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Potassium resources and integrated management in China

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Outline

- Potassium annual consumption and present balance
- Potassium integrated management

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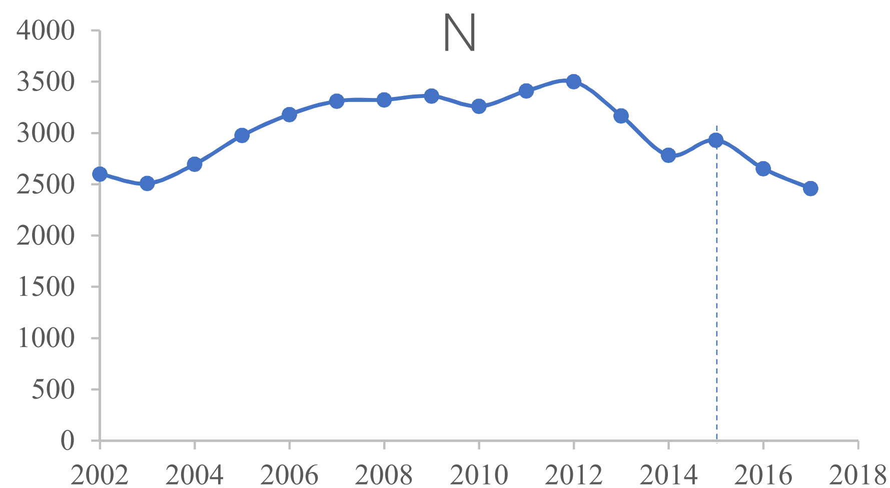
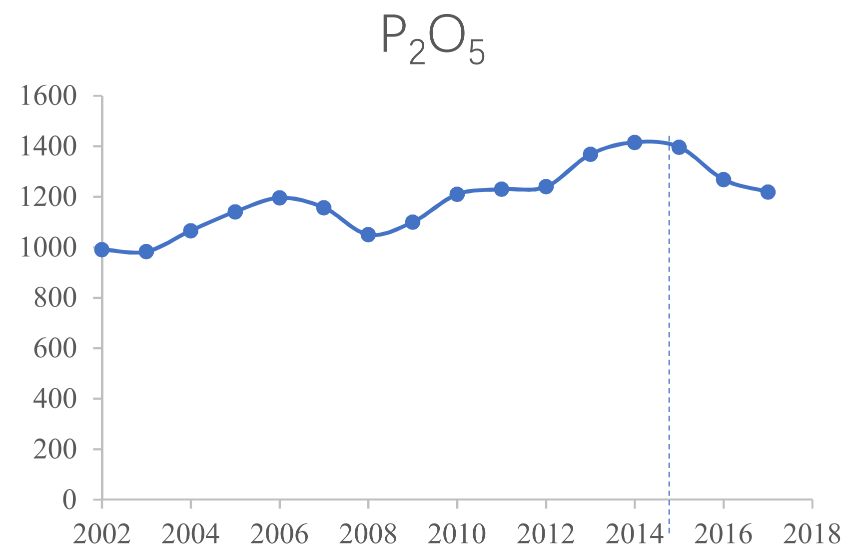
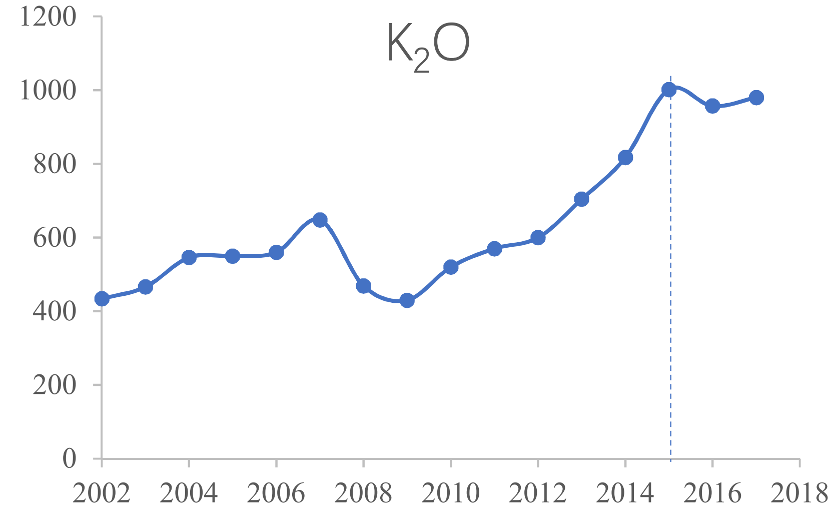
Fertilizer annual consumption over the last 16 years in China indicated that both nitrogen and phosphate consumption had declined and potassium consumption had not changed since 2015, ten years after the National Soil-testing and fertilizer recommendation Project began in 2005.







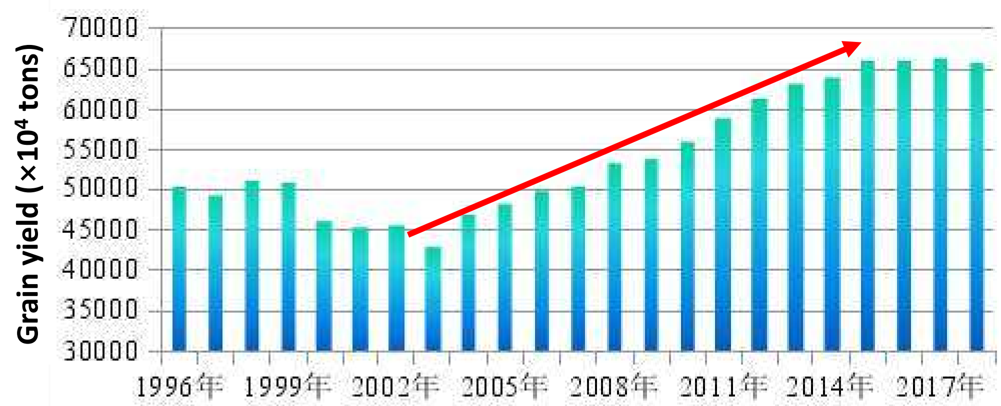


Fig. 1 Nutrient consumption growth with time

(Data source: IFA, unit: 10^4 ton)

Fig. 2 Yield production growth with the time

(Data source: National statistic Yearbook)

Table 1 K demand basing on the current recommendation for different crops

Crops	Sowing area ($\times 10^6$ ha)	Recommended fertilization (kg/ha)	Potassium demands ($\times 10^4$ tons) Data from Chinese literature		Data from Li's PhD thesis
Maize	35.0	56	196		
Wheat	24.3	49	119		
Rice	30.1	63	188	745	957.95
Other cereals	3.7	68	25		
Tuber crops	8.9	187	166		
Legume crops	9.7	53	51		
Oil crops	13.9	98	137		
Fiber crops	0.1	164	2		
Cotton	4.7	157	74	302	311.18
Sugar crops	2.0	230	47		
Tobacco	1.6	264	42		
Tea tree	1.7	133	23		
Fruit crops	12.1	337	404		
Melon crops	2.4	196	47	963	1102.87
Vegetable in field	16.9	220	372		
Vegetable in greenhouse	3.5	339	117		
In total	**170.6**		**2010**		**2372**

From 2007 to 2013, yearly straw resources increased from 5.60 to 10.22 million tons.

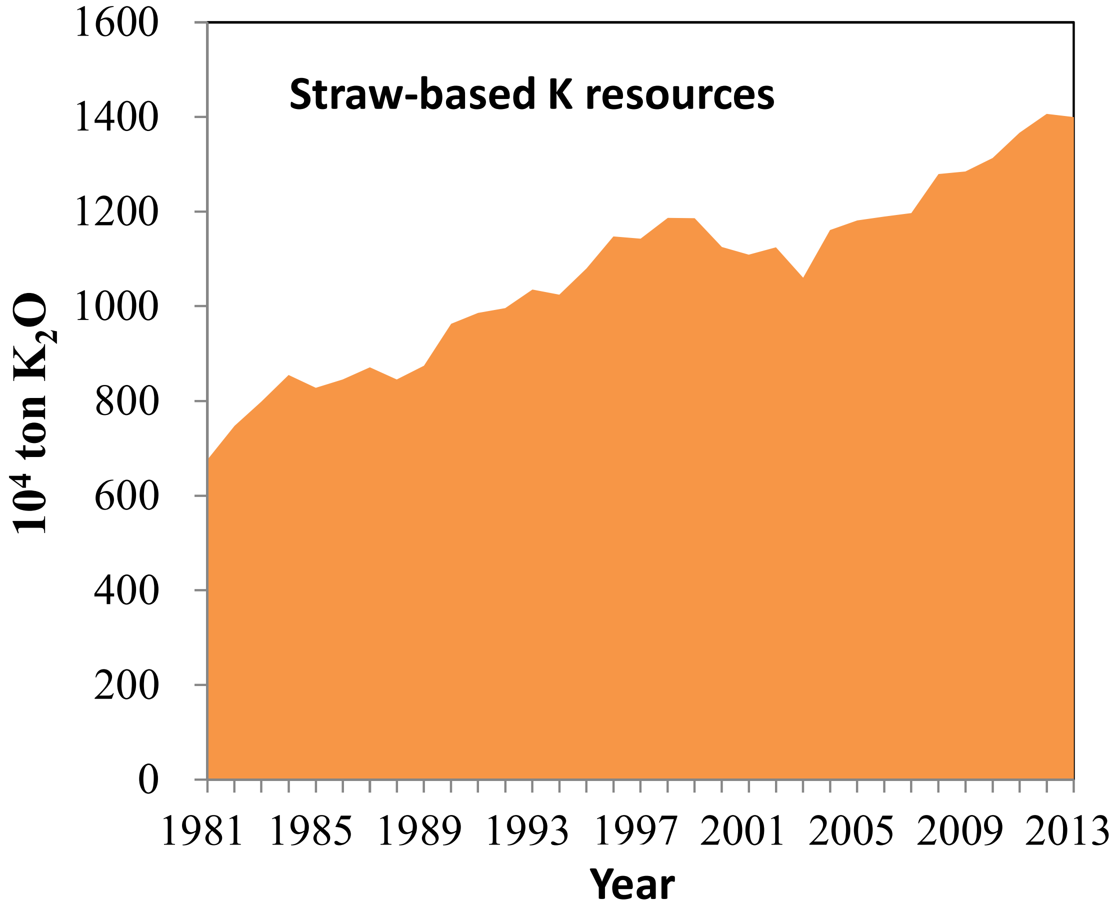


Fig. 3 Straw-based potassium resources grew largely

(Note: straw K = yield * (1/harvest index-harvest index) * straw [K])

(Data source: Fertilizer data summary research platform of the ministry of agriculture; Yield data collected from the national yearly book released by National Bureau of Statistics of China)

Straw-based potassium was increasingly returned to the field due to wide application of mechanization in sowing and harvesting, particularly in the North China Plain. According to a national survey in 2018, the straw of wheat, maize and rice was returned respectively by 98%, 84% and 79% of the total straw amount of the corresponding crop.

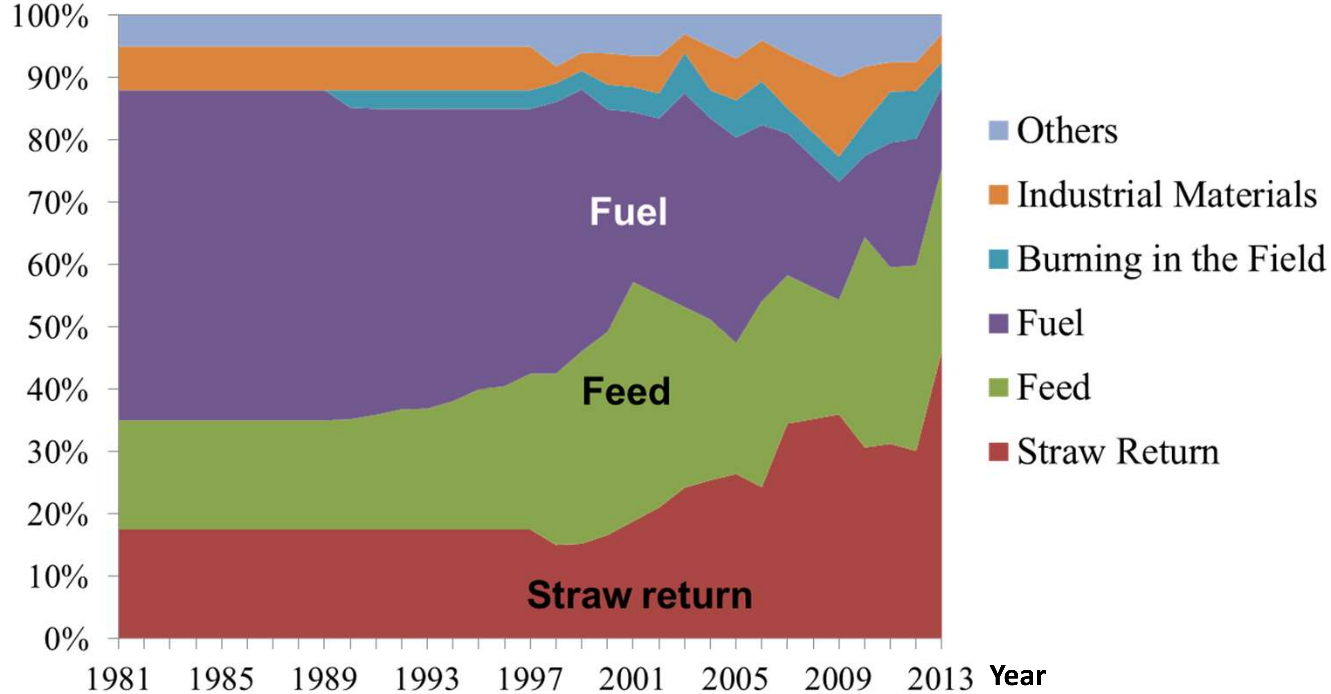


Fig. 4 Change in proportion of each straw use quantity to the total

From 2007 to 2013, potassium balance differed greatly between cropping regions in China. In wheat-maize double cropping (region V), for instance North China Plain, K balance was up to 0.87 million tons, about 36.4% of total K balance (2.39 million tons), causing high soil K accumulation.

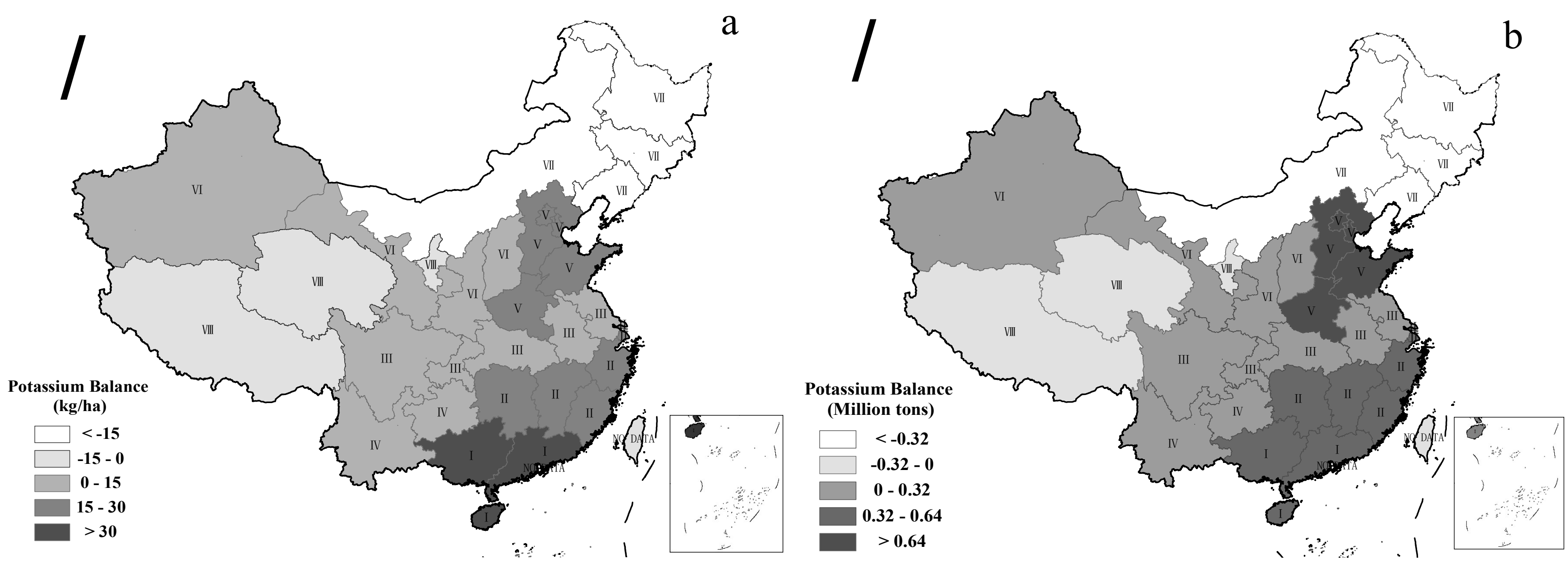


Fig. 5 Potassium balance across different regions in China from 2007 to 2013

$$Balance_k = INPUT_K - OUTPUT_K$$

$$INPUT_K = Fer_K + Org_K + StR_K \quad (1)$$

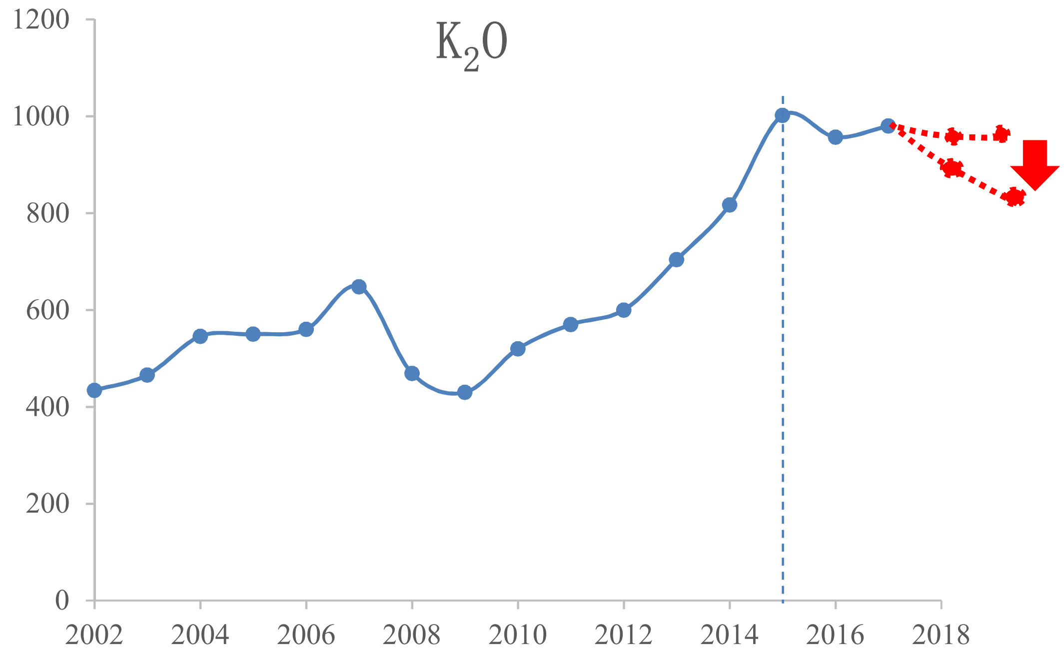
$$OUTPUT_K = St_K + Se_K \quad (2)$$

Where: $Balance_k$, $INPUT_K$, $OUTPUT_K$, Fer_K, Org_K, StR_K, St_K, and Se_K, indicated respectively the K balance, K input, K output, fertilizer K input, manure K input, straw K input, straw return K, straw output, and grain K output.

K demand
($\times 10^4$ tons)
2191
(2010+2372)/2

≈

K supply
($\times 10^4$ tons)
2039
1000 fertilizer + 1000 $\times$ 80% straw-K + 239



Is it possible to further decline K consumption, and then reduce depletion of non-renewable potash mineral?

Fig. 6 Potassium consumption growth with time

(data source: IFA, unit: 10^4 ton)

Outline

- Potassium annual consumption and present balance

- **Potassium integrated management**

Large variation of soil potassium availability across China.

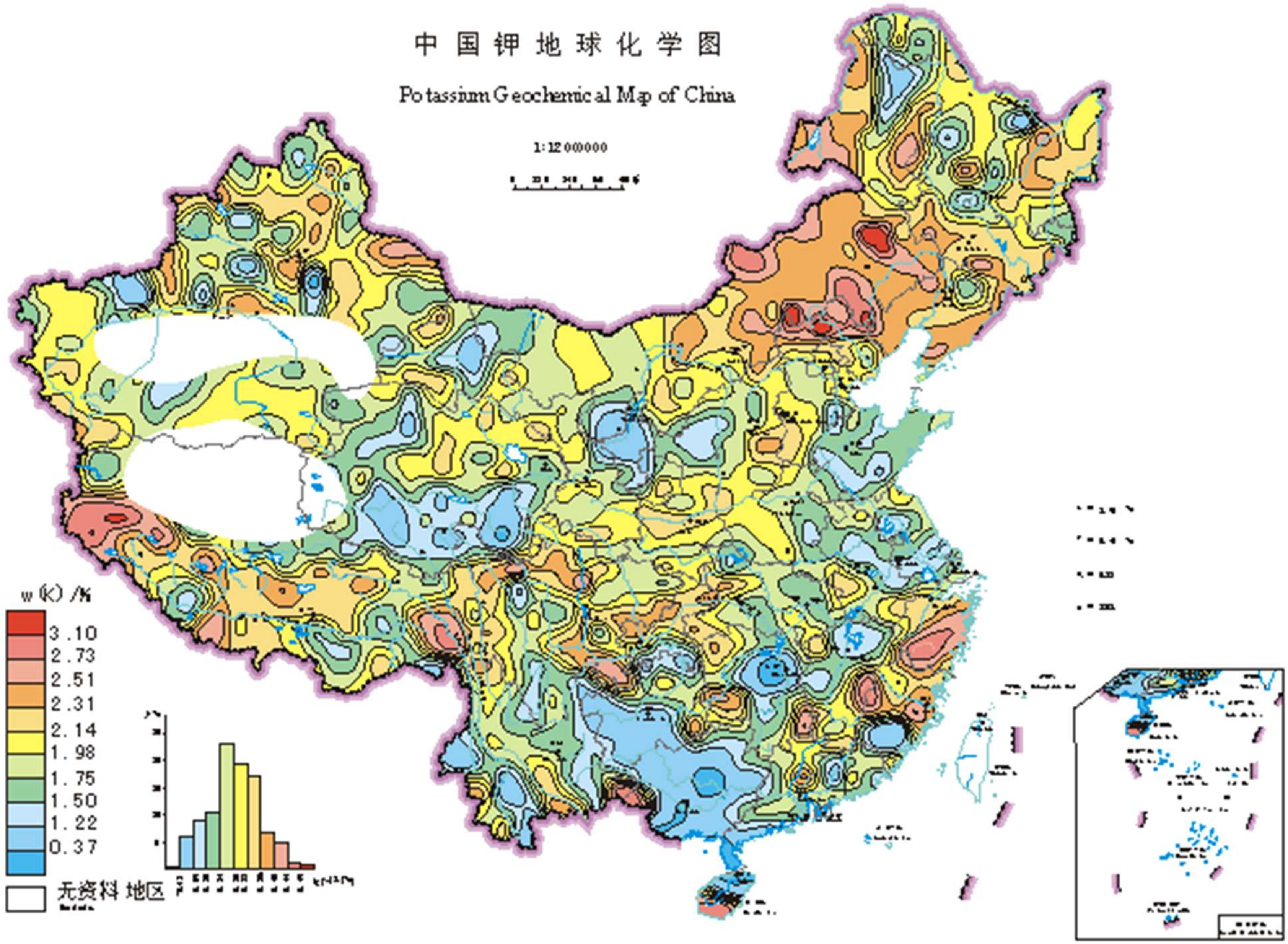


Fig. 7 Potassium geochemical map of China

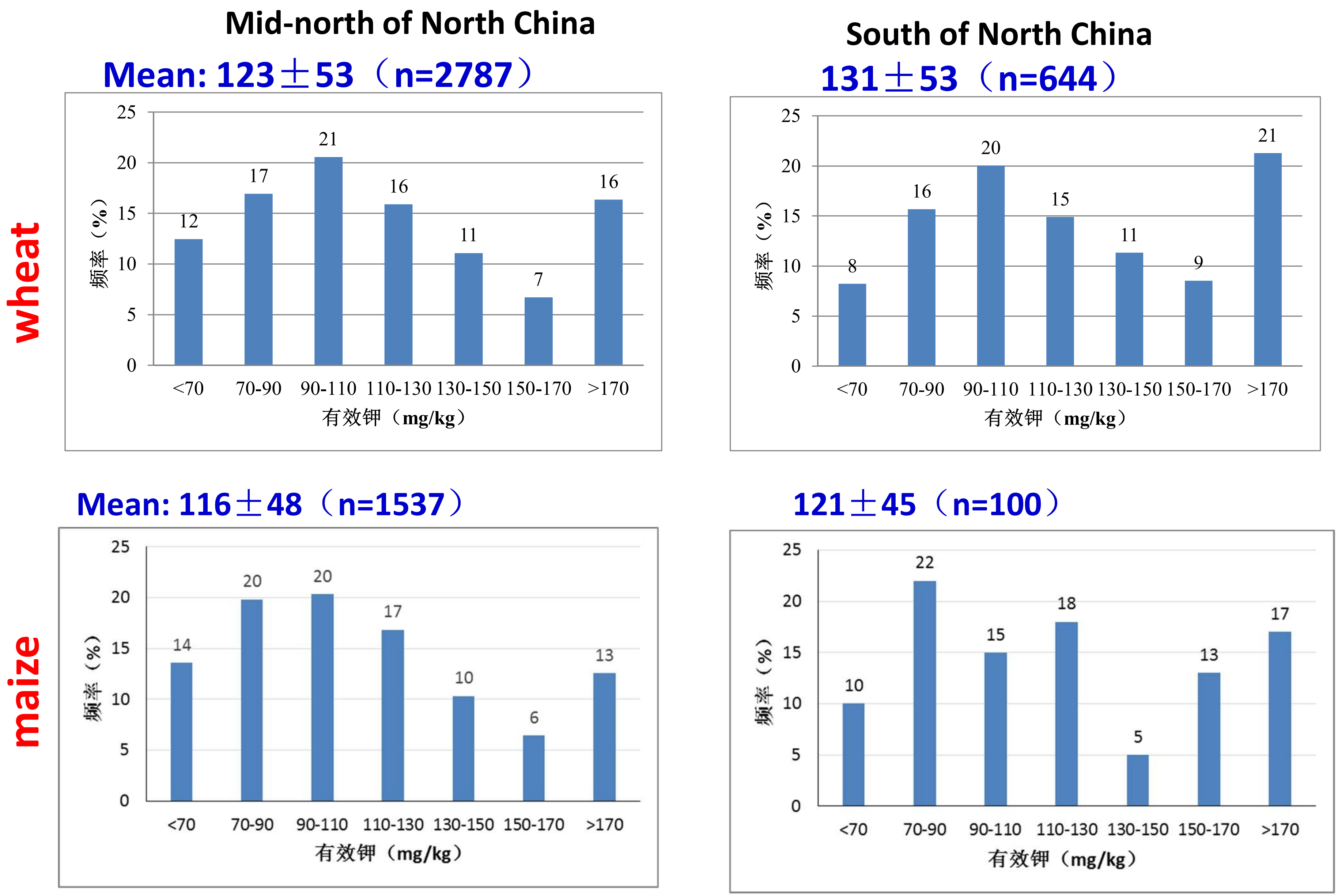


Fig. 8 Histogram of soil NH_4OAc-K of wheat-maize double cropping in North China Plain

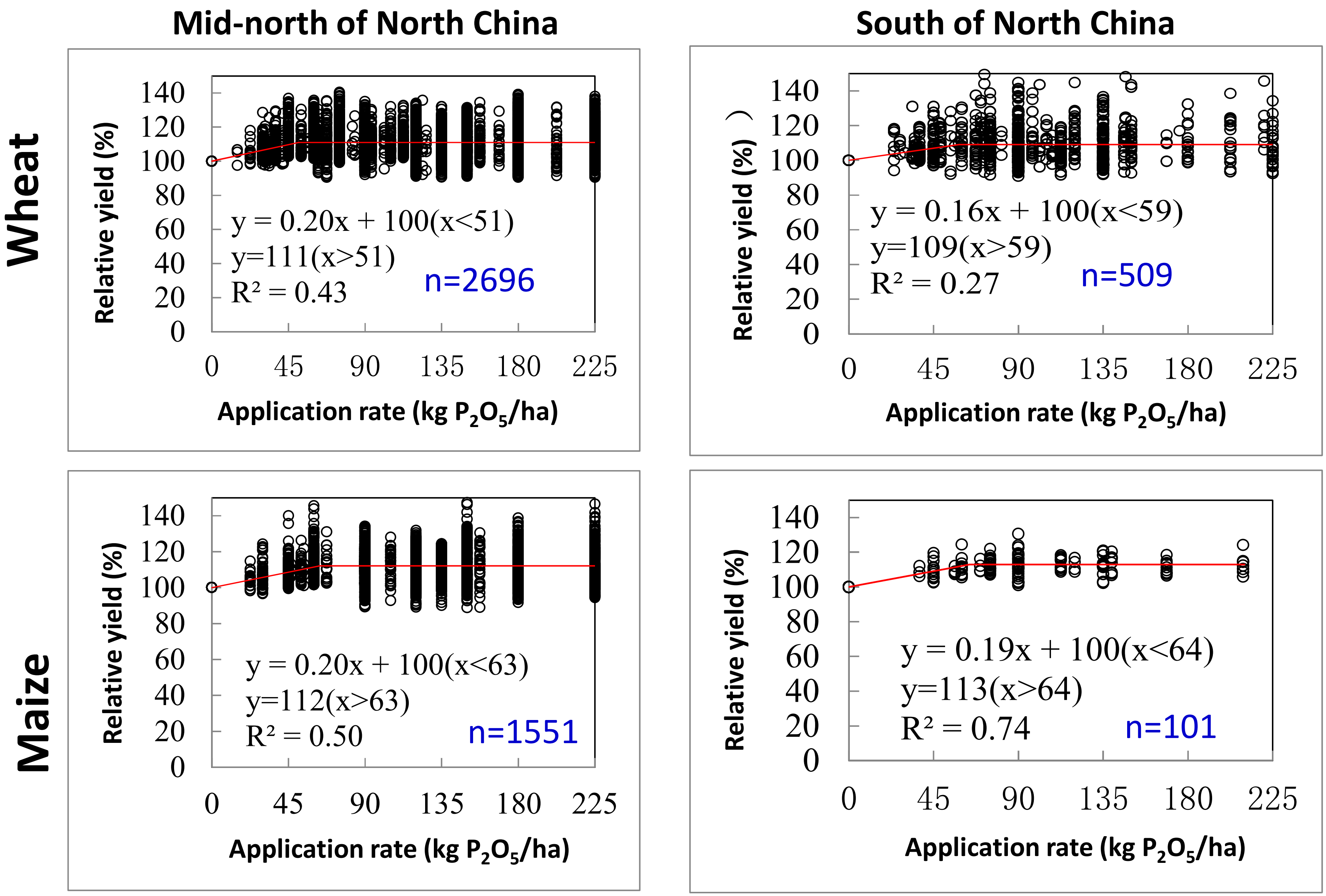


Fig. 9 Yield response of wheat-maize double cropping in North China Plain

Per ton grain requests K uptake of 15.0 kg K or 18.0 kg K_2O

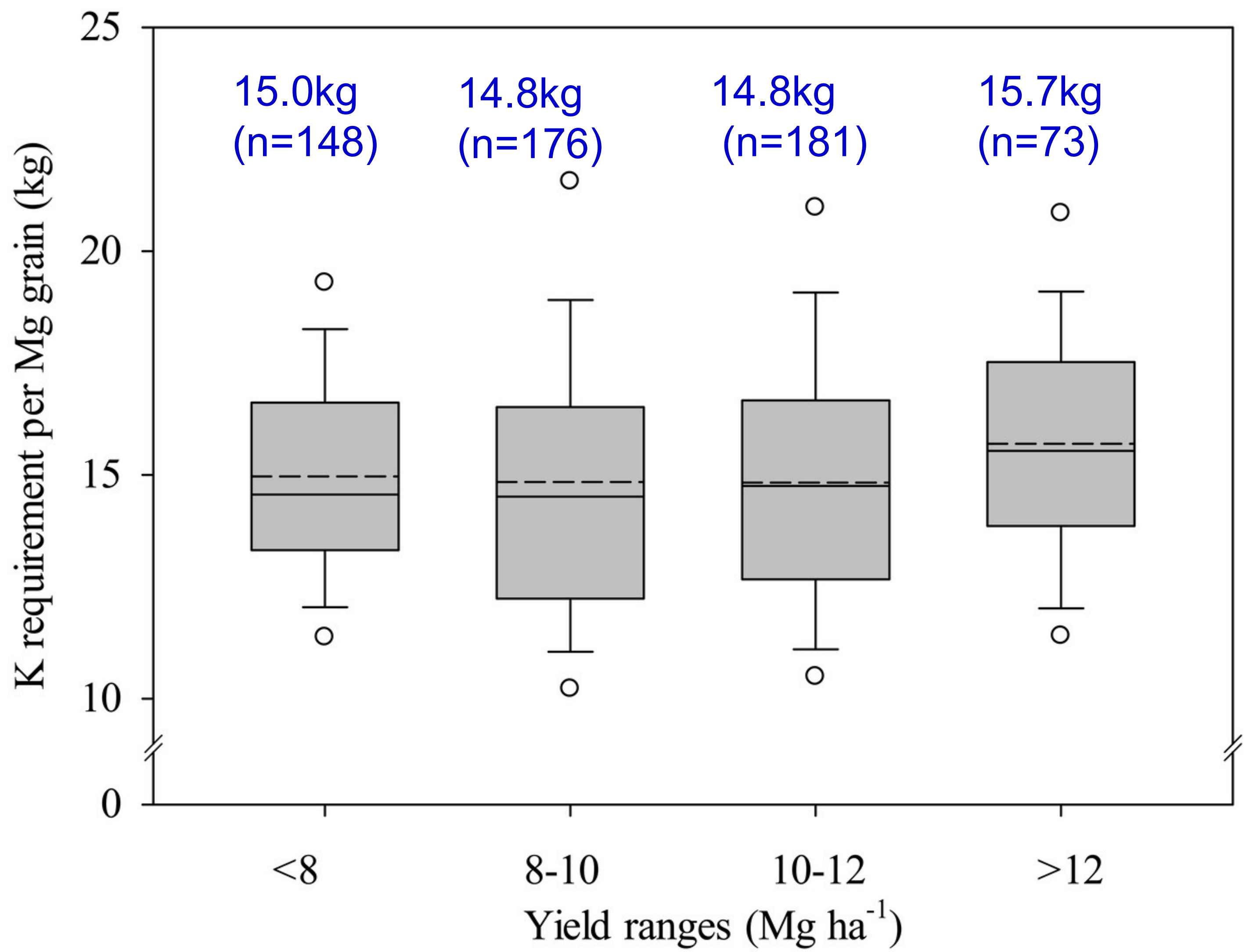


Fig. 10 Potassium demand per unit yield of summer maize

Straw return complemented with 50 kg K_2O/ha input caused no K surplus, and is substituted for 190 kg K_2O/ha fertilizer K.

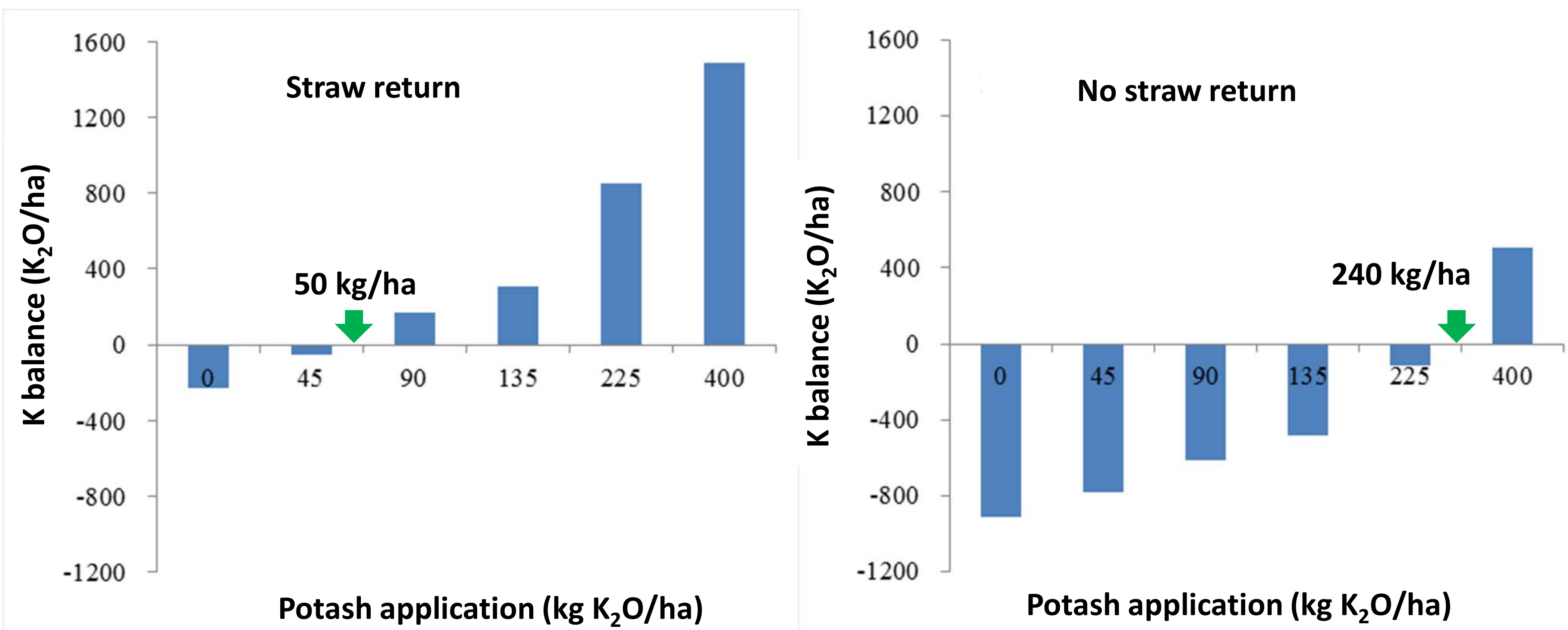


Fig. 11 K balance of wheat-maize double cropping under with and without straw returning

(Xu et al., unpublished data)

In wheat-maize double cropping in the North China Plain, soil NH_4OAc-extracted K was 120 mg/kg in average; K recommendation for this region was 50-65 kg K_2O/ha, which could be a referenced index for regional nutrient integrated management.

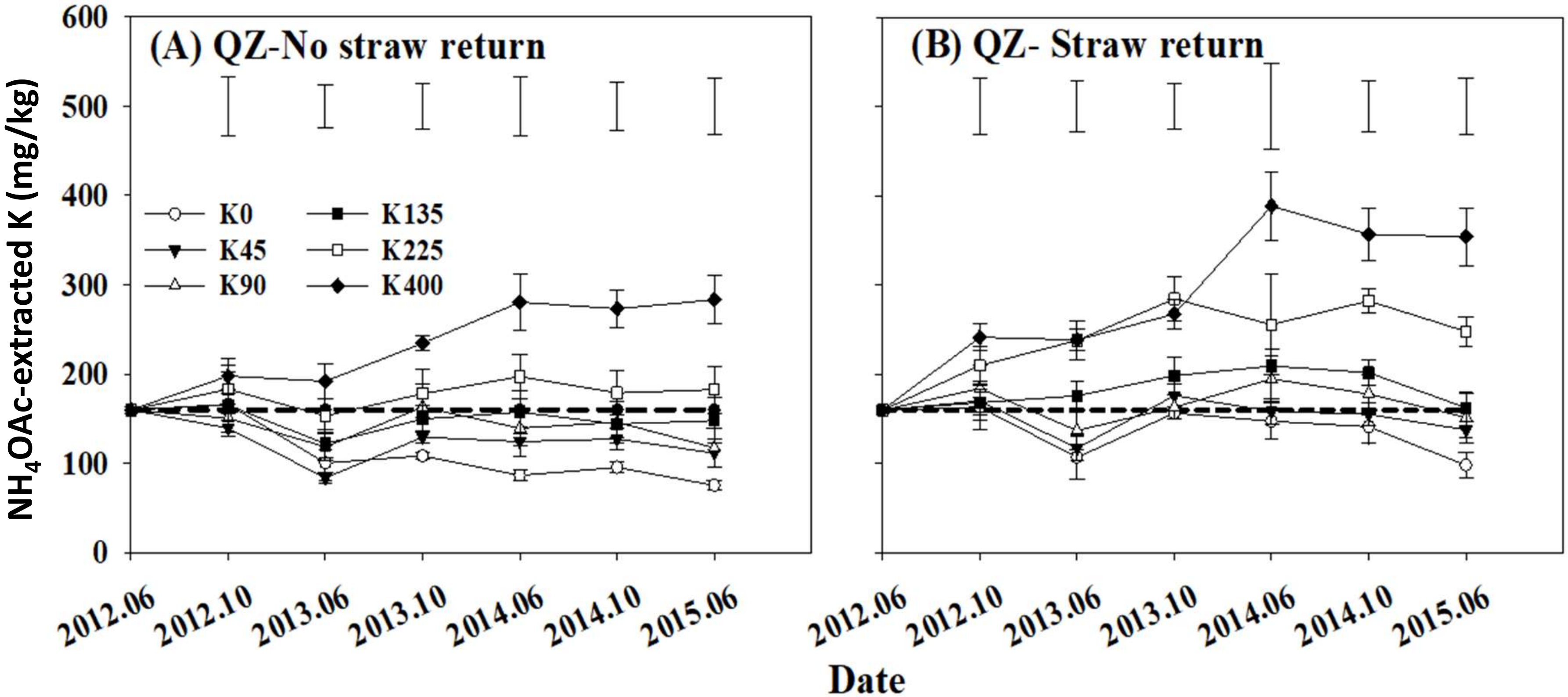


Fig. 12 Soil NH_4OAc extracted K in three years at two sites (QZ and LC), six K levels (K0, K45, K90, K135, K225 and K400), with or without straw return, on a winter-wheat summer-maize rotation system (including three seasons maize and three seasons wheat). Bars denote standard errors of the mean from each site, n=4 in QZ and n=3 in LC. Horizontal dotted lines indicate the initial values at the beginning of experiment. I-shaped bars denote the $LSD_{0.05}$ values.

(Xu et al., unpublished data)

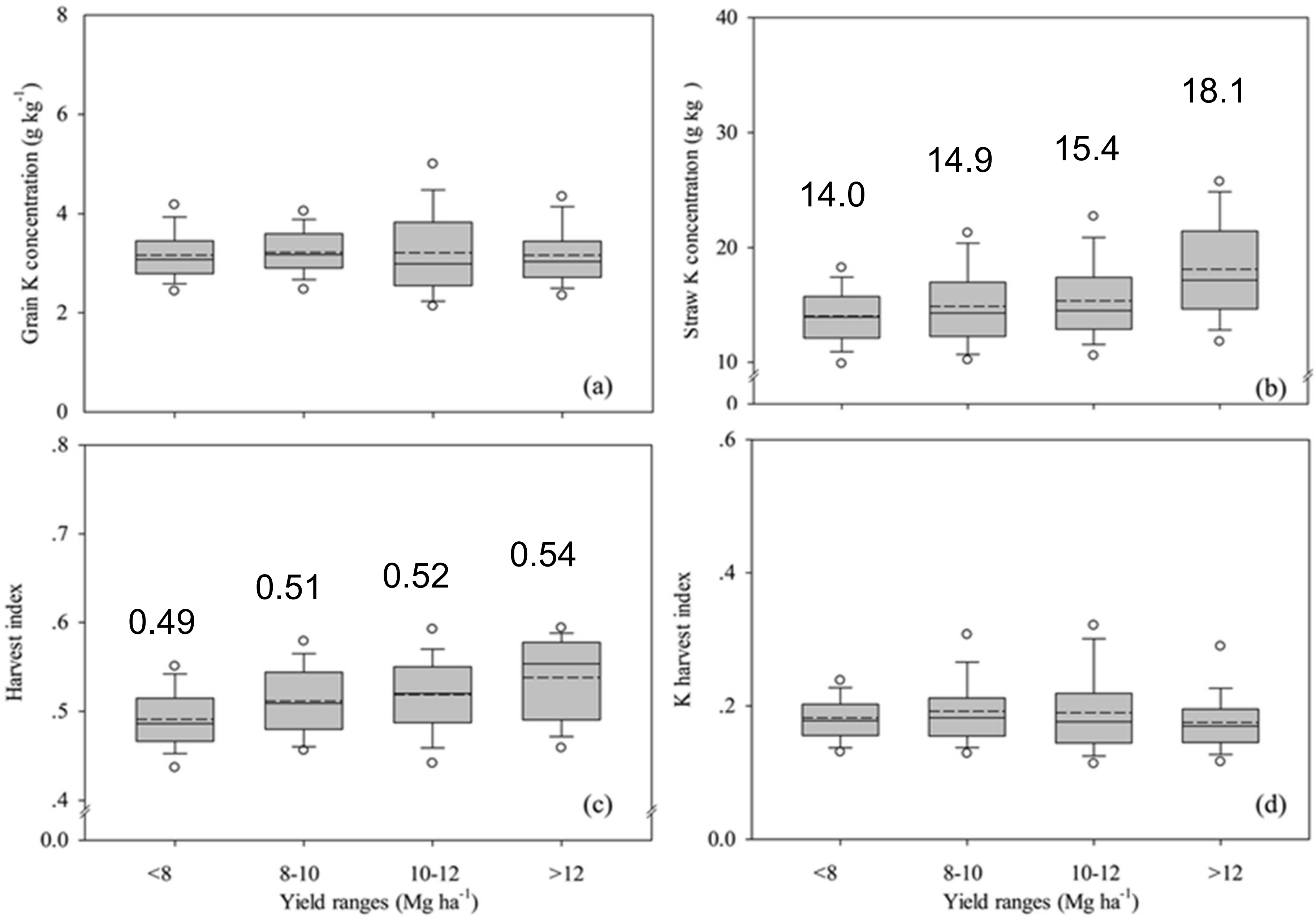


Fig. 13 K demand of summer maize increases with yield

Maize lodging due to high planting density and/or over-used nitrogen input.

Maize production using varieties with high stem and large cob, and growing in high density likely increases the risk of lodging.

(Photo taken by Prof. Jiagui Xie in Jilin Province)

Potassium application enhances maize stalk strength, consequently increasing the resistance to lodging.

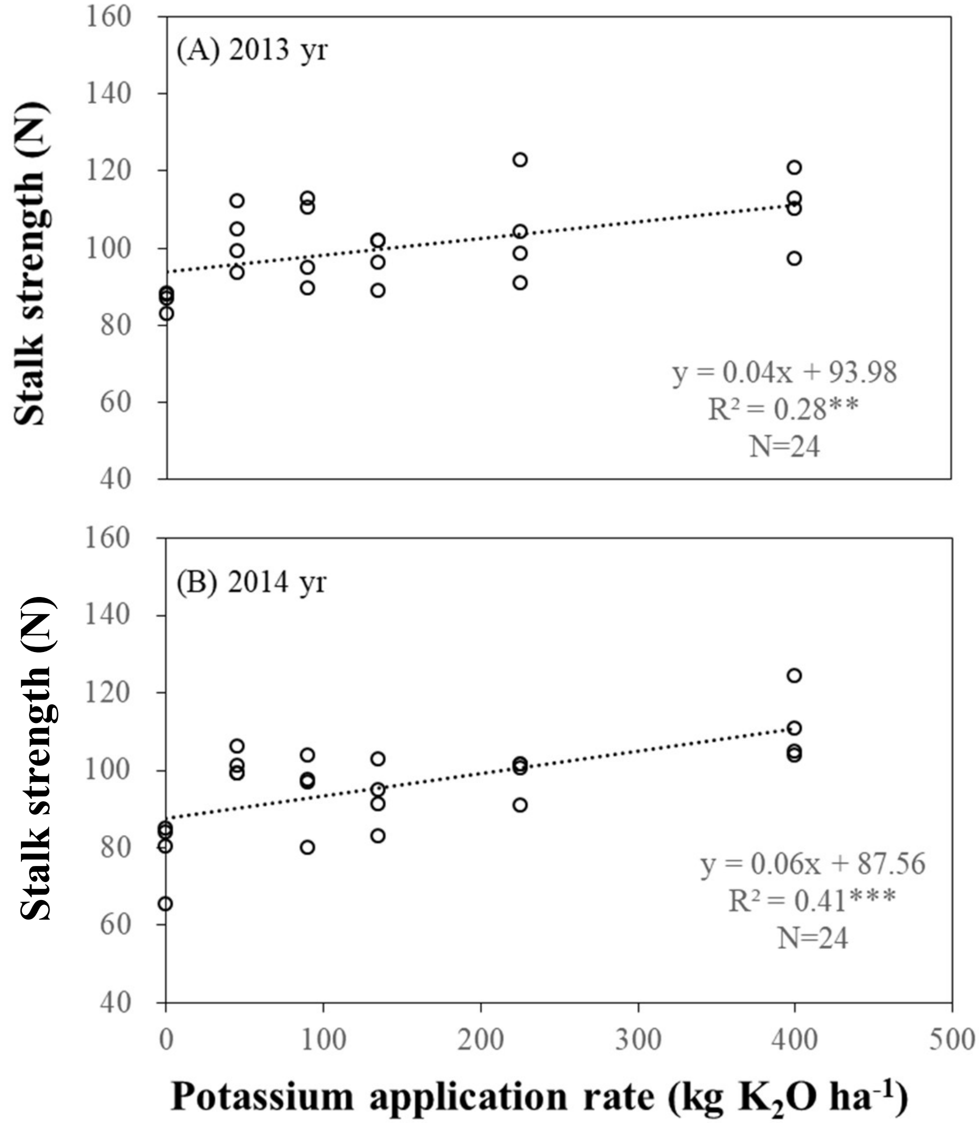


Fig. 14 Correlation between K application and stalk strength

(Xu et al., 2018, FCR)

Over-use of nitrogen but under-use of potassium apparently enhances the risk of lodging.

Recommended fertilizer
N-P_2O5-K_2O (kg/ha): 17-13-15

Farmer-used fertilizer
N-P_2O_5-K_2O: 28-6-6

(Photo taken by Dr. Yixiang Sun in Anhui Province)

Potassium application decreases stalk strength reduction created by high N input.

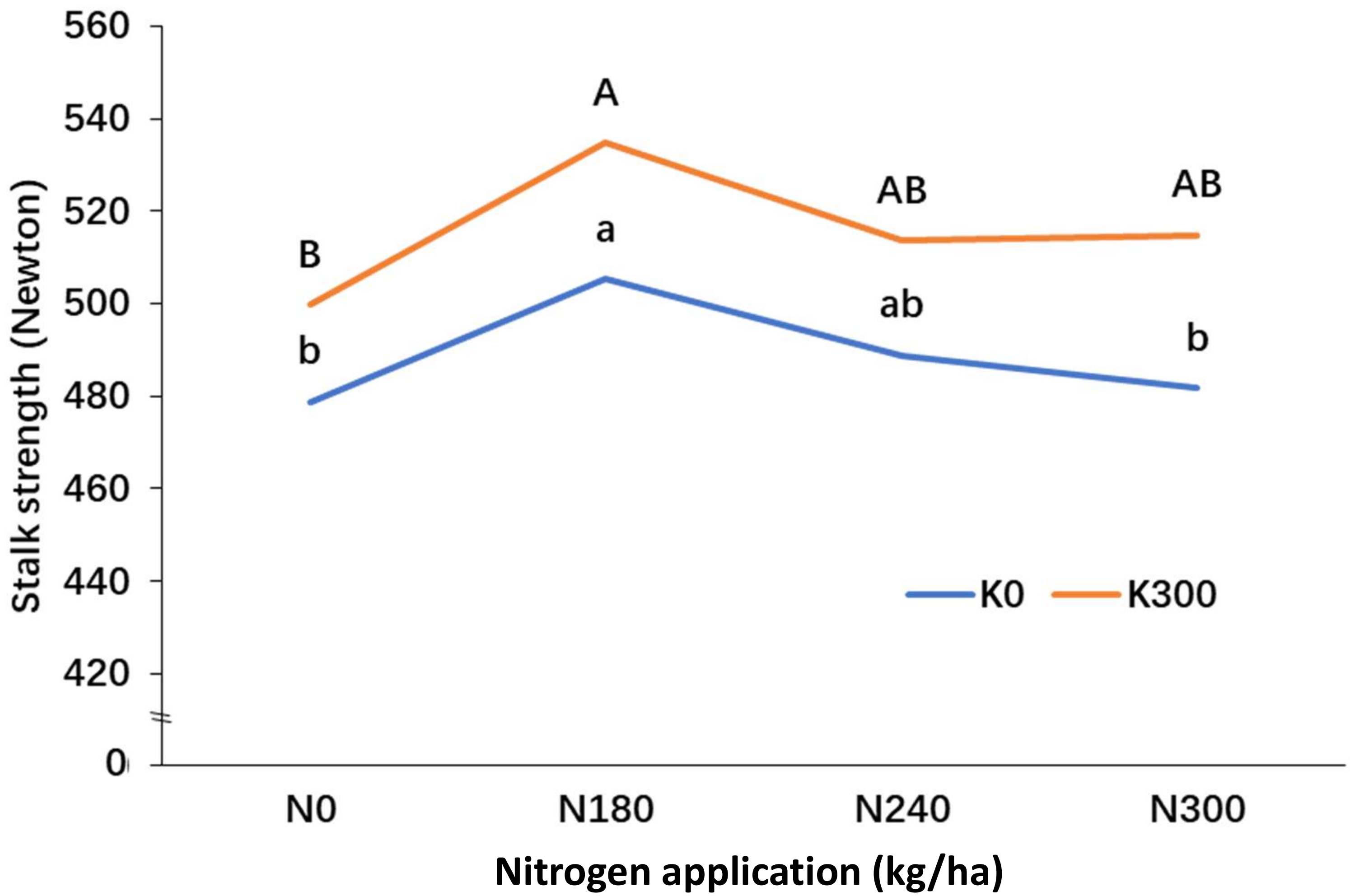


Fig. 15 The impact of K application on the correlation between stalk strength and N input.

(Xu et al., Unpublished data)

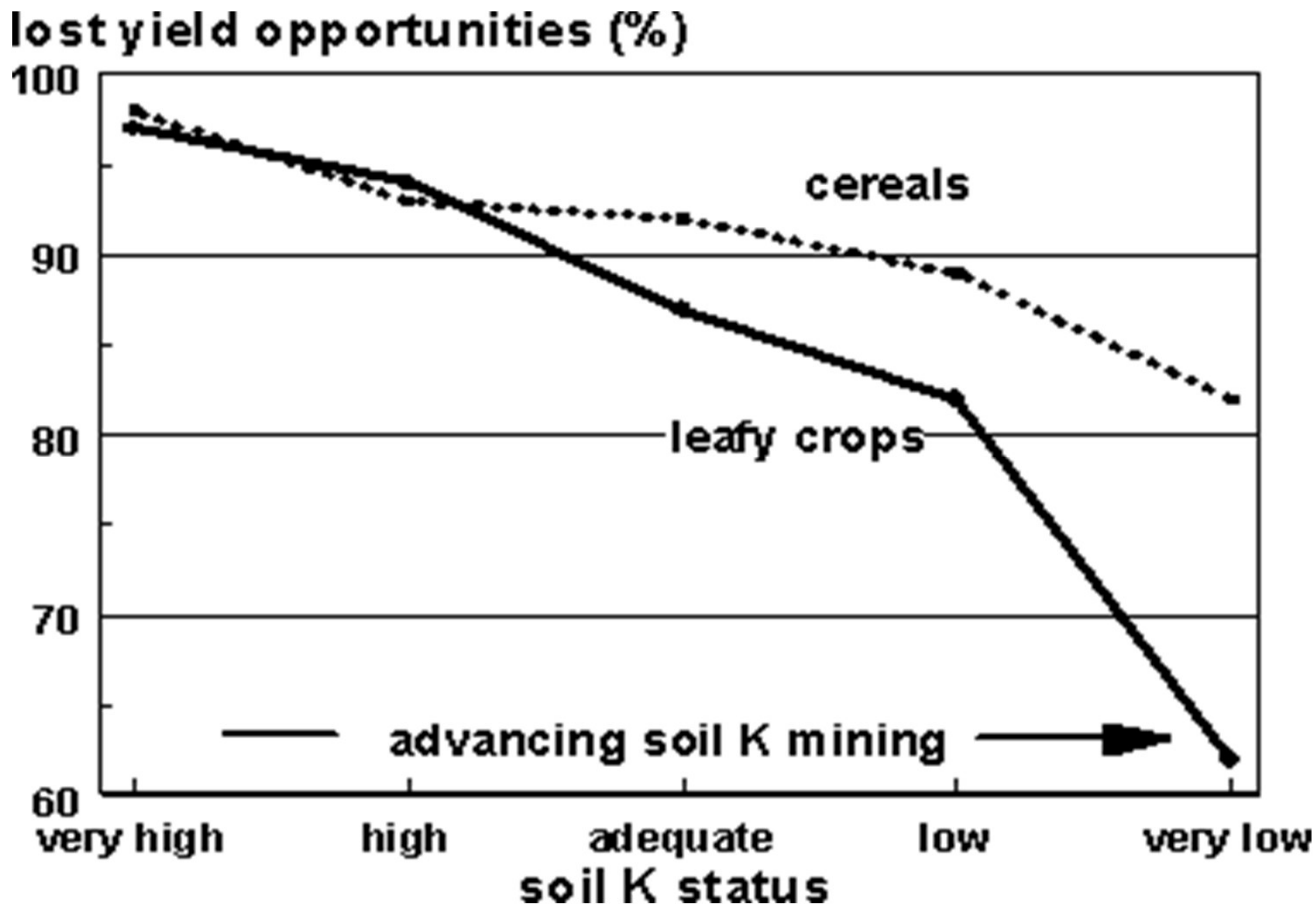


Fig. 16 Loss in opportunity yield at different levels of soil K status

KERSCHBERGER & RICHTER, 1987

(http://m.sohu.com/a/228163795_407313)

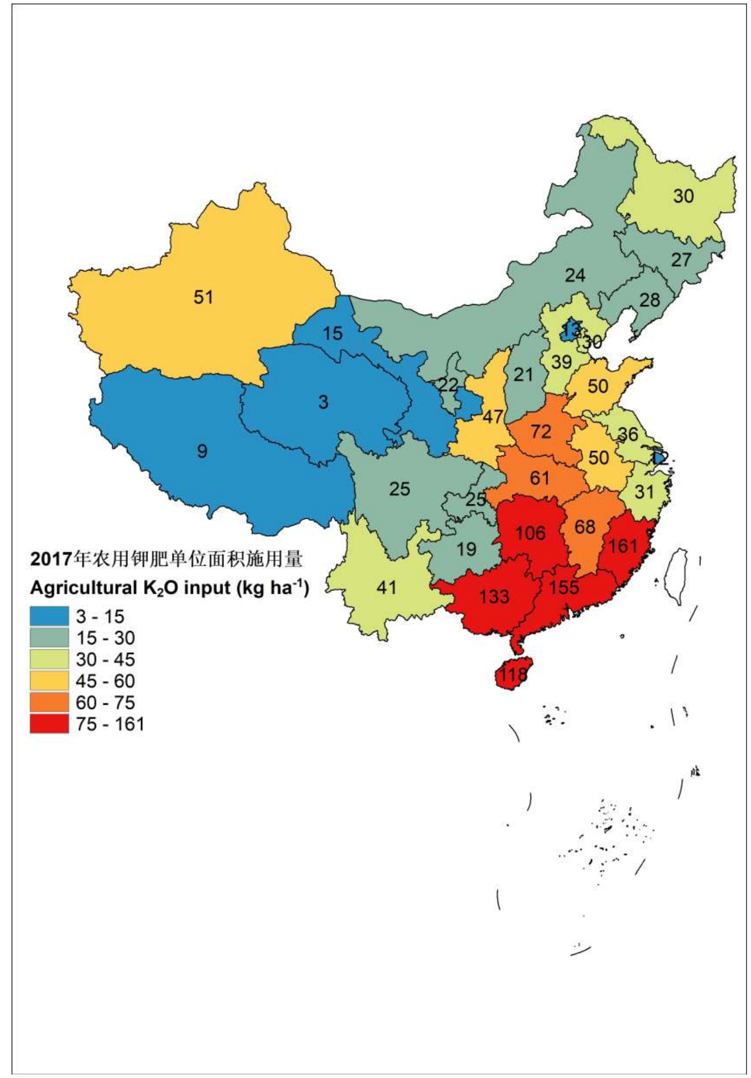


Fig. 17 Fruit production map of China (left) and K application in each province

(Data sources: 2017 Statistic Year Book)

Most crops are applied at 50-100 kg K_2O/ha, and fruit tree, vegetable and tobacco commonly over-applied K fertilizer, likely greater than 200 kg K_2O/ha.

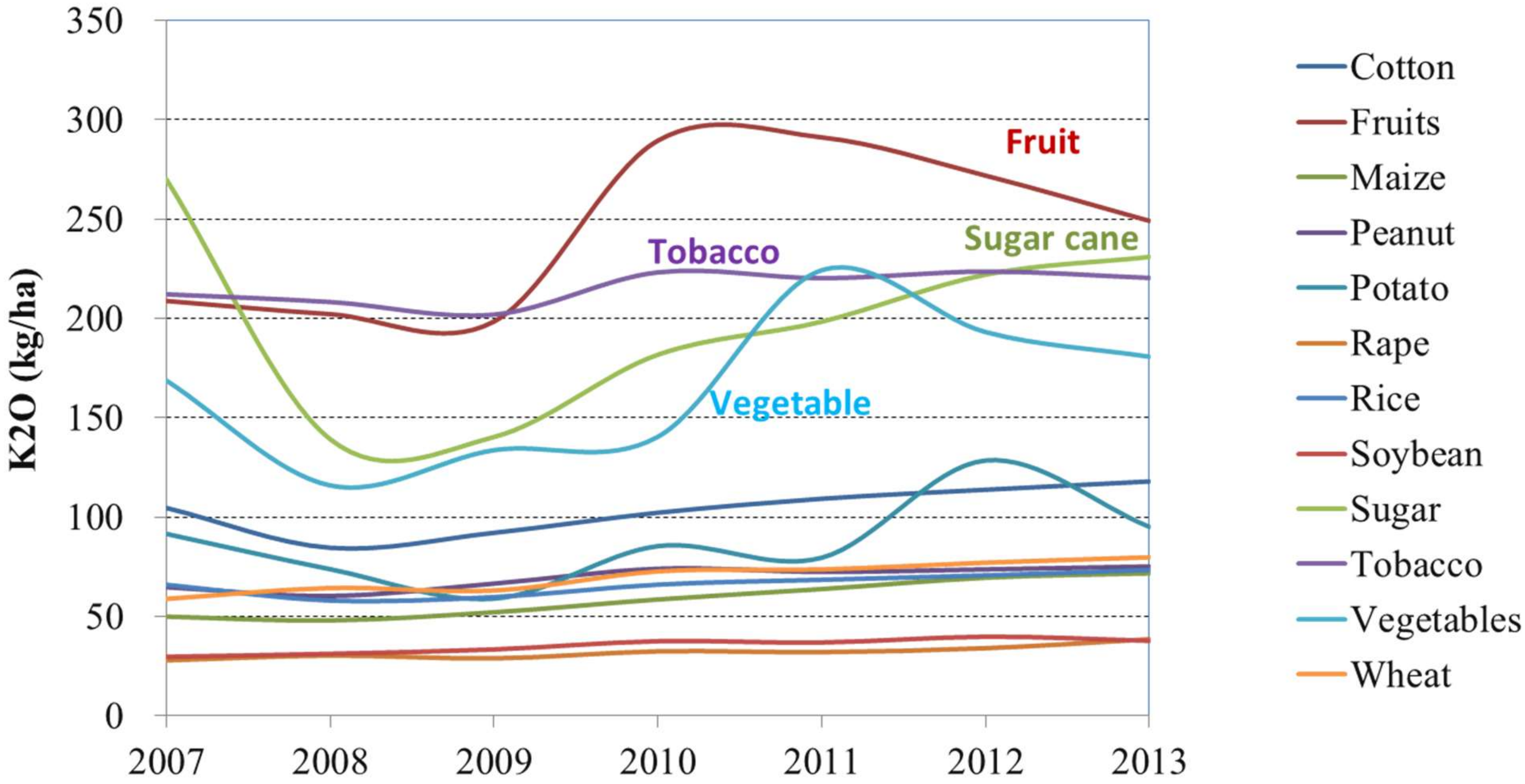


Fig. 18 Change in K application for different crops

(Data source: Data compilation of national agricultural product cost income)

From 2007 to 2013, national K surplus per unit area is about 33 kg. K surplus of 11 crops totals to 2.39 million tons, in which vegetable and fruit attribute to roughly 86% of the total.

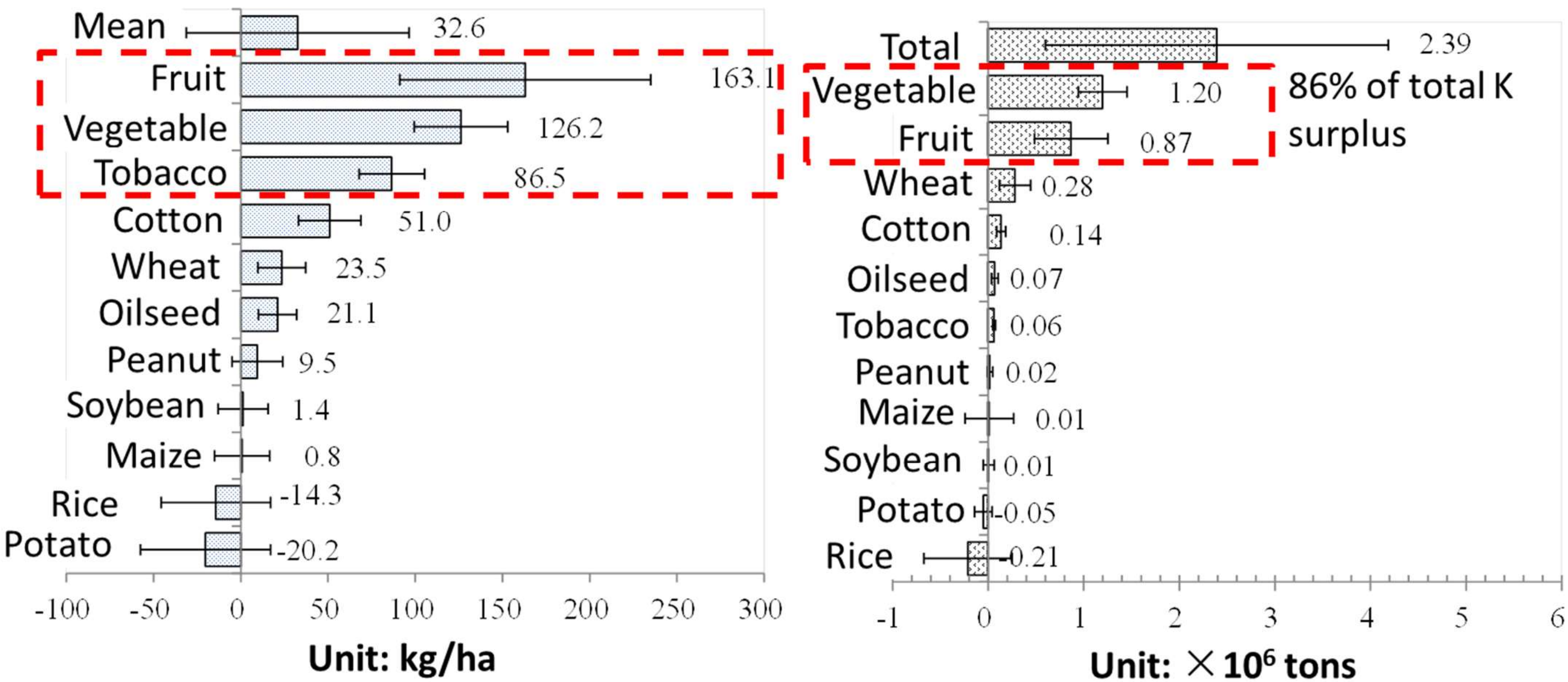


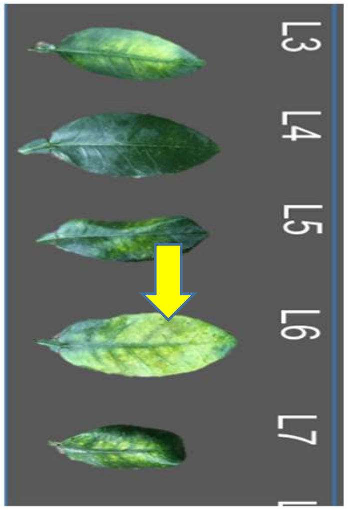
Fig. 19 Potassium balance of different crops

Table 2 nutrient balance of pumelo at Pinghe, Fujian province

Nutrient (kg/ha)	Nutrient input (kg/ha)	Nutrient removal (kg/ha)	Apparent balance (kg/ha)
N	1206±508	80±40	1126±511
P_2O_5	971±431	17.5±9.4	954±431
K_2O	955±368	81±43	874±367

(Yield: 55t/ha, n=362）

(Wu et al., unpublished； Qin et al., 2016)



(Modified from Dr. Liangqu Wu's presentation)

Severe nutrient surplus was commonly observed in fruit production and particularly K surplus causes Mg deficiency.

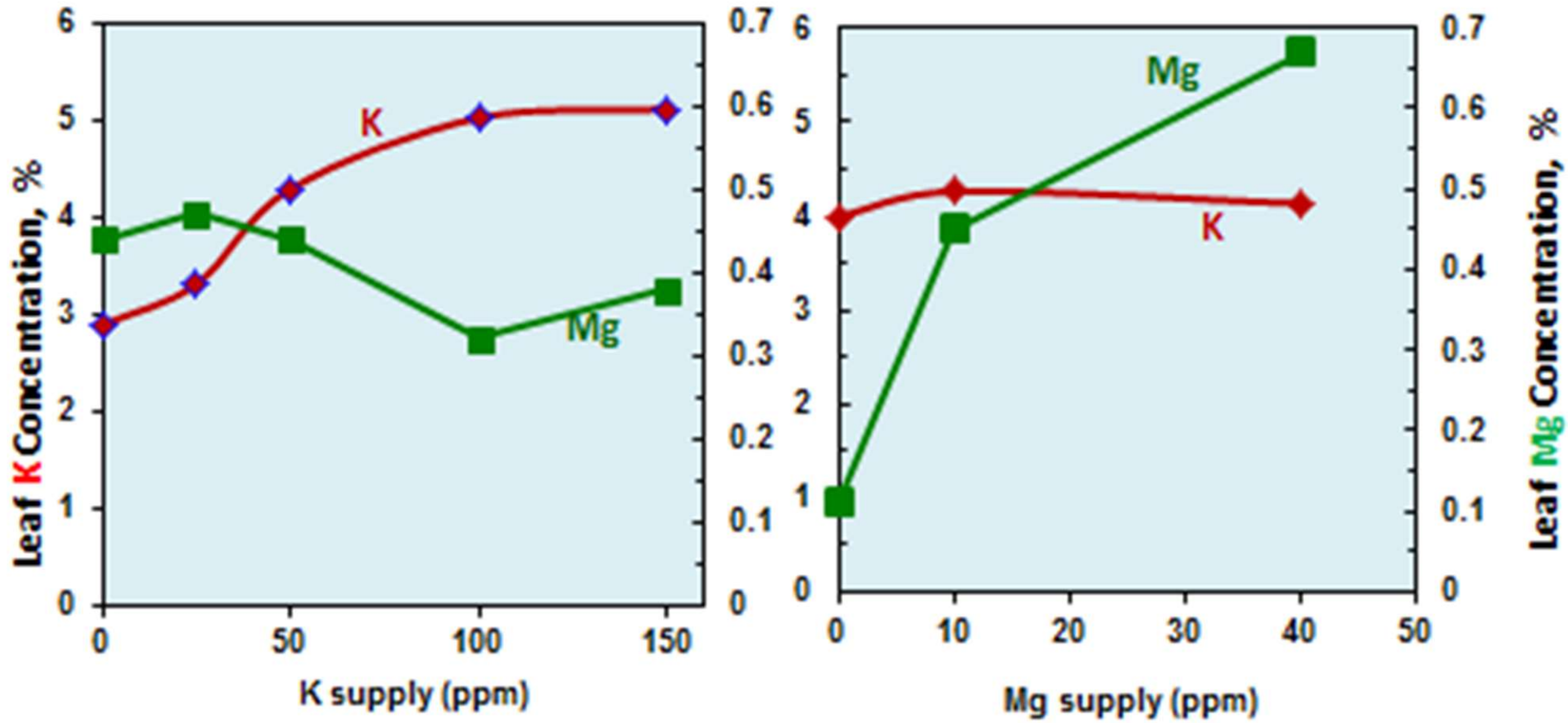


Fig. 20 Interaction between K and Mg in leaf

(Farhat et al., 2013)

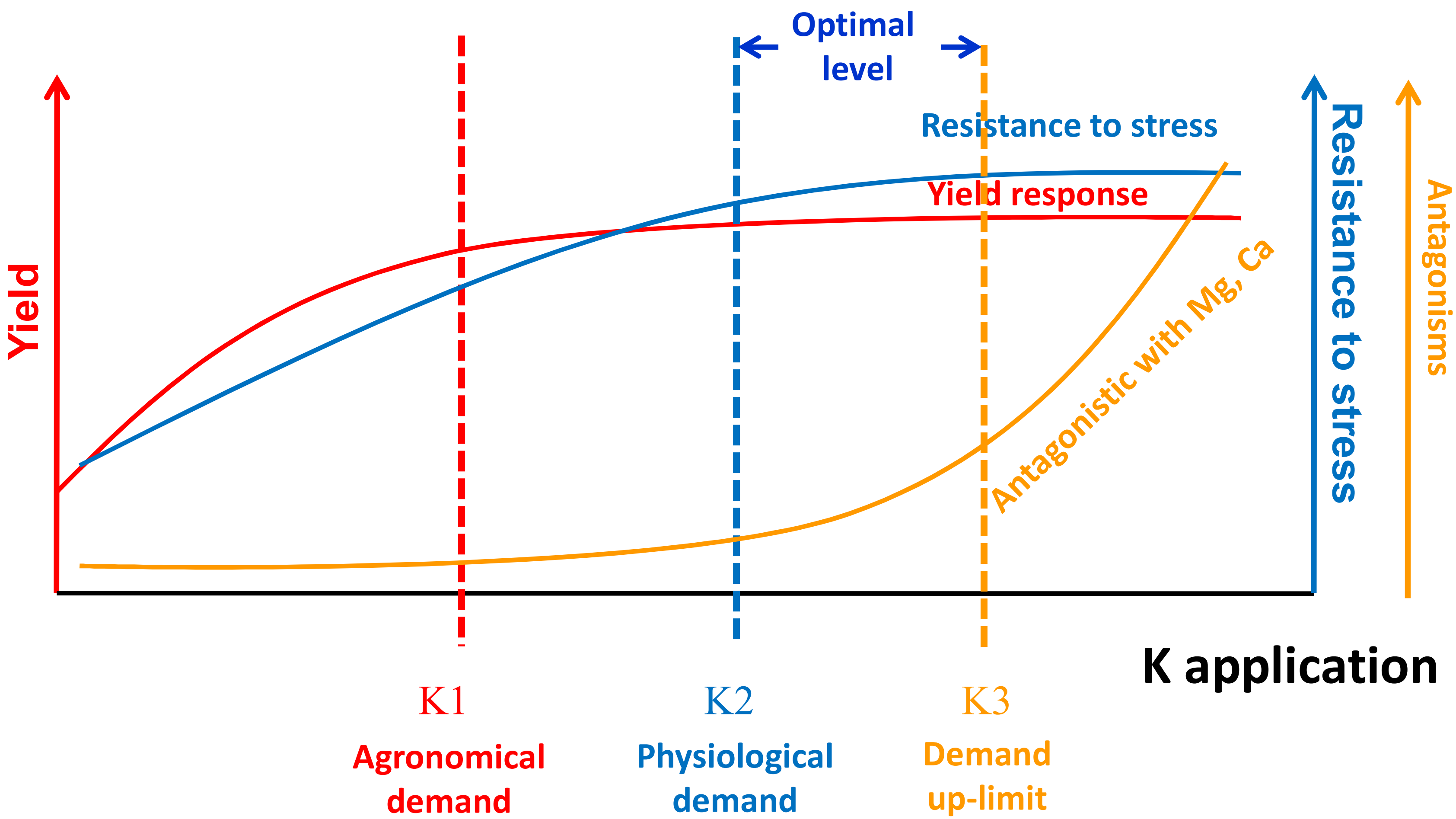


Fig. 22 A concept model showing the strategy of K integrated management

For this question, "Is it possible to further decline K consumption, and then reduce depletion of non-renewable potash mineral?", the answer would be "possible" in theory, if we could optimize both K application basing upon the concept model and K fertilizer distribution according to soil balance. In agricultural practices, however, we apparently need more studies to solve the practical problems.

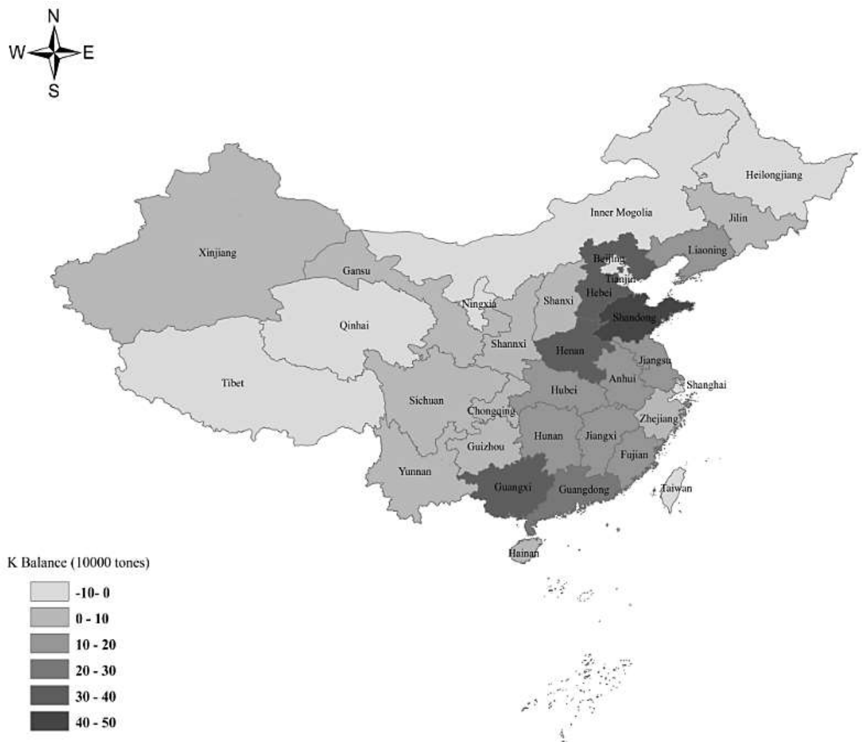


Fig. 23 K surplus appears in most of agriculture regions

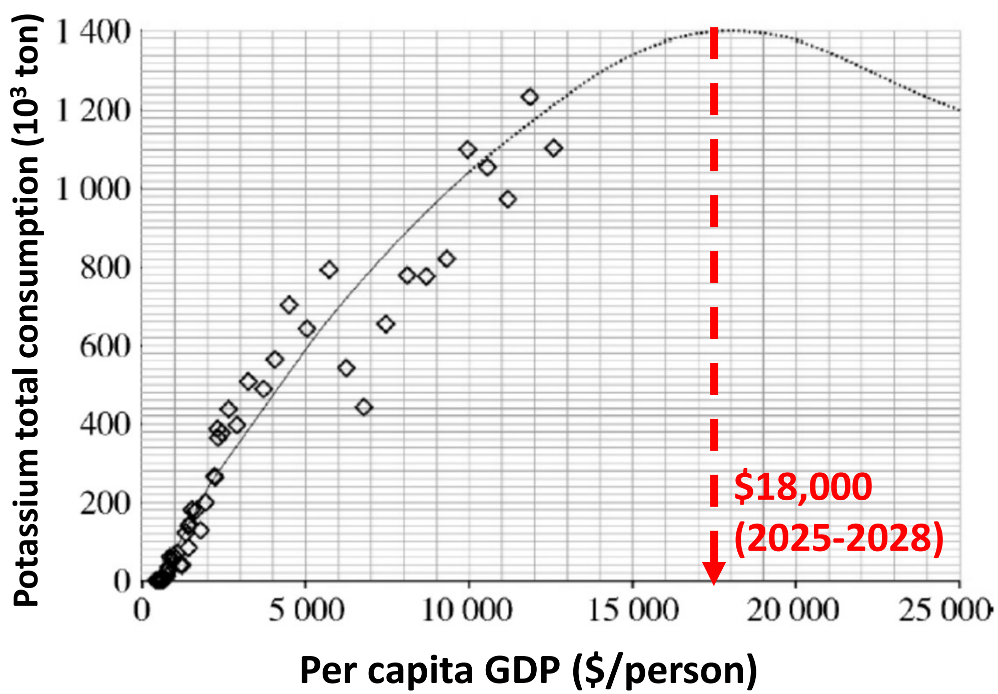


Fig. 24 Per capita GDP and potash consumption prediction in China

(Data source: Fertilizer data summary research platform of the ministry of agriculture)

(Niu et al., 2019, China Mining Magazine)

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