Yield Responses and Potassium Use Efficiency for Winter Wheat in Northcentral China

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Field experiments were conducted to study yield responses and K use efficiency parameters for wheat in three provinces across three years in northcentral China. Potassium application increased grain yield and profit for wheat in most cases. Determination of K use efficiency parameters demonstrated that there is potential to optimize K use efficiency further with best nutrient management practices.

Wheat (Triticum aestivum L.) is one of the most important cereal crops in China, and K fertilizer applications have played a major role in increasing wheat yield. However, wheat production sometimes is limited because farmers give little attention to K application. Due to the limited potash resources in China and increasing fertilizer cost, efficient application of K is very important. Understanding the yield responses, profitability and K use efficiency parameters of K application is essential for the further improvement of K use efficiency for high yielding wheat production systems.

To evaluate K responses on winter wheat in northcentral China, field experiments were carried out for nine sites/years in farmer fields in Hebei, Shandong, and Shanxi provinces from 2006 to 2009. The trial soils were fluvo-aquic, brown, and calcic cinnamon soils for Hebei, Shandong, and Shanxi respectively. Prior to sowing, soil samples (0 to 20 cm) were collected and analyzed for nutrient status. Soil nutrients were determined with procedures applied by the National Laboratory of Soil Testing and Fertilizer Recommendation using the method described by Portch and Hunter (2002). Winter wheat was sown at the beginning of October and harvested in mid-June of the next year. Each experiment was designed in a randomized complete block with three replications of two treatments: with K application, and without K. Urea, SSP, and KCl were selected as fertilizer sources. All other limiting nutrients in addition to K were applied using a rate suited to eliminate limitations on yield (**Table 1**).

About one half to one third of N, and all the P and K fertilizer, were applied basally before sowing and the remaining N was topdressed in early spring before the tillering stage of winter wheat. Irrigation, insect-control, inter-row tillage and other management activities were conducted according to farmers' practice. At harvest time, aboveground biomass including straw and grain yield were recorded. Seed and straw samples were randomly collected for determination of dry matter weight, and analyzed for total K.

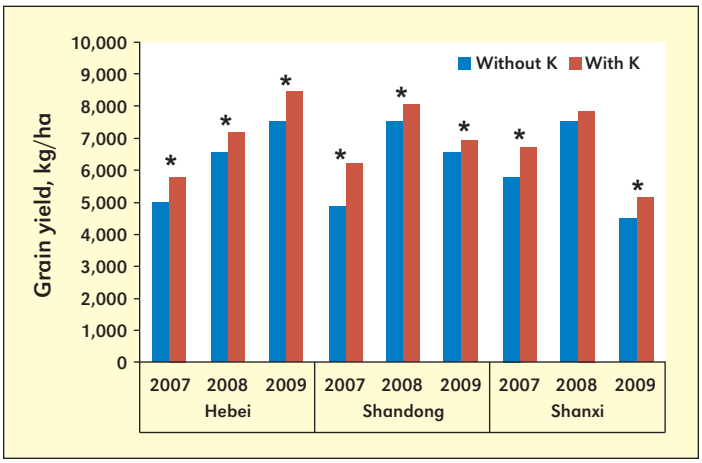


Figure 1. Grain yield of wheat in different sites-years as influenced by K application (wheat was harvested in June of 2007, 2008 and 2009; the symbol * indicates significance at $p<0.05$ between treatments without K and with K).

Yield Responses to K Application

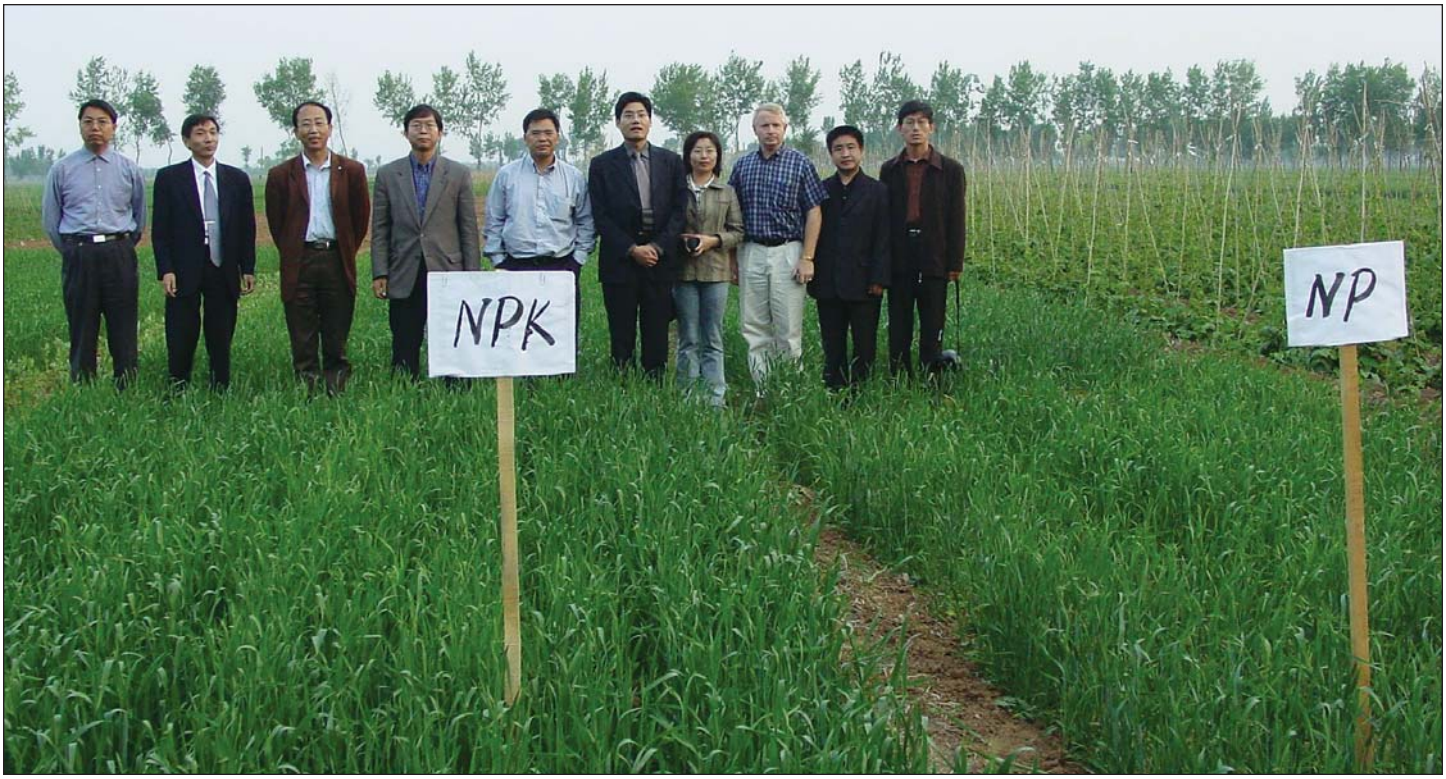
Potassium application increased grain yields of wheat sig-

Common Abbreviations and Notes: N = nitrogen; P = phosphorus; K = potassium; NO_3^- = nitrate; NH_4^+ = ammonia; KCl = potassium chloride; SSP = single superphosphate; RE = recovery efficiency; AE = agronomic efficiency; PFP = partial factor productivity; USD = United States dollar; RMB = Chinese Yuan.

Table 1. Fertilizer application rates and agro-chemical properties of tested soils.

Province	Location	Year	N	P_2O_5	K_2O	pH	OM	NO_3^--N	NH_4^+-N	P	K
			kg/ha				%	mg/L			
Hebei	Xinji	2007	180	100	75	8.4	0.70	ND[1]	4.9	22	78
	Xinji	2008	180	75	120	8.4	0.53	23.4	23.4	43	72
	Xinji	2009	180	60	90	8.3	0.49	23.9	10.6	18	50
Shandong	Haiyang	2007	240	30	120	7.9	1.17	3.5	8.9	59	45
	Qingzhou	2008	210	75	60	8.2	1.01	17.6	5.4	25	83
	Qingzhou	2009	240	75	90	7.7	0.80	20.6	12.2	28	75
Shanxi	Linfen	2007	195	90	150	8.1	0.35	3.1	20.5	21	72
	Linfen	2008	180	150	120	8.3	0.65	ND	0	29	266
	Linfen	2009	210	105	90	8.3	1.03	12.0	9.7	32	79

[1]ND = no data



Field experiments comparing the effects of K application in wheat production in Hebei. Dr. Terry Roberts (the third from right), Dr. Ping He (the fourth from right) and Dr. Shutian Li (the fourth from left) along with project cooperators.

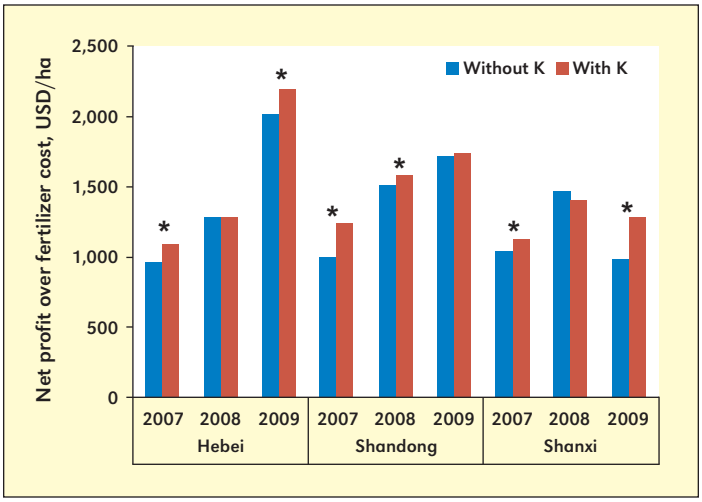


Figure 2. Net profit over fertilizer cost for wheat in different sites/years as influenced by K application (the symbol * indicates significance at $p<0.05$ between treatments without K and with K).

nificantly in all sites except Shanxi in 2008. Yield responses to K application in 2007, 2008, and 2009 were: 13, 10, and 11% in Hebei; 21, 7, and 5% in Shandong; and 13, 5, and 13% in Shanxi, respectively (**Figure 1**). The low yield response to K application for Shanxi in 2008 was at the site with a very high soil K level, and the largest yield response to K application in Shandong in 2007 was related to a very low soil test K level (**Table 1**). Therefore, to some extent, yield response was inversely related to soil fertility, in that yield response was low when soil test was high, and vice versa. These results have also been used to develop a fertilizer recommendation method based on yield response for use under conditions when soil testing is not available (Pampolino et al., 2011; He et al., 2012).

Table 2. Fertilizer and crop prices used in profit analysis shown in Figure 2.

Province	Year	Wheat	N	P_2O_5	K_2O
		RMB/kg			
Hebei	2007	1.56	3.91	4.38	4.33
	2008	1.60	5.65	8.13	8.67
	2009	2.00	4.35	6.25	7.33
Shandong	2007	1.60	3.40	4.50	3.40
	2008	1.60	4.80	7.60	6.70
	2009	2.00	3.90	4.17	6.70
Shanxi	2007	1.44	3.90	5.20	3.70
	2008	1.65	5.70	7.60	9.00
	2009	2.00	3.70	7.30	7.00

1 USD=6.9 RMB

Profitability from K Application

Generally, the net profitability over fertilizer cost from K application followed similar trends to grain yields (**Figure 2**). In most cases (six out of nine), K application significantly increased net profitability by 12% in 2007 and 8% in 2009 in Hebei, 20% in 2007 and 5% in 2008 in Shandong, and 9% in 2007 and 23% in 2009 in Shanxi. Some variability existed across years and sites due to the changes in crop price and fertilizer cost. Comparatively, good profitability was observed in 2009 with good crop prices and moderate fertilizer cost, while low profitability in 2008 in Hebei and Shanxi was related to low crop prices and high fertilizer cost (**Table 2**). In the latter case, farmers can decide on how much K fertilizer to apply to

Table 3. Potassium use efficiency parameters for wheat in different sites/years.

Province	RE, %			AE, kg/kg K_2O			PFP, kg/kg K_2O		
	2007	2008	2009	2007	2008	2009	2007	2008	2009
Hebei	47	35	47	10.2	5.5	9.9	77	60	94
Shandong	42	38	52	11.0	9.4	4.2	52	134	77
Shanxi	41	35	27	5.7	3.2	11.1	45	66	61

make K application profitable.

K Use Efficiency

Nutrient use efficiency can be expressed by crop RE, AE, and PFP (Fixen, 2007). AE refers to the crop yield increase per unit nutrient applied, RE refers to the increase in plant nutrient uptake per unit nutrient applied, and PFP refers to the crop yield per unit nutrient applied. Measurements of RE, AE, and PFP for applied K resulted in large location-to-location variability. Mean RE values across three years were 47, 44, and 34% for Hebei, Shandong and Shanxi, respectively. Mean AE values were 8.5, 8.2, and 6.7 kg/kg, while mean PFP values were 77, 88, and 57 kg/kg for Hebei, Shandong and Shanxi, respectively. The different values for K nutrient use efficiency were related to how much fertilizer was used and how much grain yield or yield increase was obtained by K application. For example, the very high PFP value of 134 kg/kg in 2008 in Shandong was due to the relatively low K application rate (60 kg K_2O/ha) and very high grain yield (**Figure 1**).

In summary, K application increased wheat grain yield, and net profitability in most cases in northcentral China. The average yield response to K application was less than 1 t/ha, and K use efficiency parameters of RE, AE, and PFP were relatively low. Therefore, further best management practices, through 4R Nutrient Stewardship (right source at the right rate, right time and right place) should be integrated into common practices to improve fertilizer use efficiency for wheat. BC

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2012 IPNI Crop Nutrient Deficiency Photo Contest Announced

Once again we welcome all those with a keen eye and ready access to agricultural production, at either the field or research plot scale, to seek out and gather their best examples of crop nutrient deficiency for entry into the 2012 edition of our photo contest.

The competition continues to foster awareness about, and focus attention on, identifying the common traits of nutrient deficiency for a wide range of crops. We are proud of how this contest has grown into an international challenge to field researchers, farmers, students, and other interested in crop production.

The competition continues with its four nutrient categories: Nitrogen (N), Phosphorus (P), Potassium (K), and Other (Secondary and Micronutrients). Entrants are limited to one entry per category (i.e., one individual could have an entry in each of the four categories). The winner in each category will receive a cash prize of USD 150 while second place receives USD 75. Selection of winners will be determined by a committee of IPNI scientific staff.

Photos and supporting information can be submitted until December 11, 2012 (5 pm EDT). Winners be notified and the results will be announced at our website and in this publication in January of 2013. Entries should only be submitted as original, digital files. Please see the contest site www.ipni.net/photocontest for all details. BC