Corn Response to Potassium on Black Soil in Heilongjiang

By Li Yuying

A 7-year study demonstrates the potential yield and profit gains from annual additions of potassium (K) fertilizer in a region traditionally considered to have 'no need'.

The northeastern province of Heilongjiang occupies 453,900 square kilometers, with more than 10 million hectares (M ha) of cultivated land. Main soil types are Black, Meadow, and Chernozem, which respectively cover 3.6, 3.0 and 1.6 M ha. Heilongjiang is the leading grain producing province in China and the main crops are corn, soybean, rice, and wheat. Corn covers about 2.5 M ha annually or nearly 25% of the total cultivated land in the province. Annual production is about 11.9 million tonnes (M t), which represents about half of all cereals produced in the province.

Farmers in Heilongjiang are accustomed to using only nitrogen (N) and phosphorus (P) fertilizers. In fact, at the initiation of this experiment, farmers had little experience with K fertilizer.

Tradition suggests that these soils are 'rich' in K, thus the lack of emphasis on K application. As a result, little was known about how corn responds to K application and what effect successive K applications would have on soil fertility. This experiment was established to specifically answer these two questions.

Plots with 112 kg K_2O/ha (right) and with no K (left) near Shuangcheng City, Heilongjiang.

The site was located at the Extension Center of Agricultural Technology in Shuangcheng City, Heilongjiang. Shuangcheng is the main region for corn production and has a higher average yield than other regions in the province. Soil at the field site was Black with 1.14% organic matter (OM). Available N, P, and K were measured at 11.6, 5.0, and 66.5 mg/kg, suggesting a K responsive soil.

Potassium fertilizer was applied each year over a 7-year period. There were three treatments with four replications (**Table 1**). Plots were 30 m^2 in size and were arranged in a randomized block design. Soil and plant samples were collected after each harvest. The NPK fertilizers used were urea, diammonium phosphate (DAP), and potassium chloride (KCl).

Table 1. Fertilizer rates (kg/ha) applied at Shuangcheng City, Heilongjiang.

Treatment	N	P_2O_5	K_2O	$ZnSO_4$
NP	172	120	0	20
NPK_1	172	120	112	20
NPK_2	172	120	225	20

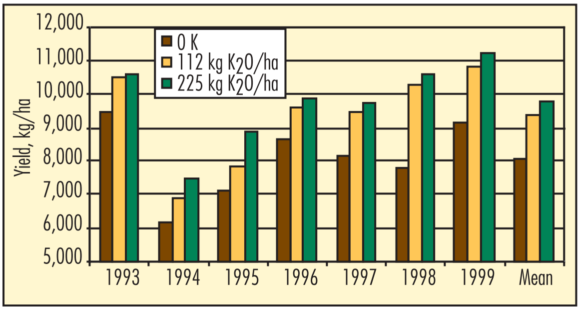

Figure 1. Corn yield response to K for seven successive years in Black soil, Heilongjiang Province.

Effect of K Fertilizer on Corn Yield and Profit

The site's low available soil K content correctly predicted a response to K as yield was consistently higher with K fertilizer application (**Figure 1**, **Table 2**). Compared to zero K, application of 112 kg K_2O/ha increased the 7-year average yield and net benefit by 1,280 kg/ha (15.8%) and US$95/ha, respectively. Similarly, the 225 kg K_2O/ha rate increased average yield and net benefit by 1,689 kg/ha (20.9%) and US$102/ha. Interestingly, the largest differences in yield between the two K supplying treatments were 560 and 1,040 kg/ha, occurring in 1994 and 1995, the two poorest years of the seven studied.

Table 2. Yearly and average yield effects of 7 years K application to corn, Shuangcheng City, Heilongjiang.

Year	Treatment	Yield, kg/ha	Increase kg/ha	Increase kg/kg K_2O	Increase %	Benefit, US$/ha[1]
1993	K_0	9,470	–	–	–	–
	K_1	10,500	1,030	9.2	10.9	73.5
	K_2	10,600	1,130	5.0	11.9	48.7
1994	K_0	6,180	-	-	-	-
	K_1	6,910	730	6.5	11.8	39.7
	K_2	7,470	1,290	5.7	20.9	61.4
1995	K_0	7,130	–	–	–	–
	K_1	7,830	700	6.2	9.8	36.2
	K_2	8,870	1,740	7.7	24.4	106.4
1996	K_0	8,660	–	–	–	–
	K_1	9,610	950	8.4	11.0	61.1
	K_2	9,870	1,210	5.4	14.0	52.5
1997	K_0	8,180	–	–	–	–
	K_1	9,500	1,320	11.7	16.1	100
	K_2	9,740	1,560	6.9	19.1	88.5
1998	K_0	7,780	–	–	–	–
	K_1	10,300	2,520	22.4	32.4	218.6
	K_2	10,600	2,820	12.5	36.2	214.2
1999	K_0	9,160	–	–	–	–
	K_1	10,800	1,640	14.6	17.9	136
	K_2	11,200	2,040	9.1	22.3	141.9
Cumulative	K_0	56,560	–	–	–	–
	K_1	65,450	8,890	–	–	–
	K_2	68,350	11,790	–	–	–
Mean	K_0	8,080	–	–	–	–
	K_1	9,360	1,280	11.4	15.8	95
	K_2	9,770	1,690	7.5	20.9	101.9

[1]The average price of corn was US$0.10 /kg. The average cost of KCl was US$187/t.
K_0 = zero K; K_1 = 112 kg/ha; K_2 = 225 kg/ha

Soil K Balance

Potassium removal by corn was higher in plots supplied with K than in plots without K (**Table 3**). Corn removed larger quantities of soil K when supplied with the high rate versus the low rate of K fertilizer. Over 7 years, the balance coefficient for the lower rate was 0.96, indicating that slightly more K was removed than was applied as fertilizer. At the higher rate, the average balance coefficient was 1.4, indicating soil K status was likely improved over the 7 years.

Potassium Fertilizer and Corn Grain Quality

Potassium fertilizer application showed a positive effect on the quality of harvested grain (**Table 4**). As K application rates increased, protein, cystine, and methionine contents increased, while percent starch content decreased. Cystine and methionine are sulfur (S)-containing amino acids important for

In addition to improved yield and profit potential, K fertilization also improved nutritional value of harvested grain.

animal and human health.

Conclusions

Results from this 7-year, fixed-site trial found rapid soil K depletion and unsustainable grain yields if no K fertilizer was applied. Application of 112 and 225 kg K_2O/ha contributed to successively better soil K balance and supplying capacity, which translated into higher yields and farmer profit.

Potassium fertilization also improved the nutritional value of harvested grain by elevating the protein content, and more specifically, the content of S-containing amino acids. Further studies on whether these improvements to animal feed might translate into more efficient livestock production would prove interesting.

It is apparent that K fertilizer is necessary to maintain or improve soil K status on these soils, which contradicts longstanding attitudes of farmers. More study is required in order to determine the optimal rate capable of providing the highest benefit to farmers while maintaining good soil K supply capacity. BCI

Table 3. Estimate of soil K output (kg/ha) and balance coefficients, Shuangcheng City, Heilongjiang.

	Treatment	1994	1995	1996	1997	1998	1999	Mean
K output	K_0	71.7	68.5	73.5	81.8	43.9	83.9	70.6
	K_1	99.5	122	113	118.6	114	142.7	118.3
	K_2	160.6	167	181.5	174.6	144.2	189.4	169.6
Balance coefficient	K_0	–	–	–	–	–	–	–
	K_1	1.1	0.92	1	0.95	0.99	0.79	0.96
	K_2	1.4	1.34	1.24	1.28	1.97	1.19	1.4

K_0 = zero K; K_1 = 112 kg/ha; K_2 = 225 kg/ha

Table 4. Analysis of corn grain quality grown on plots treated with different rates of K, Shuangcheng City, Heilongjiang.

Treatment	Protein	Starch	Cystine	Methionine	S content (amino acids)
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NPK_0	8.23	73.32	0.134	0.139	0.273
NPK_1	10.50	70.71	0.140	0.172	0.312
NPK_2	9.55	71.80	0.170	0.195	0.365

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