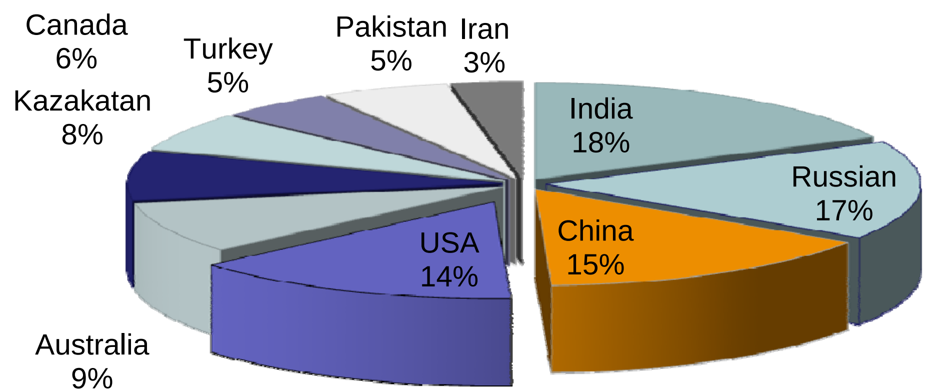
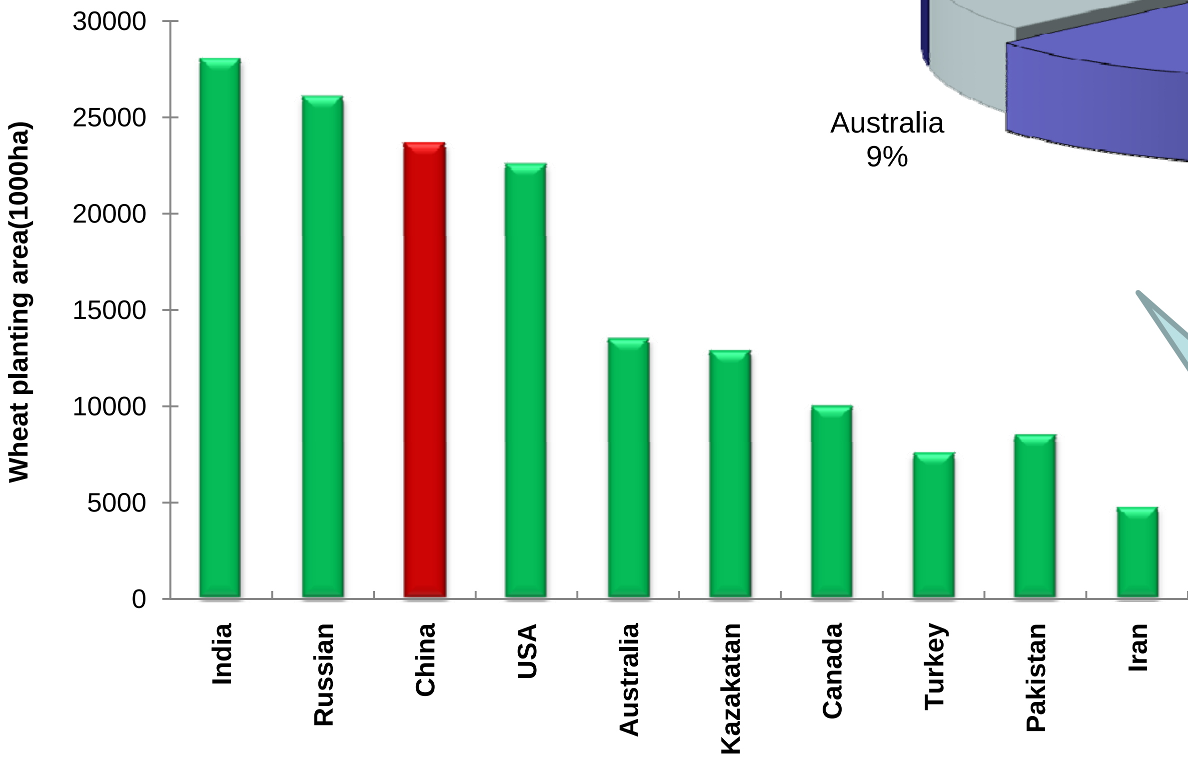
Yield gaps, indigenous nutrient supplies, and nutrient use efficiency for wheat in China

Ping He[1,2], Jiyun Jin[1,2], Xiaoyan Liu[2], Kaushik Majumdar[1], Steve Phillips[1]
1 International Plant Nutrition Institute
2 Institute of Agricultural Resources and Regional Planning, Chinese Academy of Agricultural Sciences, Beijing 100081

Wheat Production in China

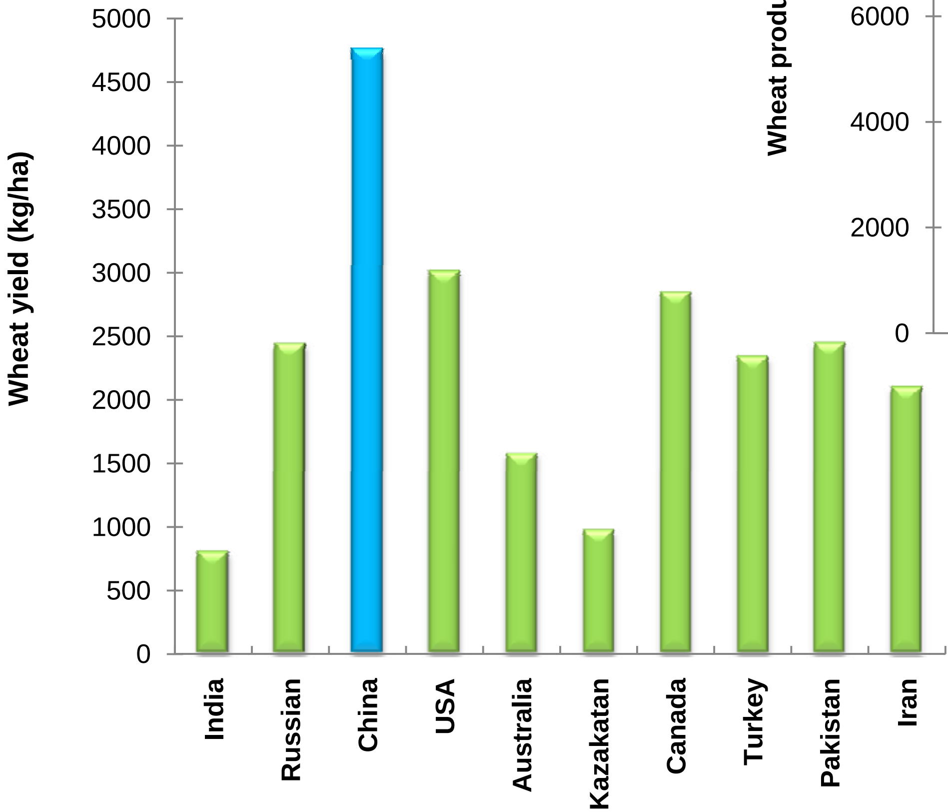


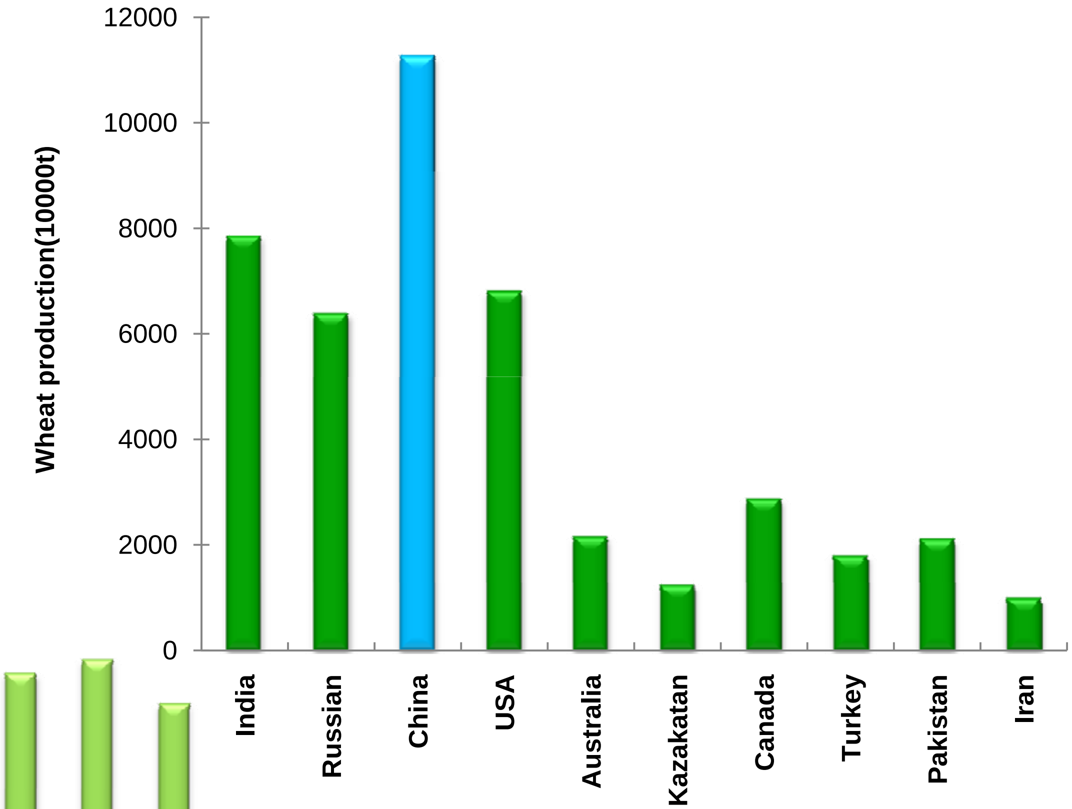


Wheat in China accounts for 15% world planting area, and ranks third in the world

Data source: FAO, 2008

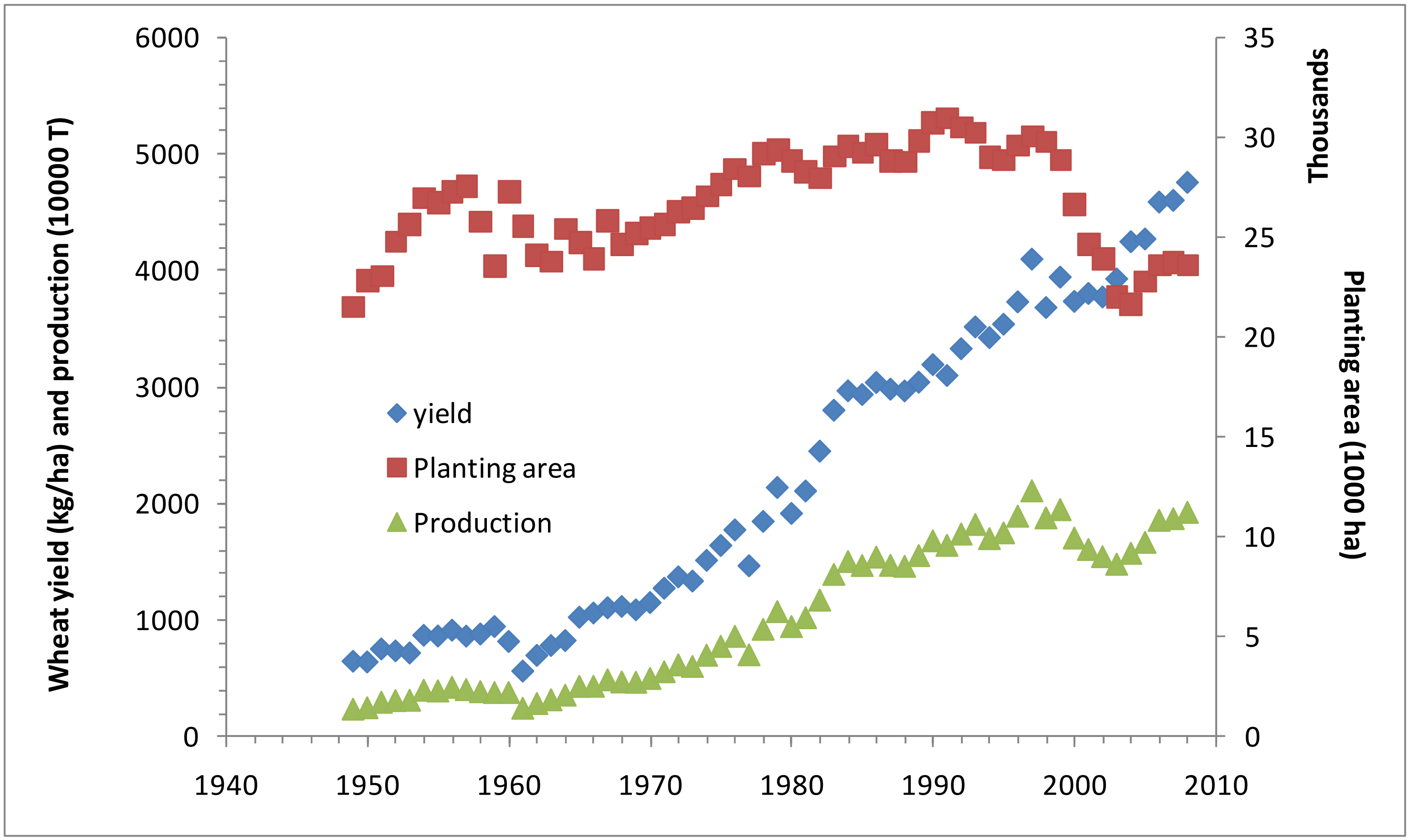
Wheat yield and production rank first in the world





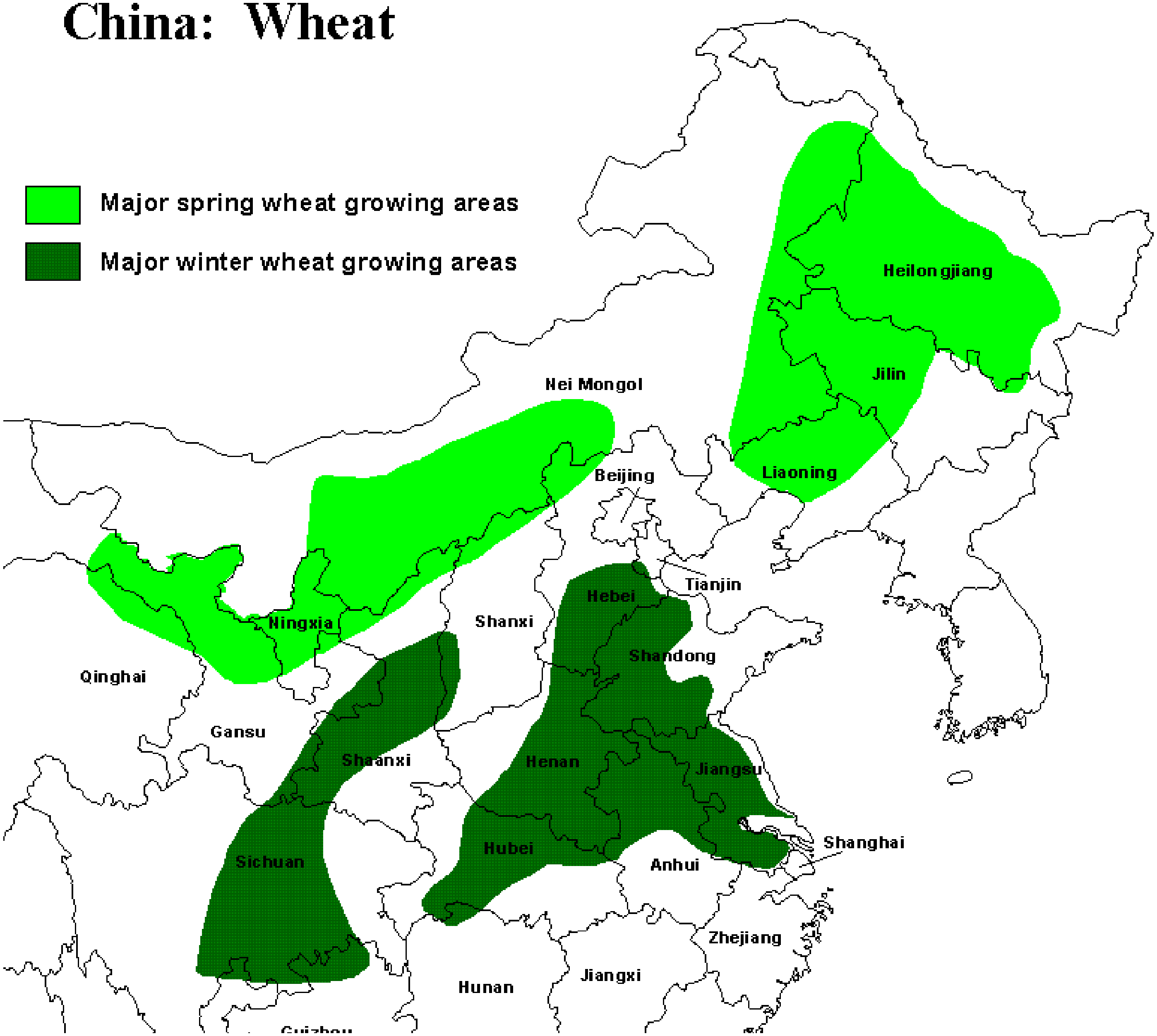
Data source: FAO, 2008

Temporal pattern of wheat production in China



Data source: China Agricultural Yearbook, 2008

China: Wheat

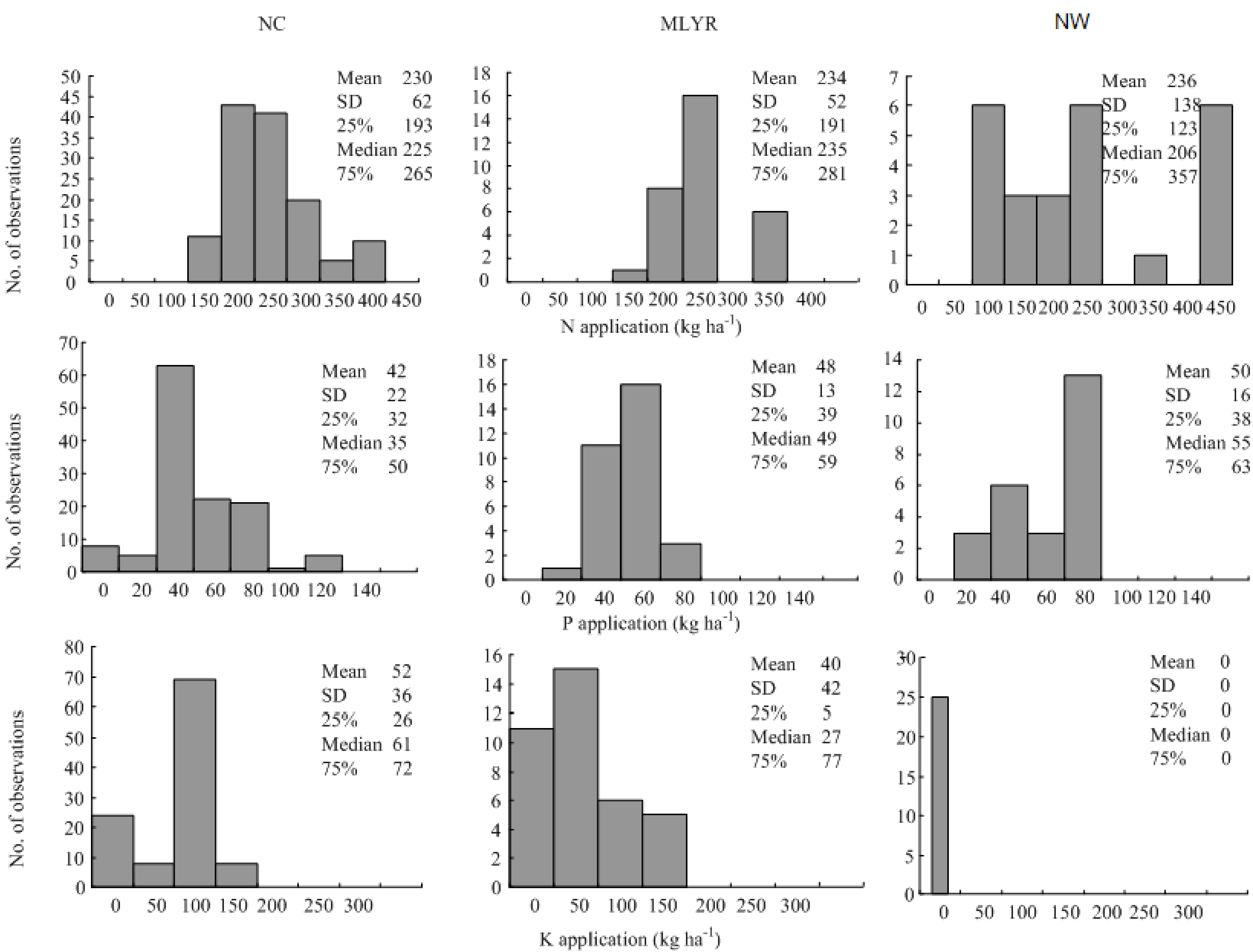

Major spring wheat growing areas
Major winter wheat growing areas
Nei Mongol
Heilongjiang
Jilin
Liaoning
Beijing
Tianjin
Hebei
Shanxi
Ningxia
Shandong
Qinghai
Gansu
Shaanxi
Henan
Jiangsu
Shanghai
Sichuan
Hubei
Anhui
Zhejiang
Jiangxi
Hunan

Farmer's fertilization practices in North Central China
-Highly Intensive Fertilization System

- Winter wheat to be 240 kg N/ha (ranged 113-360 kg/ha) and summer maize to be 260 kg N/ha (ranged 75–450 kg/ha (He et al, 2009).

- The nutrient inputs from compound fertilizer comprised 24, 61, and 35% of total N, P_2O_5, and K_2O input, and the ratio of N:P_2O_5:K_2O was 1:0.59:0.28 in Shandong , resulting in imbalanced nutrient inputs.

450-225-225 kg N-P_2O_5-K_2O/ha for super high yield



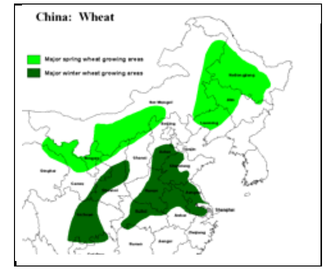
<u>Data source: He et al, unpublished</u>

Low fertilizer use efficiency

Location	Crop	AE_N(kg kg^{-1})		RE_N(%)	
		OPT	FP	OPT	FP
Shanxi	Wheat	4.1	2.7	34.5	29.0
	Maize	8.9	5.1	35.5	15.7
Hebei	Wheat	5.6	1.3	32.3	10.7
	Maize	3.9	1.8	18.0	14.7
Henan	Wheat	3.2	1.7	33.0	15.8
	Maize	3.2	1.2	20.1	7.4

Source: He et al, Agron.J. 2009,101:1489-1496

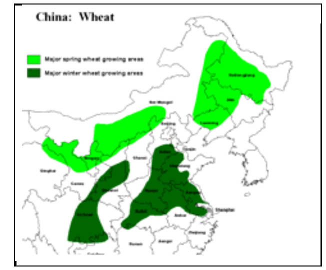
The objectives of this study



- ✓ Estimate the indigenous nutrient supply in different wheat producing areas of China
- ✓ Quantify the yield gap between Y_a and Y_f,
- ✓ Evaluate the wheat grain yield responses to applied N, P and K

Aim to optimize nutrient management practices to increase wheat yield, improve nutrient use efficiency and protect the environment.

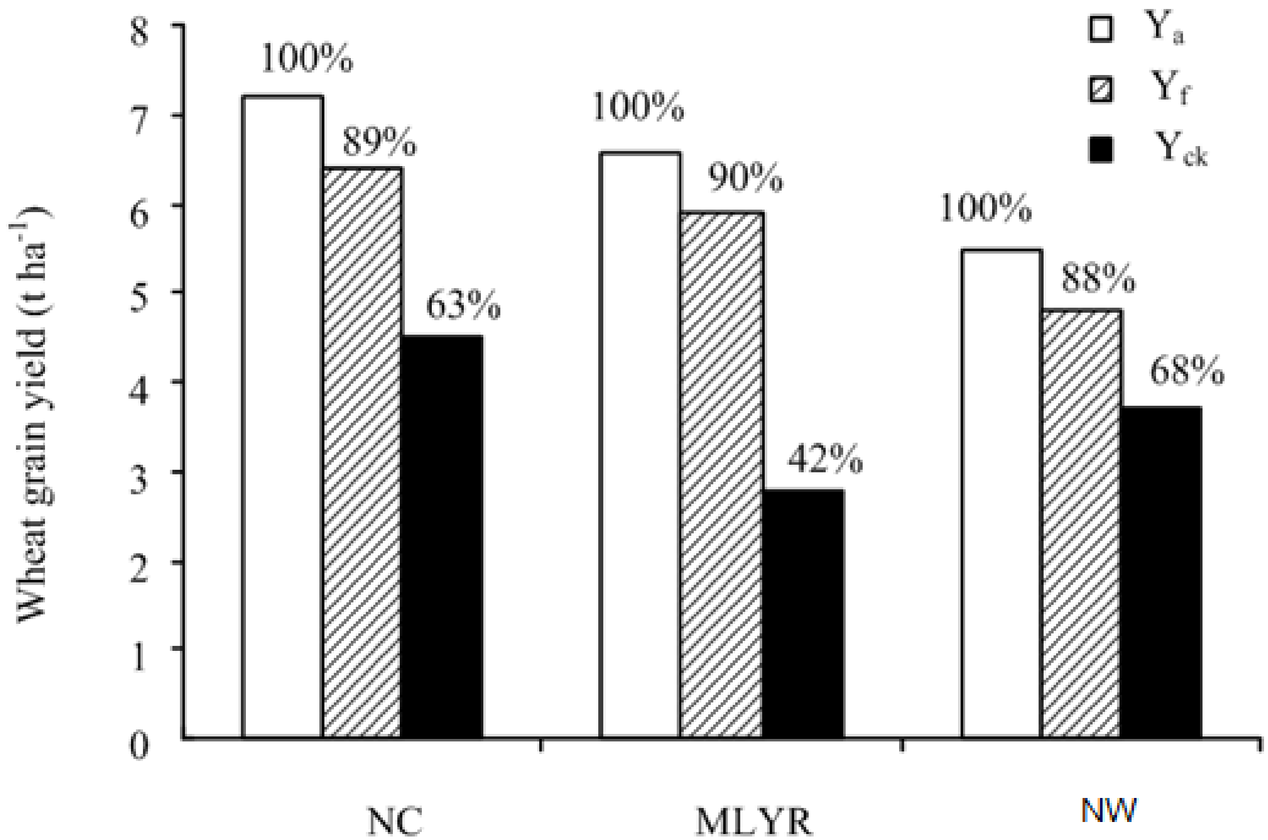
An overview of experimental sites for wheat production



Region†	Wheat season	Precipitation	Growth duration	No. of Experiments
NC	Winter	580–860	230–260	598
MLYR	Winter	1000–1800	200	301
NW	Spring	86–335	120–130	127

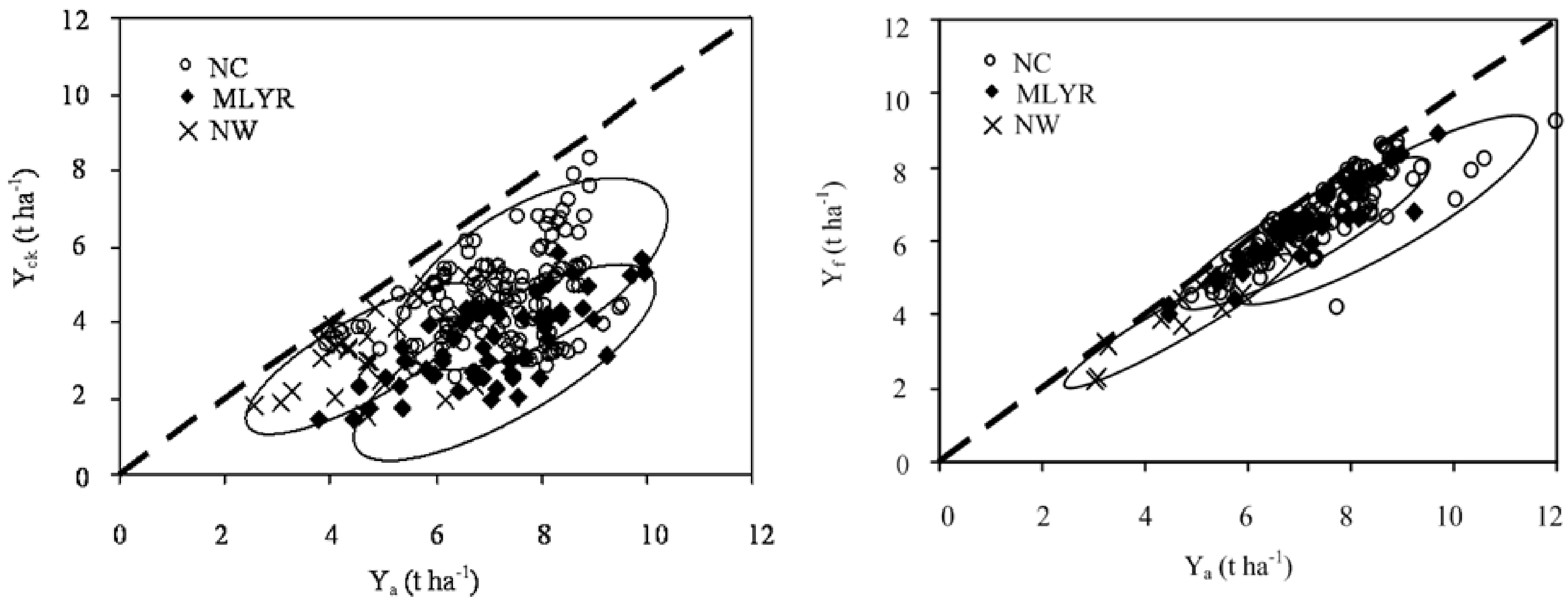
†NC (North-central China) includes Henan, Shandong, Shanxi, Beijing, Tianjin;
MLYR (Middle and lower reaches of the Yangtze River) includes Jiangsu, Anhui, Shanghai, Hubei, Hunan;
NW(Northwest China) includes Gansu, Ningxia, Qinghai, Xinjiang.

Differences among attainable yield (Y_a), farmer's fields (Y_f), and yield without fertilizer application (Y_{ck}) for wheat in NC, MLYR and NW



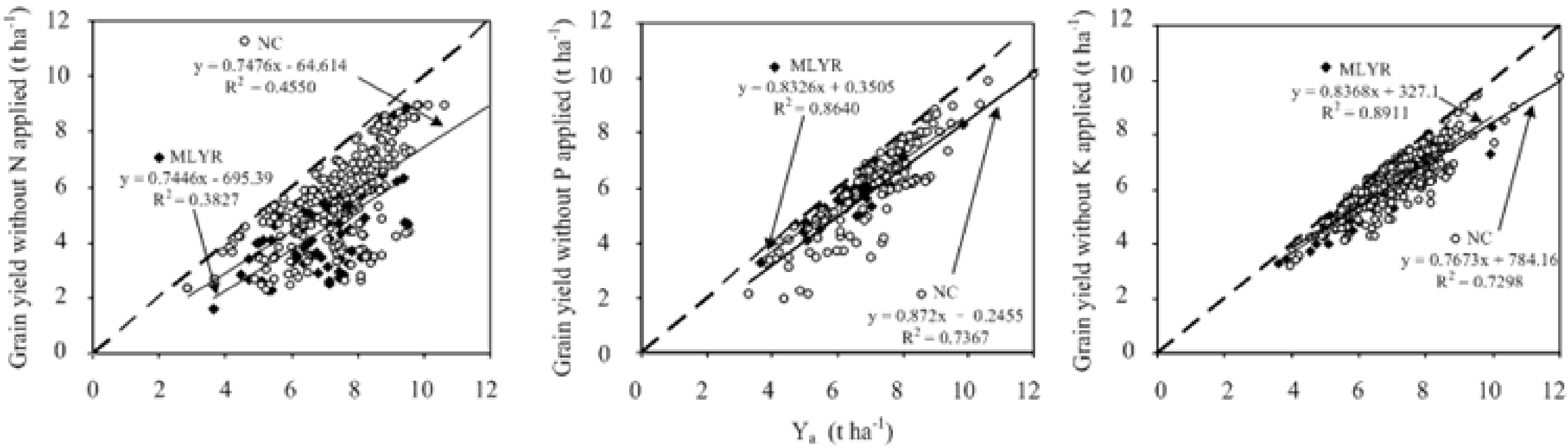
Data source: He et al, unpublished

Comparison analysis of attainable yield in experimental plots (Y_a), actual yield in farmer's fields (Y_f) and yield without fertilizer application (Y_{ck}) in NC, MLYR and NW



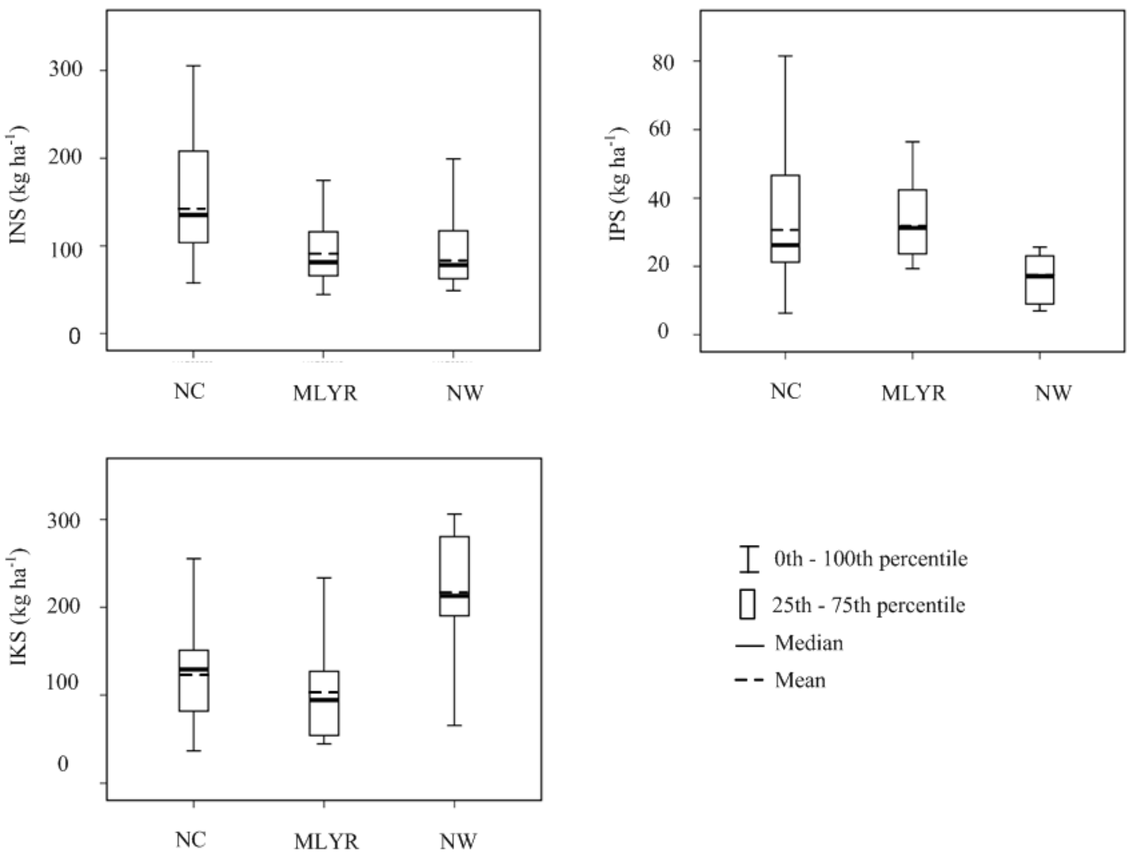
Data source: He et al, unpublished

Relationship between grain yield without N or P or K application and attainable yield with balanced NPK fertilization in experimental plots (Ya) for wheat in NC, MLYR and NW



Data source: He et al, unpublished

Indigenous nutrient supply of wheat in NC, MLYR and NW

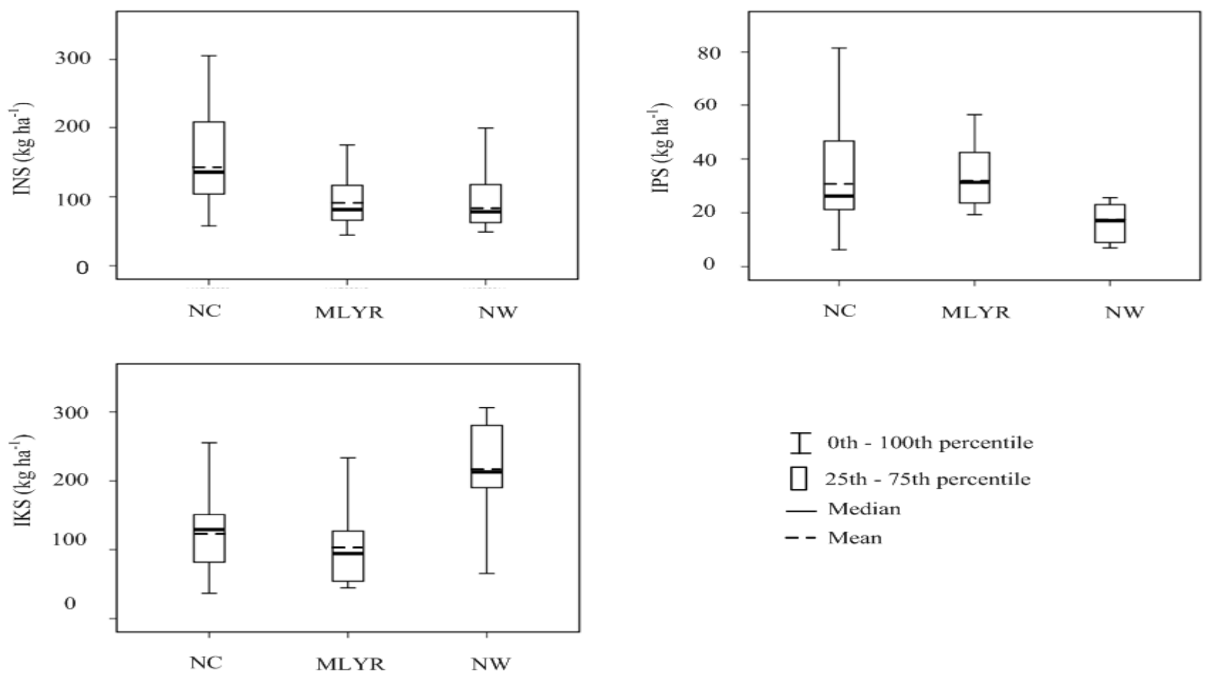


Data source: He et al, unpublished

Grain yield responses to applied N, P or K for wheat in different production regions of China

Data source: He et al, unpublished

Region†	N	P	K
NC	1932	1171	867
MLYR	2537	751	710
NW	1025	344	441
Average	2000	931	782



Internal efficiency (IE) of applied N, P and K fertilizer for optimal treatment (OPT) for wheat in different production regions of China

Region†	$IE_{N,}$ kg kg^{-1}	$IE_{p,}$ kg kg^{-1}	$IE_{k,}$ kg kg^{-1}
NC	34.6	207.7	48.4
MLYR	34.4	193.9	55.3
NW	42.5	270.8	34.8
Average	34.7	206.8	50.0

† $IE_{N,}$ IE_P and IE_K indicate internal efficiency of N, P and K, respectively.

Data source: He et al, unpublished

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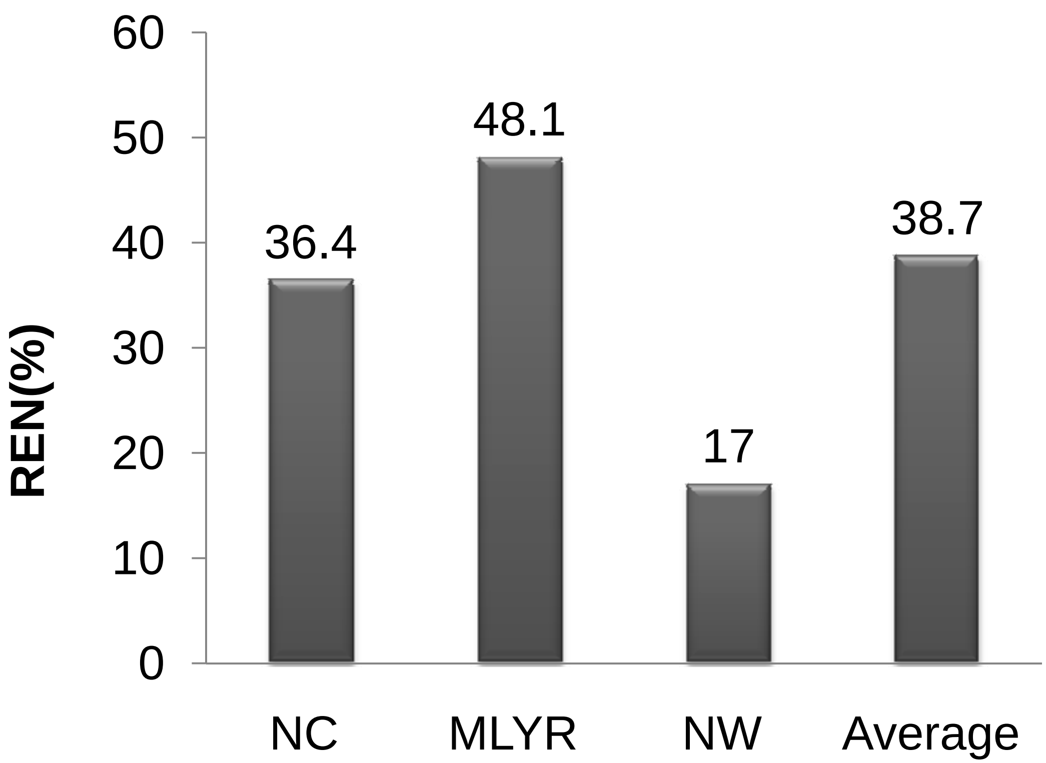
Agronomic Efficiency (AE) and Partial Factor Productivity (PFP) of applied N, P and K fertilizer for optimal treatment (OPT) for wheat in different production regions of China

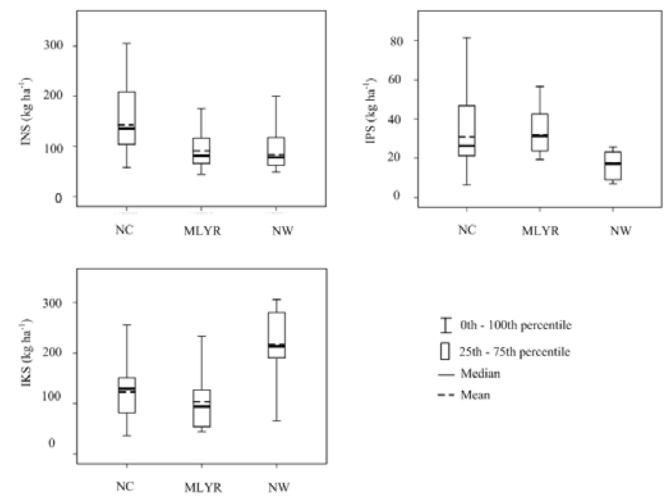
Region†	$AE_{N,}$ kg kg^{-1}	$AE_{p,}$ kg kg^{-1}	$AE_{k,}$ kg kg^{-1}
NC	9.5	23.0	7.6
MLYR	11.3	18.4	8.3
NW	6.5	7.0	4.2
Average	9.8	19.2	7.2

Region†	$PFP_{N,}$ kg kg^{-1}	$PFP_{p,}$ kg kg^{-1}	$PFP_{k,}$ kg kg^{-1}
NC	37.5	141.8	71.0
MLYR	33.3	145.7	76.2
NW	36.9	141.9	66.1
Average	36.3	142.8	71.9

Data source: He et al, unpublished

Recovery efficiency (RE) of applied N fertilizer for optimal treatment (OPT) for wheat in different production regions of China





Data source: He et al, unpublished

Partial nutrient budget (PNB) of applied N, P and K fertilizer for optimal treatment (OPT) for wheat in different production regions of China

Region†	$PNB_{N,}$ %	$PNB_{p,}$ %	$PNB_{k,}$ %
NC	1.10	1.07	1.67
MLYR	0.81	0.91	1.73
NW	0.70	0.43	2.73
Average	0.95	0.96	1.82

‡ PNB_N, PNB_P and PNB_K indicate partial nutrient budget of N, P and K, respectively.

Partial nutrient budget is calculated as nutrient accumulated in harvested crop product per unit of nutrient applied and answers the question “How much of nutrient is being taken out of the system in relation to how much is applied”

Data source: He et al, unpublished

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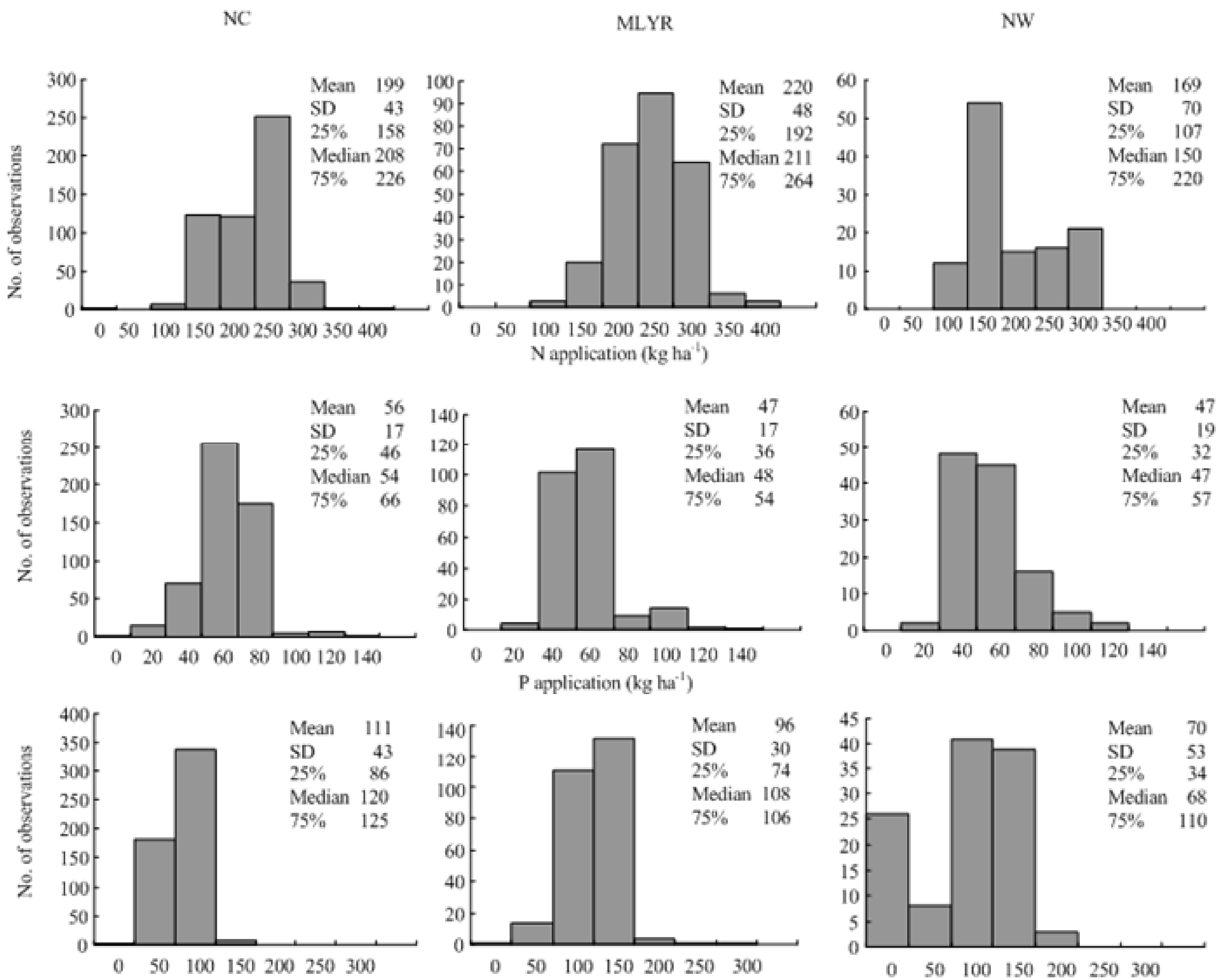

Data source: He et al, unpublished

Conclusions

- Narrowing yield gaps between attainable yields and farmer's yield over about 23 million hectares will help in sustainable food security.
- Nutrient management strategies must take into account indigenous nutrient supplying capacity at the response level.
- Major opportunities are there to improve nutrient efficiencies, minimize nutrient loss to the environment and subsequent improvement in farmers' profit.

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