Balanced Fertilization Promoted Yield and Quality of Waxy Maize in Chongqing

By Hongzhou He, Wei Li, and Shihua Tu

Optimal fertilizer treatment cannot only produce high yield and quality of waxy (fresh) maize, but also enhance the net income for growers. The contents of total sugar and amylopectin, which govern maize palatability, can be positively affected through optimal N and K application.

Waxy (fresh) maize has gained wide popularity across the households of China as an on-the-cob product due to its preferred taste characteristics. High market value has made this crop very lucrative for the region's growers. However, in the pursuit of high yields farmers tend to overuse N fertilizers due to a lack of information on best nutrient management practices.

A project was launched in 2008 to test the optimal (OPT) fertilizer rates and fertilizer combinations for high yielding, profitable waxy maize. Field experiments were conducted on an alluvial, sandy loam soil in Tongliang. Surface (0 to 15 cm) soil samples were collected from the field after harvesting the previous wheat crop. These samples were then analyzed by the National Laboratory of Soil Testing according to the ASI method (Portch and Hunter, 2005) (**Table 1**).

Table 1. Status of soil pH and selected nutrients from the field site in Tongliang (ASI method).

OM, g/kg	pH	NH_4-N	NO_3-N	P	K	B	Mg	Zn
		- - - - - - -	- - - - - - -	- - - - - - -	mg/L	- - - - - - -	- - - - - - -	- - - - - - -
4.4	8.1	13	37	22	29	1.1	98	2.8

Soil test results indicated that the soil was alkaline, had adequate P, B, and Zn, but was deficient in N and K. The experiment was set up in a randomized complete block design with three replications. There were four rates of N (150, 225, 300, 375 kg N/ha), P (0, 75, 150, 225 kg P_2O_5/ha), and K (0, 75, 150, 225 kg K_2O/ha), which combined to form 10 treatments (**Table 2**). The OPT NPK treatment was 300-150-150 kg N-P_2O_5-K_2O/ha. This N rate was identified by previous field experimentation while the P and K rates were determined by soil testing. Urea, SSP, and KCl were used as fertilizer sources. All P fertilizer was applied at seeding (a basal dose). Fertilizer N application was split between basal (30%) and topdress applications (i.e. 30% at the two-leaf and 40% at heading stages). Fertilizer K was split between a basal dose (50%) and a topdressing (50%) at the heading stage. Maize seeds were planted on a nurse bed in mid-February and seedlings were transplanted in early March using a plant population of 37,880 plants/ha. Maize cobs were harvested in early June and yield was recorded on a fresh weight basis. Maize kernel samples were collected from each plot, oven-dried, and analyzed for vitamin C, amino acids, total sugar, amylopectin, and prolamine.

Maize Yield

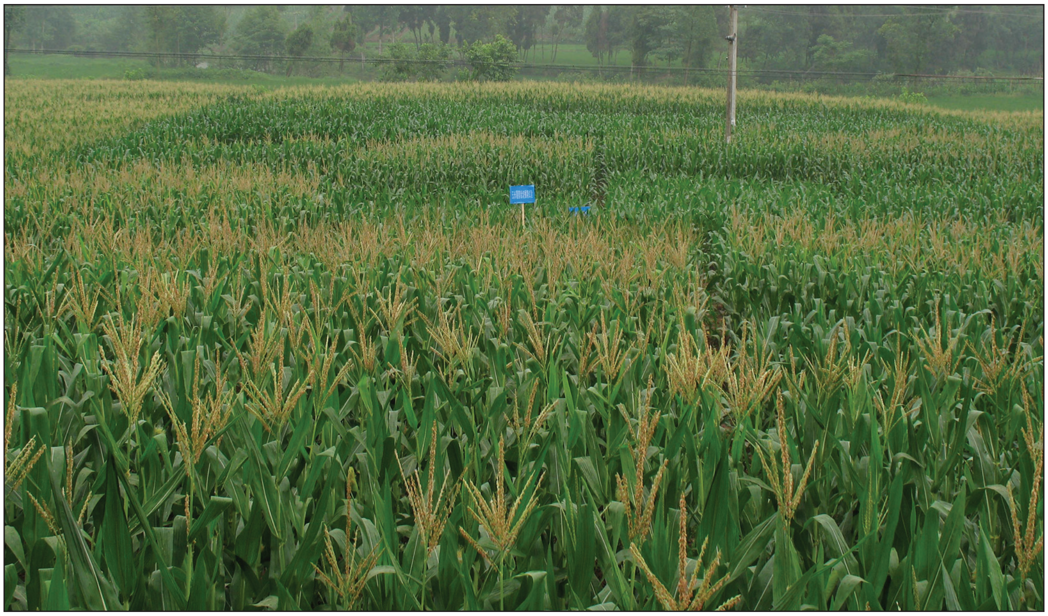
Different rates of N, P, and K fertilizers significantly affected maize yield, but the effect varied considerably between 2 years (**Table 2**). In 2008, maize yields responded significantly to all the N, P, and K rates applied, which increased with an increase in fertilizer rates and then leveled off when the fertilizer rates exceeded those used in the OPT treatment. Omission of P or K from any fertilizer program would reduce maize yield by 17 and 19%, respectively, if compared to yield under the OPT. In 2009, maize pollination was affected due to three rainfall events that occurred during the flowering stage. This resulted in higher numbers of barren ear tips and lower yields. Besides these lower yields, the yield response to fertilizer application rate was comparable. Although the relative yield of the P omission treatment did not differ between the 2 years (82.6% in 2008 and 82.5% in 2009), the omission of K lowered relative yield from 81% in 2008 to 77% in 2009. This is because soils in southern China are nearly always K responsive due to continuously removal by crops and leaching, while soil P reserves are more highly buffered from these influences (Xie et al., 1991).

Common abbreviations and notes: N = nitrogen; P = phosphorus; K = potassium; Mg = magnesium; B = boron; Zn = zinc; NH_4 = ammonium; NO_3 = nitrate; SSP = single superphosphate; KCl = potassium chloride; OM = organic matter.

Table 2. Waxy maize yields as affected by N, P, and K rate, Tongliang.

	- - - - 2008 - - - -		- - - - 2009 - - - -		- - - Average - - -	
Treatment	Yield[1], kg/ha	Relative yield, %	Yield, kg/ha	Relative yield, %	Yield, kg/ha	Relative yield, %
150-150-150	15,750 b	90.7	14,882 b	89.0	15,316 b	89.9
225-150-150	16,933 a	97.5	14,630 b	87.5	15,782 b	92.6
300-150-150 (OPT)	17,367 a	100.0	16,717 a	100.0	17,042 a	100.0
375-150-150	17,100 a	98.5	14,647 b	87.6	15,873 a	93.1
300-0-150	14,350 c	82.6	13,788 c	82.5	14,069 c	82.6
300-75-150	15,550 b	89.5	14,545 b	87.0	15,048 b	88.3
300-225-150	17,367 a	100.0	14,798 b	88.5	16,082 a	94.4
300-150-0	14,050 c	80.9	12,845 d	76.8	13,448 c	78.9
300-150-75	16,067 ab	92.5	13,906 c	83.2	14,986 b	87.9
300-150-225	16,983 a	97.8	14,747 b	88.2	15,865 a	93.1

Means in each column followed by the same letter are not significantly different at p = 0.05.
[1]Fresh weight yields.



Tongliang county is a newly developed production base with 6 million ha of planting area aimed at supplying waxy maize to both rural and urban people in Chongqing city.

Maize Quality

Kernel quality parameters were obviously affected by the rate and balance of N, P, and K application (**Table 3**). Protein and vitamin C (Vc) govern the food value, while total sugar and amylopectin influence palatability. Data in Table 3 were a 2-year average of one replication of the maize experiments and thus, were insufficient for statistical analysis. However, as was found by Shi and Zhang (1994) and Shi (1995), contents of Vc and prolamine in maize seeds appeared to increase with N, P, and K rate; while percentage of total sugar declined under higher rates of N or K, they remained constant within the range of P rates tested. As with total sugar, the content of amylopectin in kernels also seemed to be influenced by NPK rate and balance.

Table 3. Waxy maize kernel quality as affected by N, P, and K rate (average of 2 years), Tongliang.

Treatment	Vc, mg/kg	Total sugar, %	Amylopectin, %	Prolamine, %
150-150-150	168.8	29.8	26.8	7.8
225-150-150	183.9	29.1	26.2	8.8
300-150-150 (OPT)	180.5	27.3	19.3	9.1
375-150-150	178.7	26.6	20.6	8.4
300-0-150	176.4	27.4	24.6	8.7
300-75-150	172.8	27.0	24.3	8.8
300-225-150	176.3	27.1	24.4	9.0
300-150-0	180.8	28.7	25.9	7.9
300-150-75	181.4	28.8	25.9	8.5
300-150-225	173.6	26.8	24.1	8.7

Economic Benefit

As is shown in **Table 4**, the profitability varied considerably with fertilizer treatment. The OPT treatment produced the highest net income of USD 2,556/ha—a good income for the region's grain growers. The differences between the OPT and the other treatments ranged between 327 to USD 755/ha. Omission of K and P resulted in the two least profitably scenarios in this study.

Table 4. Net income generated from waxy maize production as affected by N, P, and K rate, Tongliang.

Treatment	Cost of production[†]	Gross income	Net income
	---------------	USD/ha	---------------
150-150-150	8,055	3,488	2,229
225-150-150	8,385	3,429	2,119
300-150-150 (OPT)	8,715	3,918	2,556
375-150-150	9,045	3,433	2,020
300-0-150	7,920	3,232	1,994
300-75-150	8,242	3,409	2,121
300-225-150	9,338	3,468	2,009
300-150-0	7,740	3,011	1,801
300-150-75	8,302	3,259	1,962
300-150-225	9,428	3,456	1,983

[†]Cost of production includes: seed and plastic film \$160/ha, labor \$656/ha; N \$0.67/kg, P_2O_5 \$0.98/kg, K_2O \$0.98/ha. Waxy maize value = \$0.23/kg.

Summary

Yields of waxy maize responded significantly to N, P, and K in both years of this study, with the highest yield obtained from the selected "optimum" treatment and the lowest from treatments omitting K and P. Repeating K omission for 2 years further reduced relative yield. Among the kernel quality parameters, vitamin C and prolamine responded positively to N, P, and K and reached their maximum at the selected OPT treatment. Total sugar and amylopectin decreased as the rates of N and K increased, but were not affected by P rate. Maize kernel sweetness and/or palatability can be controlled by adjusting N and K rates. Use of the selected OPT treatment for this location resulted in both the highest yield and net income. BC

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