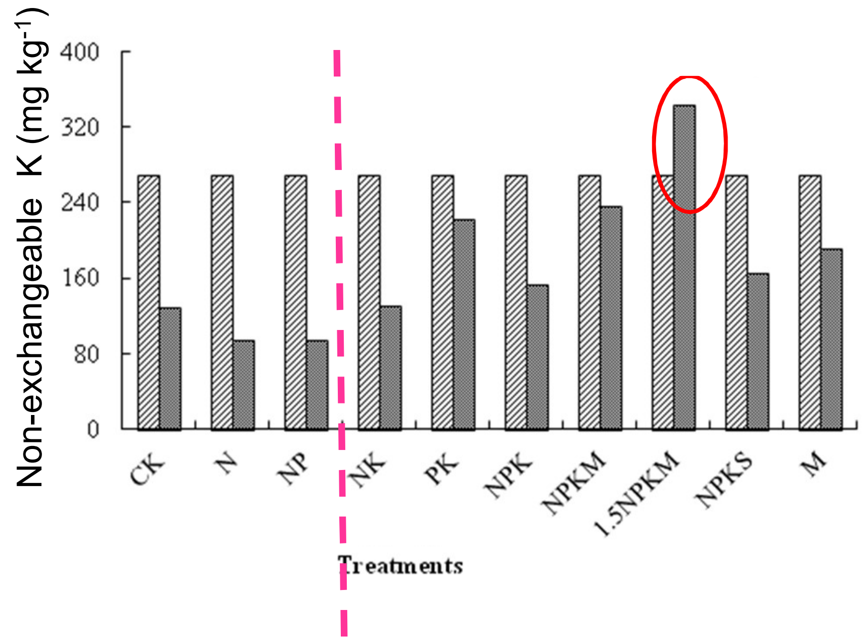
Maize-maize

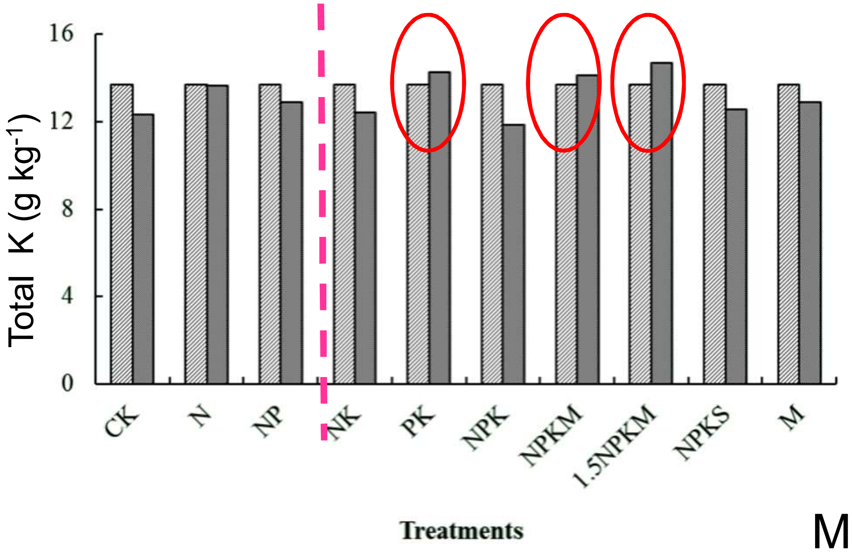
E:116.30°, N:28.59°

Significant differences in soil productivity and fertility under different fertilization

3.2.1 The K content in red soil of long-term fertilization —Qiyang





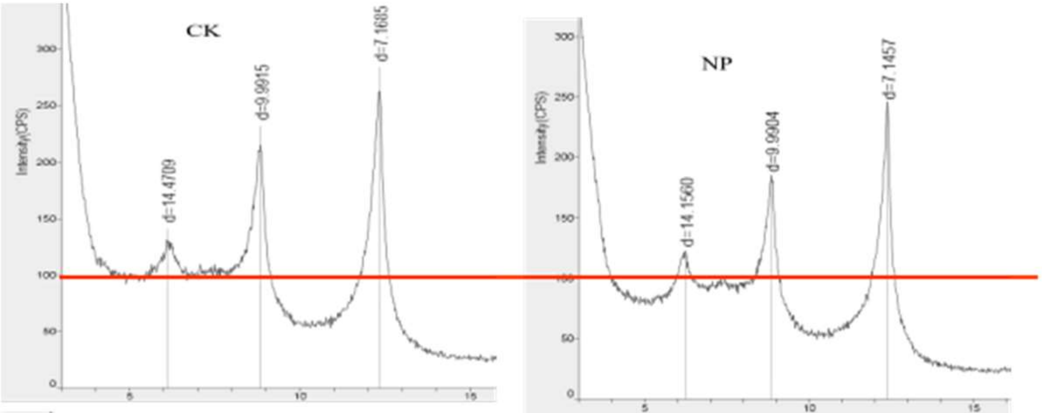


After 22 years, the EK was increased significantly with K input than without K, especially in chemical K fertilizer plus manure.

M: pig manure; S: straw

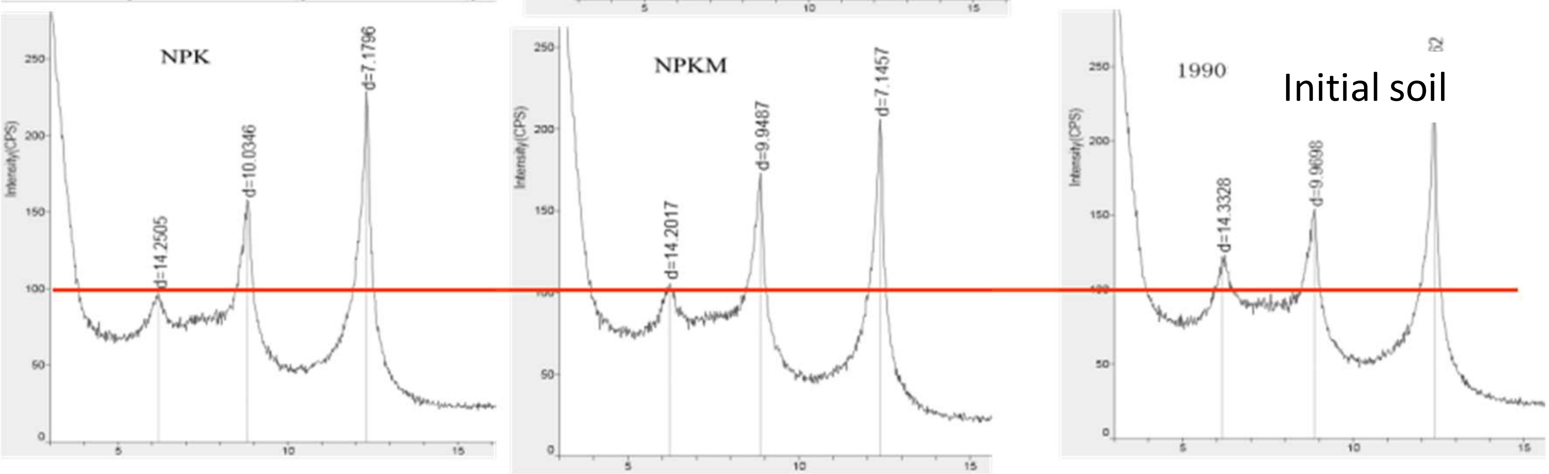
3.2.2 The K-bearing mineral composition in red soil of long-term fertilization—Qiyang

X-ray diffraction patters of clay after 22 years fertilization



NP

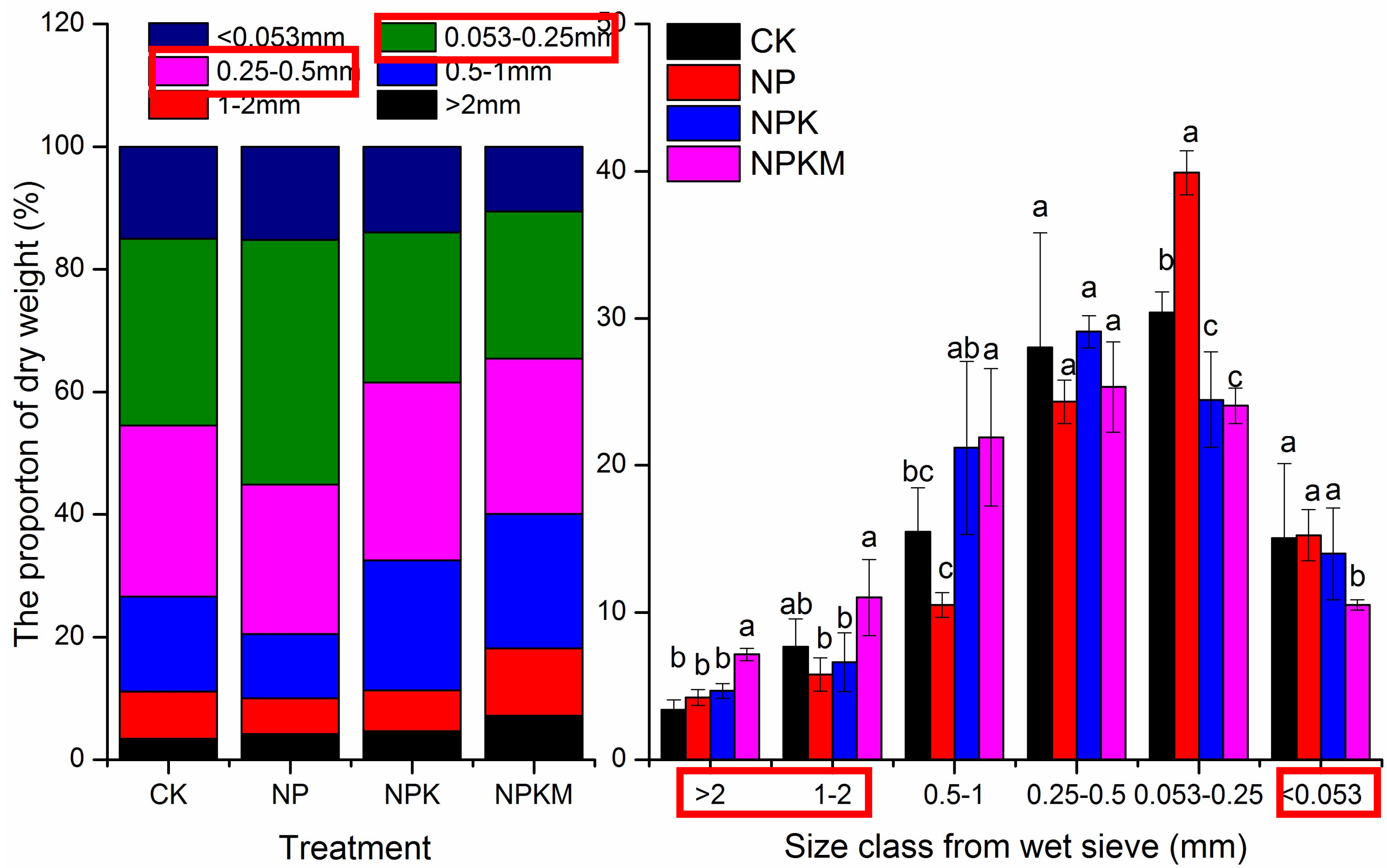
Mica (2:1) content decreased by 22.90 g kg^{-1} and 1.4nm transition mineral increased by 1.27 g kg^{-1}



Mica content increased by 28.79 g kg^{-1} and 1.4nm transition mineral decreased by 14.87 g kg^{-1}

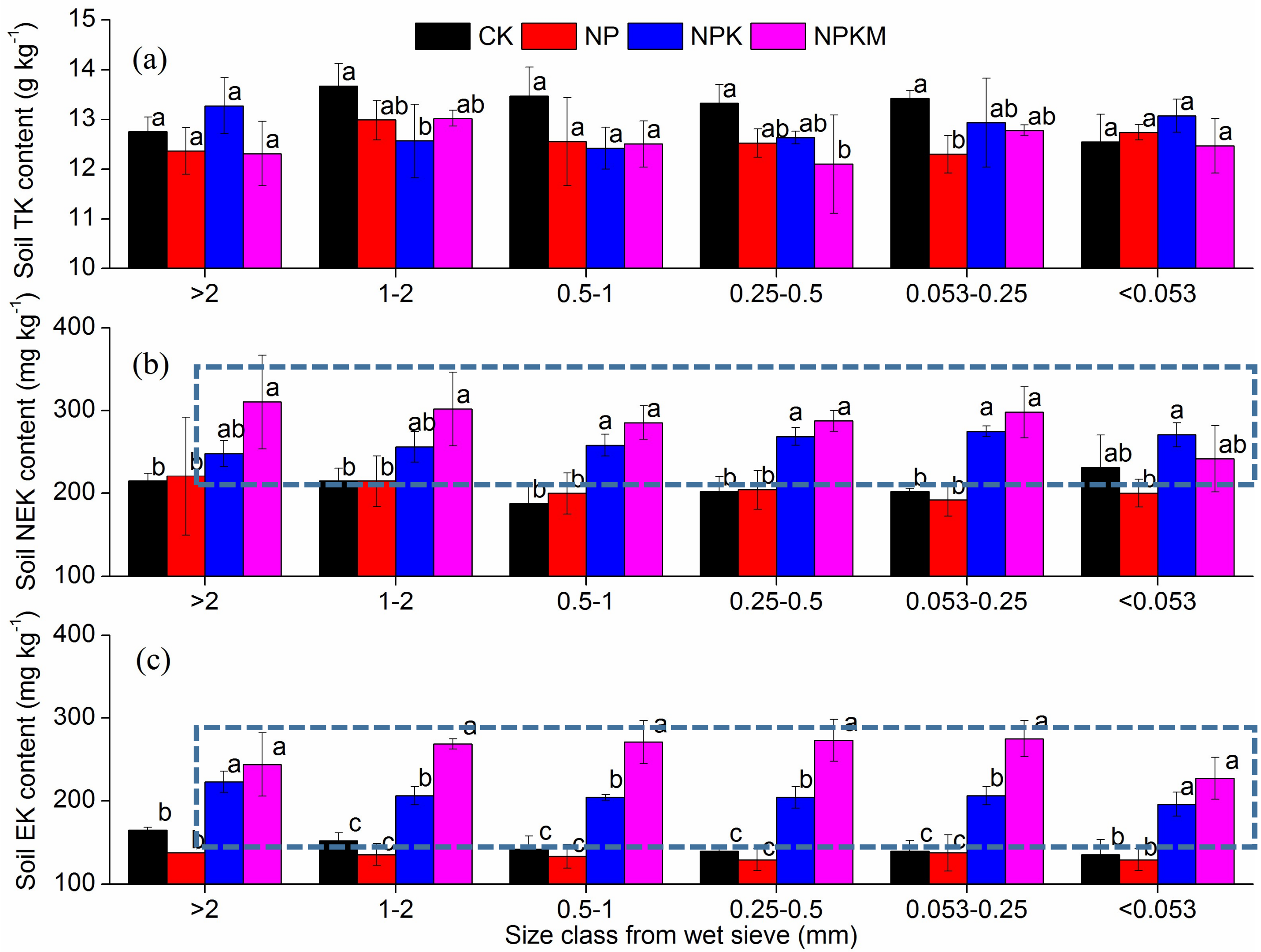
NPK and NPKM

3.2.3 The aggregate fraction under long-term fertilization —Jinxian



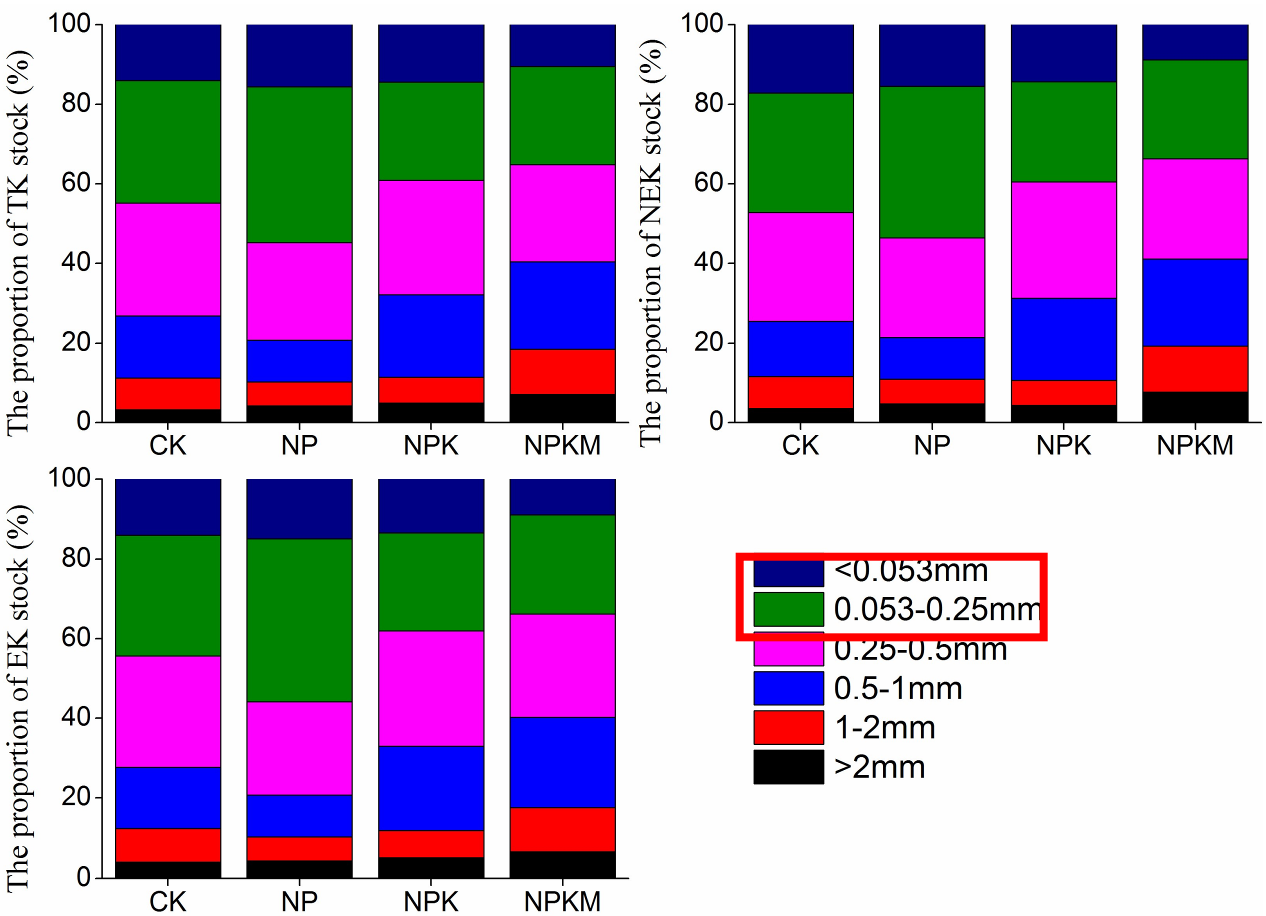
Compared with CK treatment, NPKM treatment increased the proportion of > 2mm and 1-2mm by 110.73% and 41.63%, respectively. The ratio of 0.053-0.25 mm and < 0.053 mm decreased by 20.80% and 30.16%, respectively.

3.2.4 The aggregate-K content under long-term fertilization —Jinxian



The EK and NEK content of NPKM and NPK in all fractions were significantly higher than those of NP and CK.

3.2.4 The aggregate-K stock in red soil of long-term fertilization—Jinxian



TK stocks

> 0.5 mm   < 0.25 mm

NPKM vs NP

NEK stocks

> 0.053 mm   < 0.053 mm

NPKM vs NP

EK stocks

> 0.053 mm   < 0.053 mm

NPKM vs NP

NPKM decreased TK, NEK, and EK stock in micro-aggregates

3.2.5 K uptake by maize—Jinxian

Treatments	K uptake by maize kg hm^{-2}			
	Grain	Straw	Corncob	Sum
CK	1.74±0.13b	8.83±1.32c	1.83±0.49b	12.39±1.36c
NP	6.10±3.48b	22.56±3.70c	4.20±2.32b	32.86±9.45bc
NPK	7.87±3.09b	43.43±13.46b	6.77±1.27b	58.08±17.20b
NPKM	**50.20±6.73a**	**143.86±23.22a**	**23.05±7.21 a**	**217.11±35.67a**

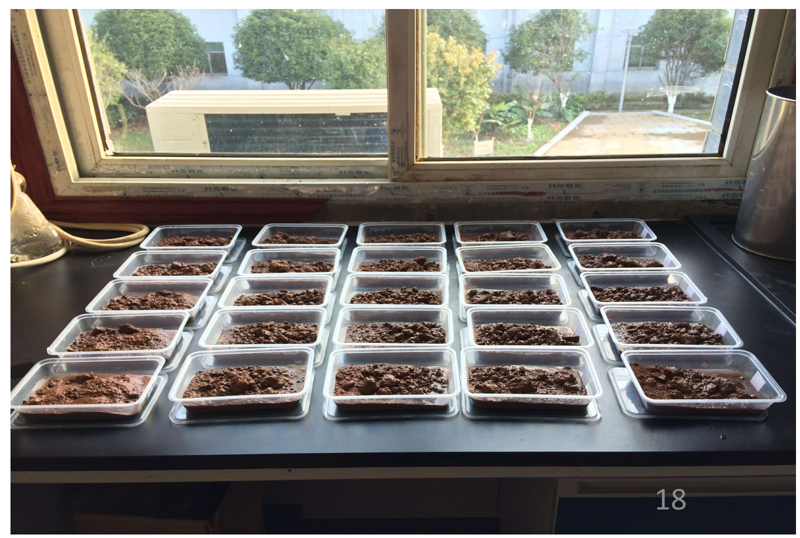
K fertilizer input significantly increased the K uptake by maize compared with that without K, especially chemical K fertilizer plus manure.

3.2.7 The relationship between K uptake and soil aggregate-K stock—Jinxian

Soil aggregates	Soil TK stock		Soil NEK stock		Soil EK stock	
	R^2	p	R^2	p	R^2	p
>2mm	**0.7926**	**1.04E-04**	**0.8859**	**5.00E-06**	**0.8803**	**6.37E-06**
1-2mm	0.4574	0.01574	0.6795	9.74E-04	0.7867	1.20E-04
0.5-1mm	0.3415	0.046	0.5539	0.0055	0.6931	7.77E-04
0.25-0.5mm	0.0945	0.33099	0.2768	0.07891	0.5993	0.00312
0.053-0.25mm	0.2676	0.085	0.0422	0.52188	0.5118	0.0089
<0.053mm	0.2872	0.07253	0.1059	0.30192	0.1357	0.23864

Liu et al., Geoderma, 2019; Liu et al., Acta Pedologica Sinica, 2018 (in Chinese).

3.3 Changes of soil aggregates-K under different pH levels —Jinxian



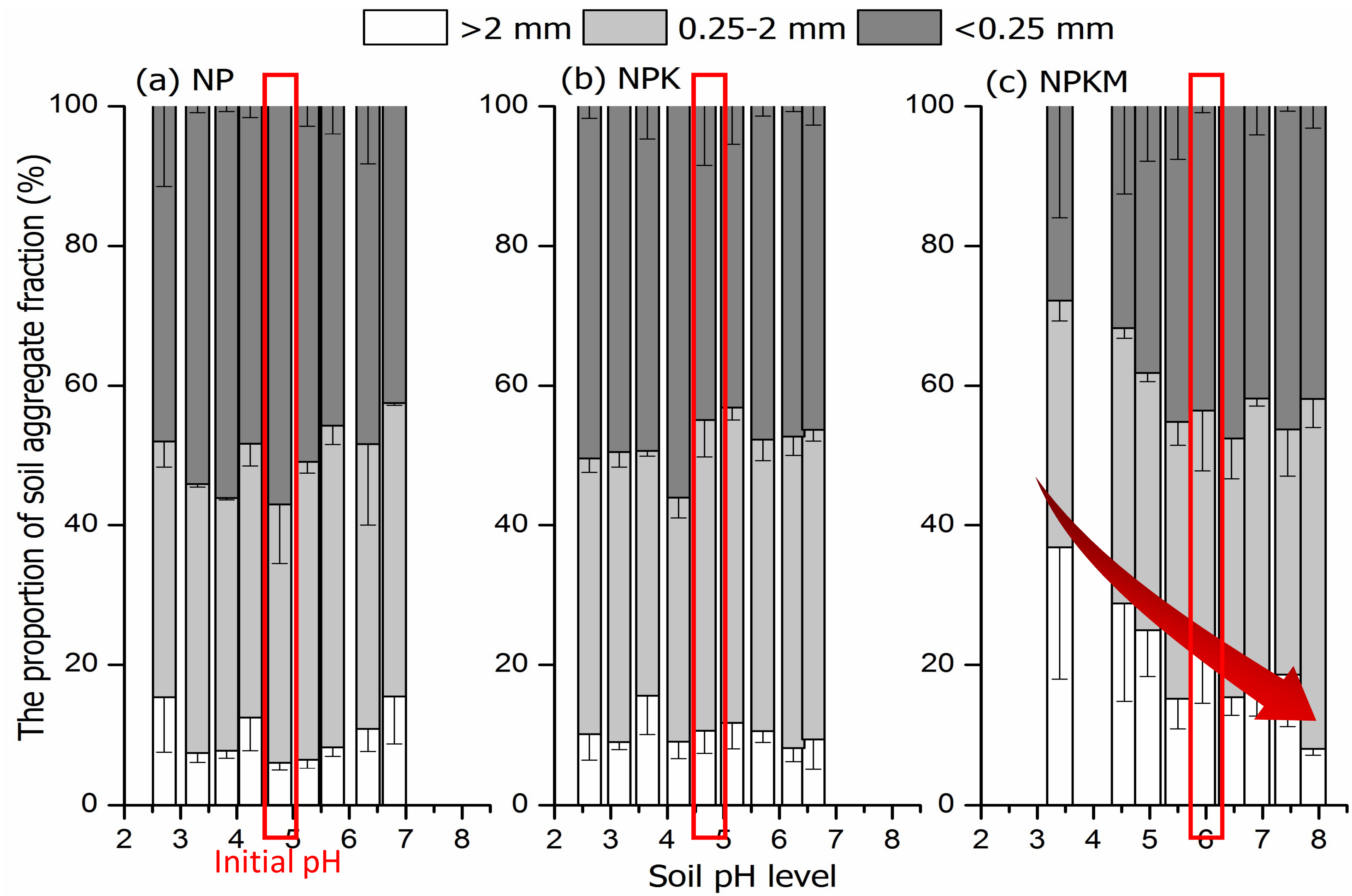
NP, NPK, NPKM

Increase pH: HCl; decrease pH: $Ca(OH)_2$

pH levels: Initial pH, ±0.5, ±1, ±1.5, ±2

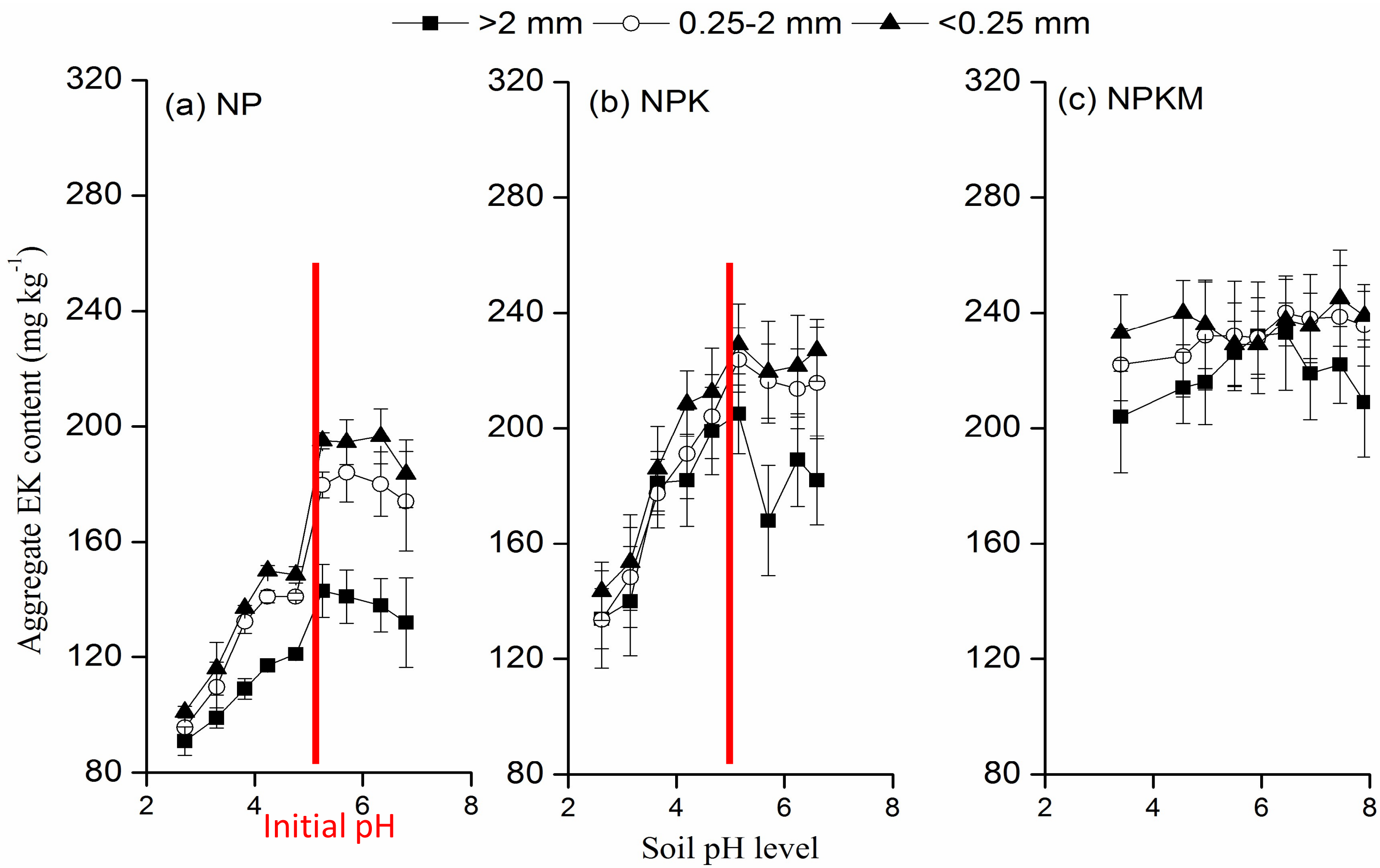
Incubation time: 90 days

3.3.1 Changes of soil aggregates under different pH levels



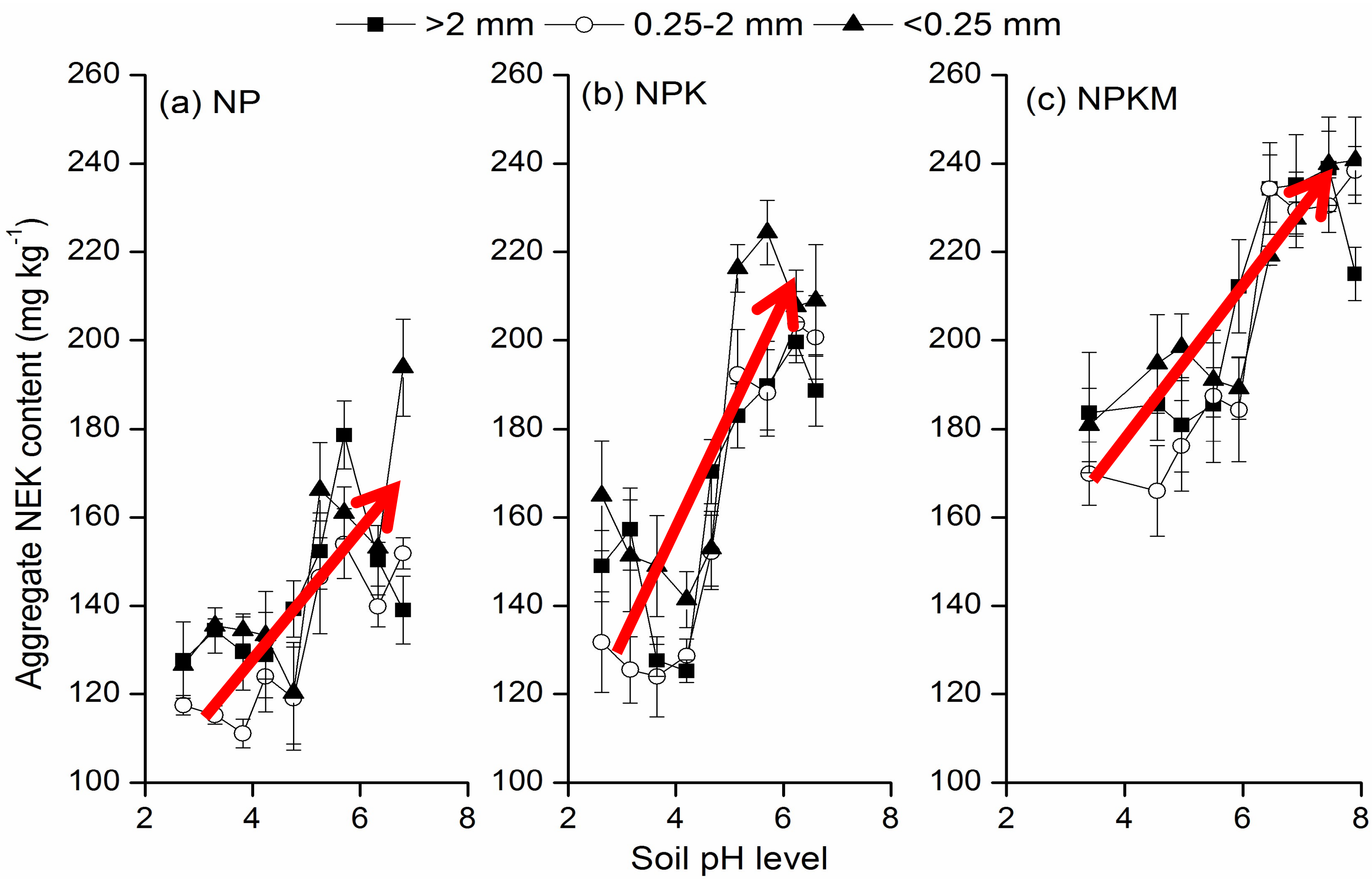
The proportion of >2 mm aggregates in NPKM soil was higher than in NP and NPK soils for most pH levels, and decrease with the soil pH increasing.

3.3.2 Changes of soil aggregates-EK content under different pH levels

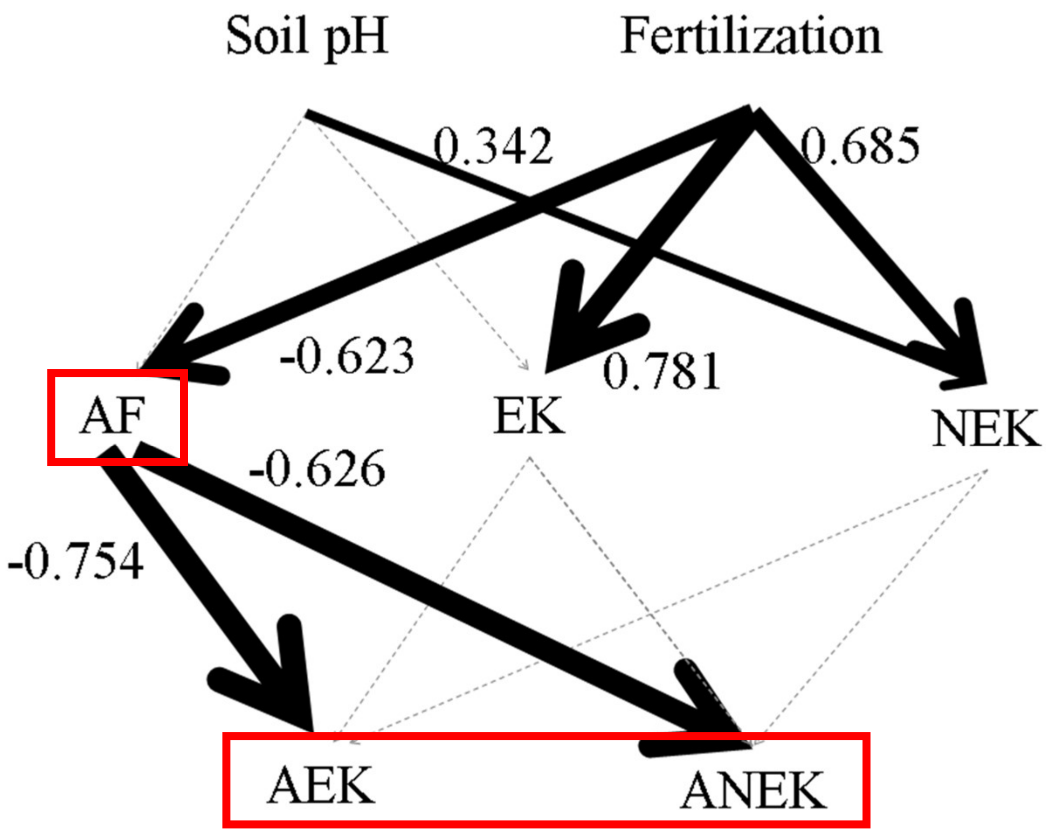


For NP and NPK soils, the aggregate EK contents decreased gradually along with soil pH decreasing when soil pH was lower than initial pH.

3.3.3 Changes of soil aggregates-NEK content under different pH levels



The NEK contents increased gradually along with soil pH increasing in all fraction



The PLS-PM (partial least squares path model) analysis showed that the soil aggregates fraction (AF) had important directly effects on the stock of EK and NEK (path coefficients were -0.754 and -0.626, respectively)

Liu et al., Soil and Tillage Research (Accepted)

3.4 The K availability in rhizosphere and non rhizosphere of crops under different lime levels—Qiyang

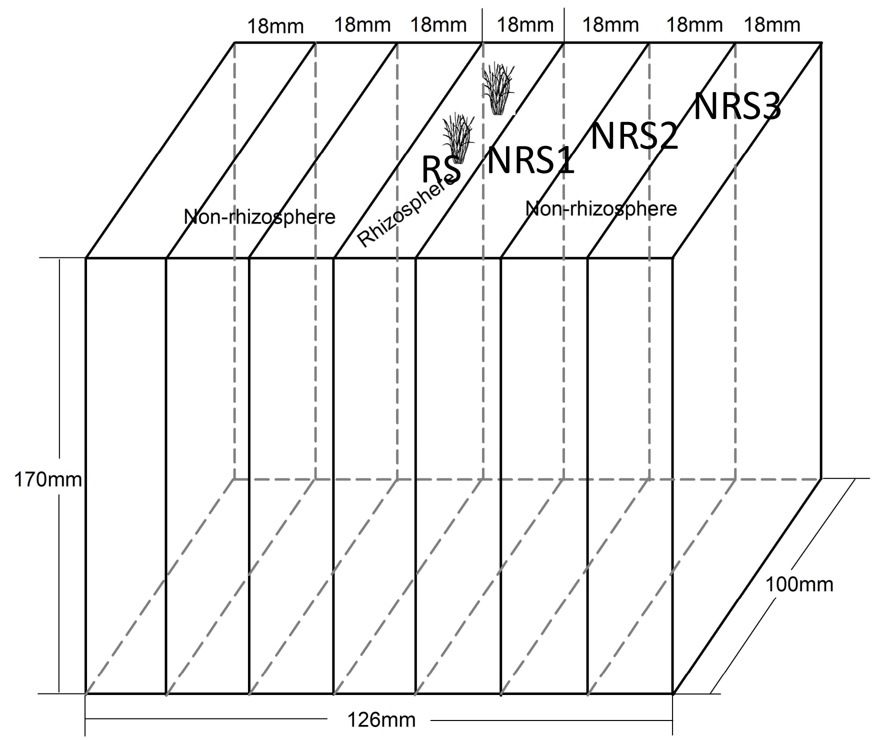
NP、NPK、NPKS

Lime levels: 0, 0.57, 0.85, **1.13**, 1.41, 1.70, 2.26 g kg^{-1}

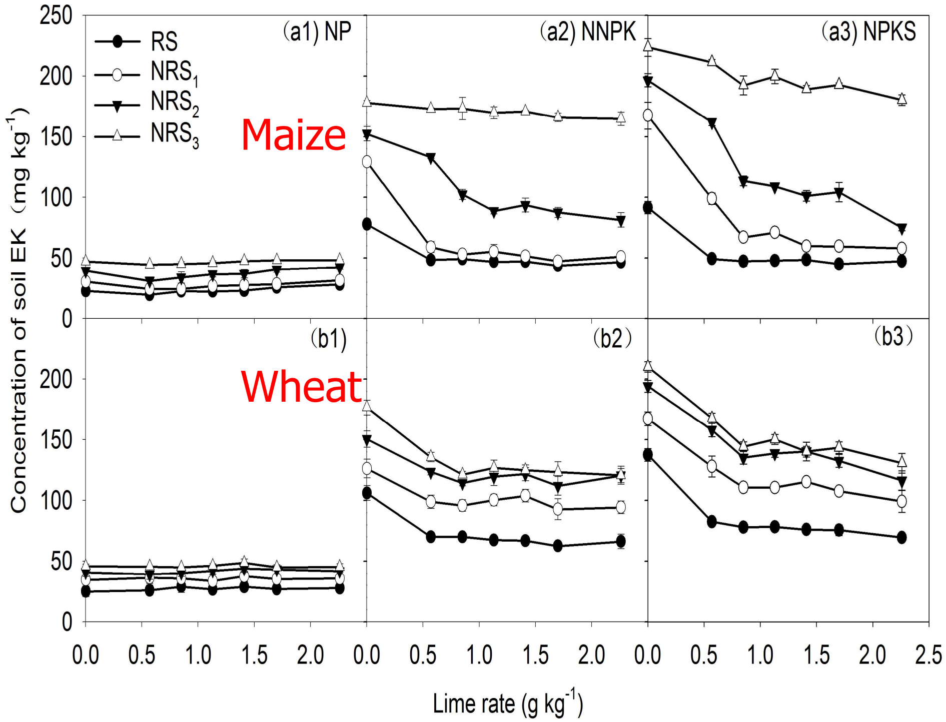
Maize: 45 days

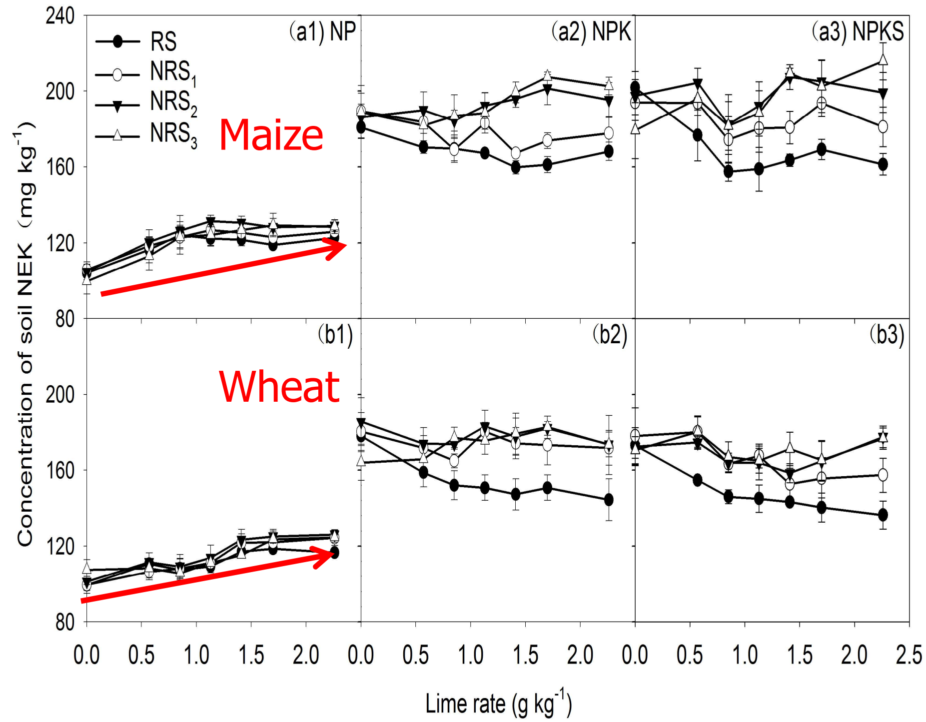
Wheat: 70 days

RS: Rhizosphere soil
NRS1: Non-rhizosphere soil 0–18 mm,
NRS2: Non-rhizosphere soil 18–36 mm,
NRS3: Non-rhizosphere soil 36–54 mm.



The changes of soil K under lime application





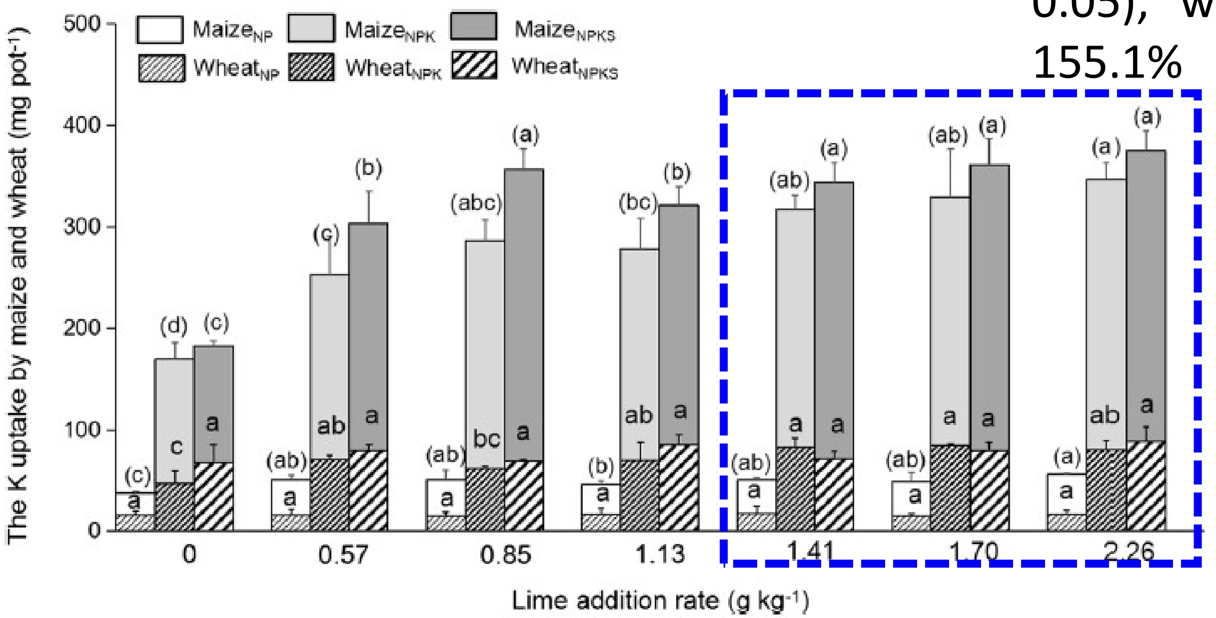
The EK in the rhizosphere of NP, NPK and NPKS treatments were lower than that of non rhizosphere, and showed increase trend with the distance increasing from roots

Biomass

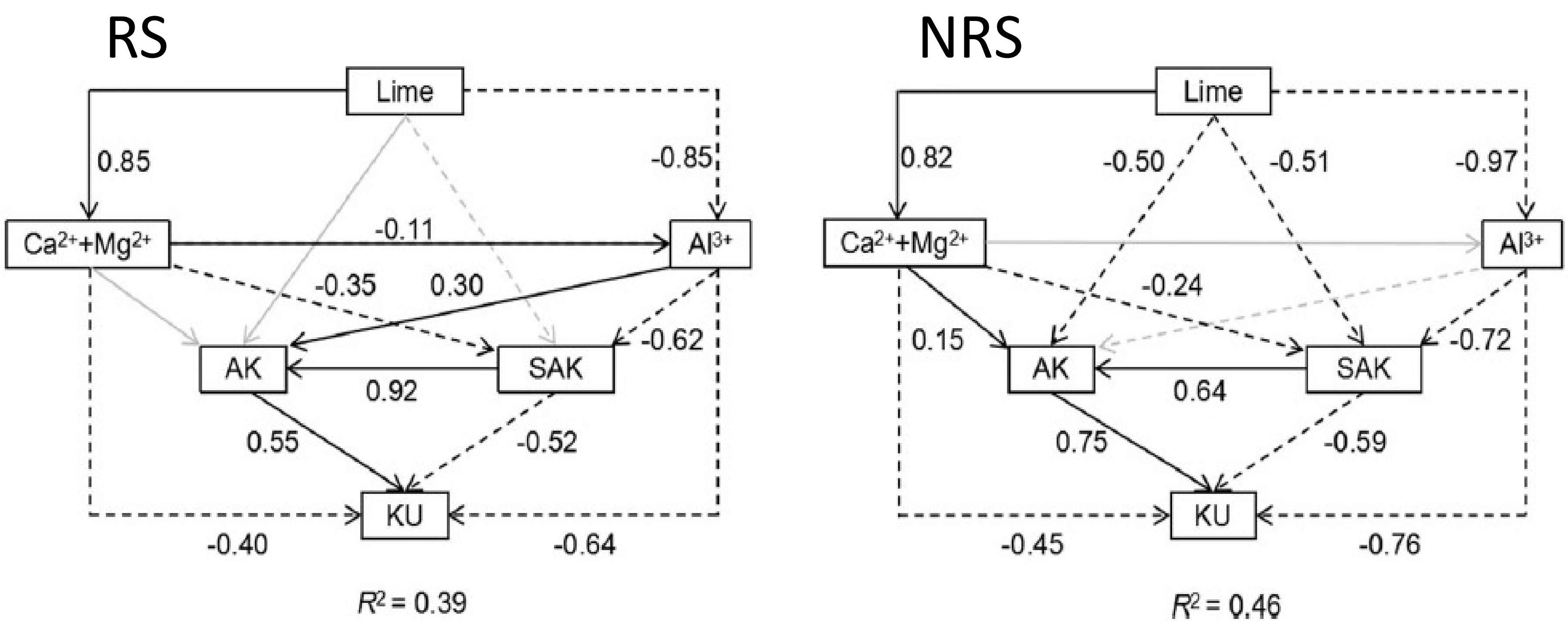
Lime rate (g kg^{-1})	Maize	Wheat	Fertilization	Maize	Wheat
0	86.1c	43.5c	NP	32.6c	15.7c
0.57	146.6b	55.3ab	NPK	211.9b	70.8b
0.85	182.7a	48.2bc	NPKS	243.1a	77.4a
1.13	157.8b	57.1ab			
1.41	180.1a	56.9ab			
1.70	186.8a	59.2a			
2.26	197.6a	61.6a			
Lime × fertilization	**	*			

Compared with the treatment without lime, the application of lime significantly increased the biomass of crops

K uptake



Application of lime significantly increased the K uptake by crops ($P < 0.05$), with an increase of 37.6% - 155.1%

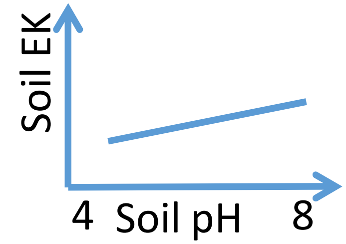


The path analysis (SEM) showed that lime-induced increase K uptake by crops was mediated by K^{+}, Ca^{2+}, and Al^{3+}

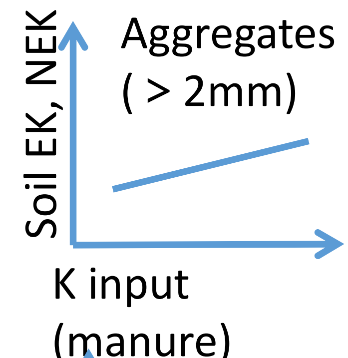
Han et al., Journal of Soils and Sediments, 2019; Han et al., Acta Pedologica Sinica, 2017 (in Chinese).

4. Main conclusions

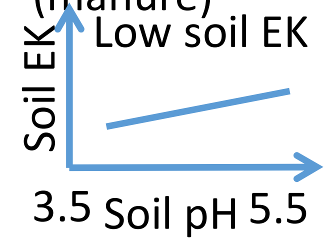
- National monitor data showed that soil pH and EK were significant positive correlated;



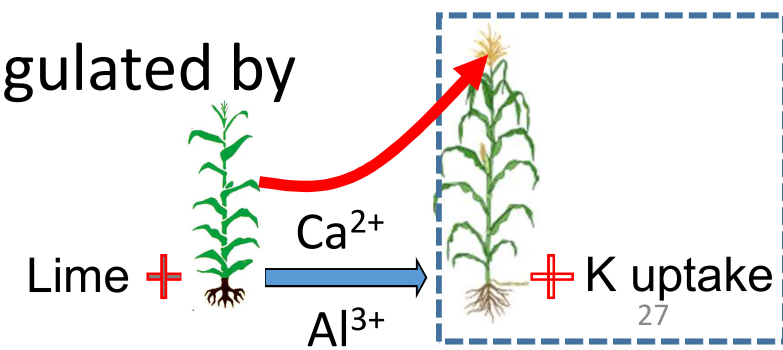
- K input (especially plus manure) could increase soil EK content and stock, especially in macro-aggregate;



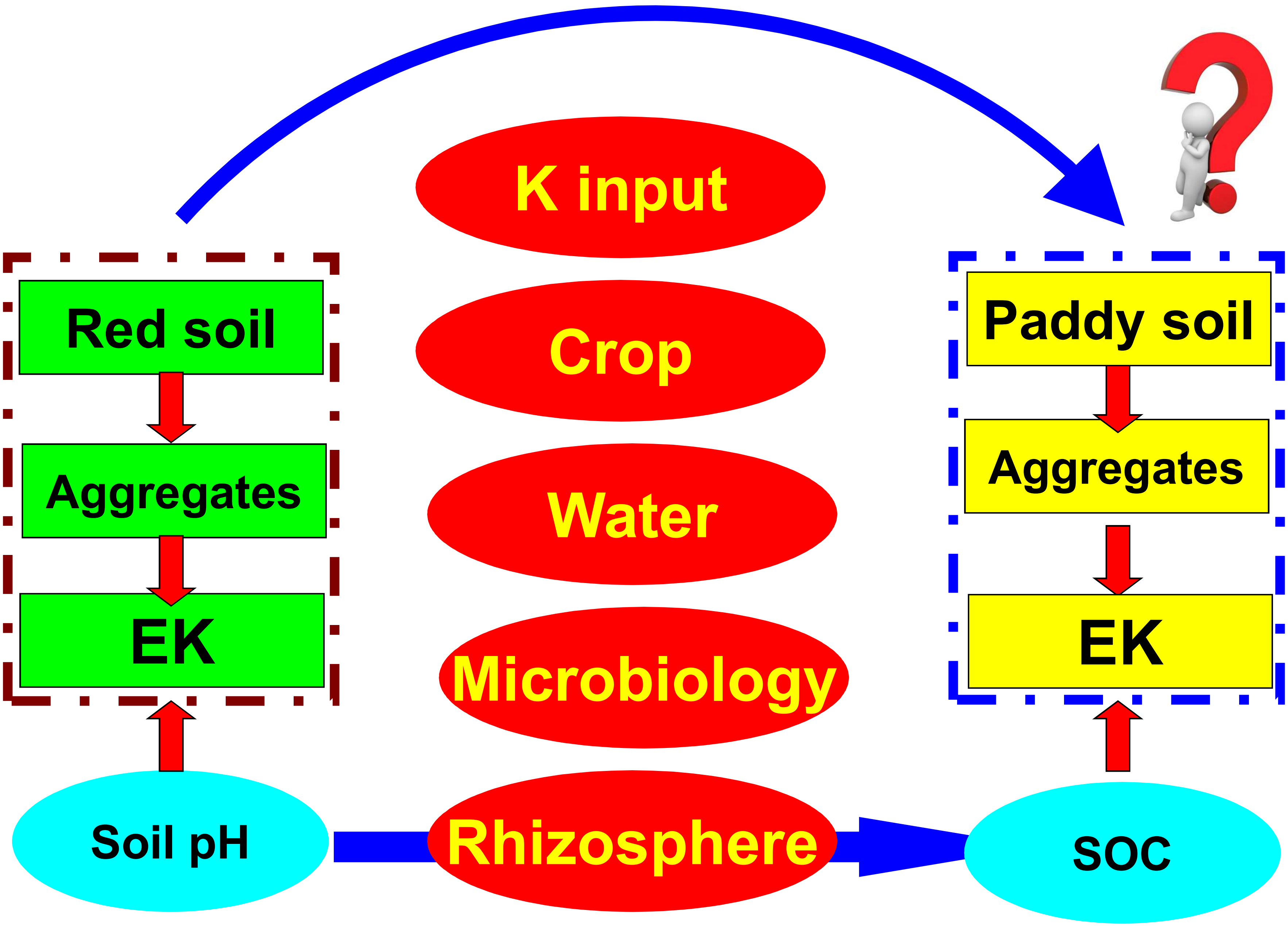
- EK and NEK in aggregate decreased gradually along with soil pH decreasing when initial soil pH and K were lower;



- Lime-induced increase K uptake regulated by Ca^{2+} and Al^{3+}.



5. Further research



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Center of Arable Land Quality Monitoring and Protection, Ministry of Agriculture and Rural Affairs

Qiyang red soil station

Thanks for your attention