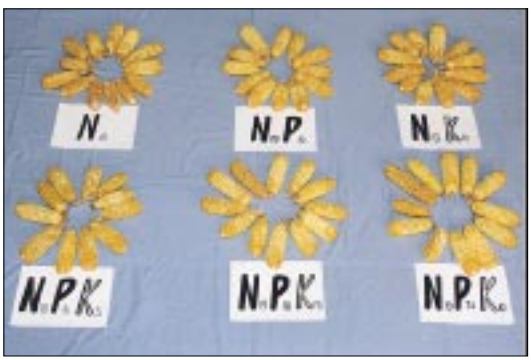
Responses to Phosphorus and Potassium Application in a Wheat-Corn Rotation in Hebei Province

By Guo Jianhua, Xing Zhu, and Liu Zongheng

Results of an experiment in the Hebei Plain show the importance of balanced fertilization for higher yields and economic returns in a wheat-corn rotation.

A wheat-corn rotation is the main cropping system in the Hebei Plain. It has been fertilized with nitrogen (N) and phosphorus (P) for the past several years. However, insufficient P rates and no potassium (K) application have resulted in imbalanced levels of soil P and K.

Crop yields have improved with newer crop varieties, but the experiment outlined in this article shows winter wheat grain yield increased by 39 percent using N and P compared to N alone. Corn yield increased by 15 percent by applying N and K compared to N alone. Proper balancing of N, P and K in the wheat-corn rotation produced the highest yields and economic benefits for farmers.



Proper balancing of N, P and K in the wheat-corn rotation produced the highest yields and economic benefits for farmers.

The experiment was located in Zhengding county, Hebei province. Annual precipitation in the region ranges between 500 to 600 mm. Soil organic matter was 1.0 percent, and available soil N and P (P_2O_5) were 62 and 38 mg/kg, respectively. The established system of crop rotation was winter wheat followed by summer corn. The wheat variety was Jimai-26 planted at about 2.7 million plants/ha. The corn variety was Yedan-2, planted at about 67,500 plants/ha. All crop management practices were optimum for the two crops.

Treatments were arranged in a randomized complete block design with four replications. Nitrogen was held constant at 195 kg/ha for wheat and 210 kg/ha for corn. Three levels (0, 112.5 and 150 kg/ha) of both P_2O_5 and K_2O were applied only to wheat and were tested in varying combinations. The subsequent corn crop received only N while the residual effects of P and K were studied. Fertilizer sources were urea, single superphosphate (SSP), and potassium chloride (KCl).

Results and Discussion

Response to P and K application in a wheat-corn rotation. Results showed that P application could improve both wheat root and tiller growth before the onset of winter. Comparing P and non-P treatments without added K, tillers increased 3.92 million/ha (**Table 1**), and average tillers per plant increased by 0.77 (data not shown). In addition, wheat spikes increased 2.12 million/ha, above ground dry matter weight increased 70 percent (data not shown), and wheat grain yield increased 1,533 kg/ha (39 percent).

The treatment with P absent, but K added, increased wheat yield by only 0.9 percent, indicating the importance of P to wheat at this location. Even when P was added at 112.5 kg P_2O_5/ha and K at 150 kg K_2O/ha, wheat yield failed to reach the same level (5,445 kg/ha) as that obtained with 150 kg/ha P_2O_5 and no K.

Only when P_2O_5 was applied at 150 kg/ha and K_2O at 112.5 kg/ha was there a positive response (349 kg/ha) to K application. This clearly indicates the importance of applying at least 150 kg/ha P_2O_5 to this rotation for both efficient use of applied K and high yields.

The corn experiment studying the residual effects of P and K application to wheat showed corn yield increased 1,543 kg/ha (25 percent) with 150 kg P_2O_5/ha compared to no P (**Table 1**). The corn kernel number per ear increased 11.0, and the barren part of the ear shortened 0.7 cm with application of K fertilizer.

Table 1. Yield and agronomic responses to P and K applied to wheat in a wheat-corn rotation in Hebei.

		Winter wheat			Corn		
P_2O_5	K_2O	Yield,	Maximum tillers	Spikes	Kernel	Bare ear length,	Yield,
kg/ha		kg/ha	million/ha		number	cm	kg/ha
0	0	3,912	9.59	3.59	399	1.9	6,261
150	0	5,445	13.51	5.71	464	1.3	7,804
0	150	3,949	9.24	3.96	410	1.2	7,230
112.5	150	5,350	14.67	5.11	479	1.2	8,410
150	112.5	5,794	13.09	5.99	485	1.1	8,902

Table 2. Economic benefit (Yuan/ha) of P and K applied to wheat in a wheat-corn rotation in Hebei.

P_2O_5	K_2O	Wheat income[1]	Corn income[2]	Total income	Total input cost	Net income
kg/ha				Yuan/ha		
0	0	3,912	4,383	8,295	810	7,485
150	0	5,445	5,463	10,908	1,185	9,723
0	150	3,949	5,061	9,010	1,035	7,975
112.5	150	5,350	5,887	11,237	1,316	9,921
150	112.5	5,794	6,231	12,025	1,354	10,672

[1]Wheat price = 1 Yuan/kg, [2]Corn price = 0.7 Yuan/kg

As with wheat, application of K in the absence of P did not produce as high a corn yield as P application in the absence of K. This confirms the importance of P over K even though there was a yield response to K (969 kg/ha).

The best combination of fertilizer was a balanced application of 150 kg P_2O_5 and 112.5 kg K_2O/ha to wheat. This treatment produced 444 more kg grain/ha than the yield obtained with 112.5 kg P_2O_5 and 150 kg K_2O/ha. These results emphasize the importance of applying adequate P for consistently high yields and a most economic response to applied K. However, for more definitive results, higher levels of all three plant nutrients should be tested at this location. In particular, P at 150 kg/ha may be limiting response to applied K.

Application of P fertilizer was important in achieving higher economic response to K fertilizer.

The economic benefit of P and K applications in a wheat-corn rotation. As is often the case, the highest net income was achieved with the highest yield, using balanced NPK fertilization (**Table 2**). Phosphorus alone increased farmer profit 2,238 Yuan/ha compared to plots receiving no P. Response to K was only 490 Yuan/ha compared to yields with no applied K, when both received adequate N. However, when balanced P and K were used, the profit was 3,187 Yuan/ha over plots with only N applied. Balanced fertilization gave a total profit of 10,672 Yuan/ha for the two crops. (Note: US$1 = approximately 8.2 Yuan.)

Conclusions

Results from this experiment clearly demonstrated the need for applying both P and K in soils of the Hebei Plain, once thought to be 'rich' in K. Such applications need to be large enough to produce high, economic yields. The results are not definitive because the treatment with the highest level of applied P was also the highest yielding. And while K response seemed to peak at 112.5 kg K_2O/ha, it is not known what the response would have been had P – the more limiting of the two – been tested at higher levels with K.

Regardless, information from this trial indicates that at the N levels used, the minimum P_2O_5 application for this rotation should be 150 kg/ha while K should be added at 112.5 kg K_2O/ha. Following such a recommendation will make the farmer money and will also help maintain the fertility level of the soil.

Further research at different locations and with higher levels of all three plant nutrients would seem a practical recommendation to achieve more definitive results in the future. **BCI**

Guo Jianhua, Xing Zhu, and Liu Zongheng are staff members of the Soil and Fertilizer Institute, Hebei Academy of Agricultural and Forestry Sciences, in Shijiazhuang, Hebei.