Attaining High Yield and High Quality Banana Production in Guangxi

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Small improvements in high value plantation crop production can generate very large economic benefits to farmers. Field trials indicate that conventional nutrient management practices greatly limit the profitability of banana production systems in southwest China. Potassium (K) is a key nutrient in higher yields and quality.

Guangxi's sub-tropical climate is well-suited to the production of many tropical fruits. Of these, banana has received the most attention, resulting in a rapid transformation of the planted area. In 2003, 60,000 hectares (ha) of banana were planted in the province. Extensive cultivation with rather poor nutrient management has resulted in low yields and poor fruit quality. Average yields range between 18 to 20 t/ha, or approximately one-third the level attained under optimal management practices.

Banana's large biomass, and its high concentration of K in the fruit, are factors responsible for the crop's large annual demand for K. Biomass production ranging between 80 to 200 t/ha requires 290 to 1,970 kg K_2O/ha. Soils growing banana in Guangxi are usually acidic, light to medium textured, and deficient in K. Present soil testing surveys indicate available K ranges between 75 and 155 mg/kg.

The objective of this study was to determine proper application rates for K and other nutrients for optimal banana production systems. A replicated field experiment conducted in the Nanning suburb of Jilin Town compared farmer practice against five treatments supplying combinations of one rate of nitrogen (N), two rates of phosphorus (P), and four rates of K (**Table 1**). The farmer practice treatment relied on low N and K inputs, moderate use of P fertilizer and a significant quantity of farmyard manure (FYM) applied once as a basal application. Treatments provided all the P at planting while N and K fertilizers were split eight times, supplying 4% basally, and 9%, 11%, 17%, 18%, 18%, 12%, and 11% during the other seven dressings spaced throughout the growing season. Researchers planted *Villains* cv., a high yielding, tissue-cultured variety, at 1,920 plants/ha.

Effect of P and K on Growth and Yield

Differences in plant height or stem diameter were not obvious across treatments (**Table 2**). However, the effect of K was large for all NPK treatments, including farmer practice, which produced more fruit fingers per plant and higher single fruit weights compared to the NP treatment. Number of fingers per plant, and particularly, single fruit weight varied considerably amongst NPK treatments. Finger number was not

Guangxi Province produces about 60,000 ha of bananas, but yields ranging from 18 to 20 t/ha are about one-third of the potential.

Potassium increased single fruit weight, yield, and banana quality.

Table 1. Plant nutrients applied (kg/ha) to banana grown in Jilin Town, Nanning, Guangxi.

Treatments	N	P_2O_5	K_2O	Manure†	$N:P_2O_5:K_2O$
1. NP_2K_0	1,016	355	0	0	1: 0.4: 0
2. NP_2K_1	1,016	355	916	0	1: 0.4: 0.9
3. NP_2K_2	1,016	355	1,375	0	1: 0.4: 1.4
4. NP_2K_3	1,016	355	1,832	0	1: 0.4: 1.8
5. NP_1K_2	1,016	177	1,375	0	1: 0.2: 1.4
6. Farmer practice	530	288	576	9,600	1: 0.6: 1.1

†Farmyard manure content: 0.32% N, 0.25% P_2O_5, 0.36% K_2O

Table 2. Treatment effect on banana growth characters, Guangxi.

Treatments	Plant height, cm	Stem diameter, cm	Fruit fingers per plant	Single finger weight, g
1. NP_2K_0	230.5	58.6	153.3	80.0
2. NP_2K_1	234.5	61.5	166.6	98.3
3. NP_2K_2	232.8	60.8	164.0	120.7
4. NP_2K_3	233.4	61.0	163.9	124.8
5. NP_1K_2	234.4	61.6	163.2	92.7
6. Farmer practice	235.0	61.0	161.3	89.6

Table 3. Treatment effect on banana yield, Guangxi.

		Yield increase by K			Yield increase by P		
Treatments	Yield, t/ha	t/ha	%	kg/kg K_2O	t/ha	%	kg/kg P_2O_5
1. NP_2K_0	23.6	–	–	–	–	–	–
2. NP_2K_1	31.2	7.6	32	8.3	–	–	–
3. NP_2K_2	38.0	14.4	61	10.5	8.7	30	48.9
4. NP_2K_3	39.3	15.7	66	8.6	–	–	–
5. NP_1K_2	29.3	5.7	24	–	–	–	–
6. Farmer practice	27.7	4.1	17	–	–	–	–

Table 4. Effect of K fertilizer on banana fruit quality, Guangxi.

Treatment	NP_2K_0	NP_2K_1	NP_2K_2	NP_2K_3
Vitamin C, mg/kg	7.9	8.7	8.7	8.8
Soluble sugar, %	13.6	14.3	14.2	14.8
Edible portion, %	58.4	62.6	62.9	64.0

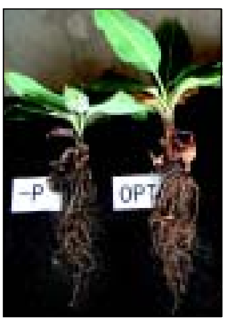
strongly influenced by K rate, although single fruit weight showed a strong, positive relationship to increased K supply. The impact of P supply was especially large as a 50% reduction in application rate resulted in a 23% reduction in single fruit weight.

Farmer practice also produced relatively low single fruit weight. This treatment provided fewer nutrients in the form of fertilizer, but considerable amounts of N, P, and K as FYM. Considering the nutrient concentrations of the manure sources, the overall macronutrient input for farmer practice had 45% less N, 12% less P, and 67% less K than the most effective NPK treatment NP_1K_2. This indicates the substantial impact of imbalanced nutrition on yield when fertilizer inputs are not matched to FYM nutrient content and crop demand.

Plant growth improvements mirrored banana yield response. Final fruit yield increased with K fertilization rate. Thus, the highest K rate of 1,832 kg K_2O/ha produced a maximum yield of 39.3 t/ha, which was 66% higher than the zero K control and nearly 42% higher than farmer practice (**Table 3**). The next lowest K rate, at the same level of P input (treatment 3), produced 1.3 t/ha less than the maximum. Yields were cut another 8.7 t/ha (30%) by reducing P input 50% (i.e., treatment 5 vs. treatment 3).

Yields and single fruit weight were low with the nutrients provided by normal farmer practice.

Optimal rates of N-P_2O_5-K_2O for banana production were determined to be 1,016-355-1,832 kg/ha.



Optimum fertilization produced a better root system than the minus P (-P) treatment.

Table 5. Economic analysis (US$/ha) of treatments applied to banana, Guangxi.

Treatment	NP_2K_0	NP_2K_1	NP_2K_2	NP_2K_3	NP_1K_2	Farmer practice
Fertilizer input[1]	743	1,001	1,129	1,258	1,051	711
Other input[2]	966	966	966	966	966	966
Total input	1,709	1,967	2,095	2,224	2,017	1,677
Total income[3]	5,976	7,911	9,639	9,956	7,436	6,030
Net income	4,267	5,944	7,544	7,732	5,419	4,353
Net income increase vs. K_0	-	1,677	3,277	3,464	1,152	86
Net income increase, %	-	39	77	81	27	2

[1]Fertilizer cost US$/kg: N = 0.58, P_2O_5 = 0.44, K_2O = 0.28; farmyard manure = 0.01
[2]Other inputs included seedlings, labor, pesticides, etc.
[3]Banana prices, US$/kg: improved = 0.25; farmer practice = 0.22

Effect of K Fertilizer on Fruit Quality

Potassium had a pronounced effect on the vitamin C content of the fruit, although differences amongst K supplying treatments were not significant (**Table 4**). Soluble sugar content showed a similar trend although advantages to the highest K application rate were more apparent. The edible portion of fruit clearly increased with K application rate, which is consistent with the observations for single finger weight. Specific observations included increased length, breadth and surface area of fruit, and decreased banana peel weight.

Economic Analysis

The economic benefit from balanced nutrient management was highly significant (**Table 5**). Besides the larger fruit inventories resulting from higher yields, any improvement in fruit quality garnered farmers a higher market price per unit. Treatment 4, with the largest P and K input, generated the highest net income of US$7,732/ha. That was 81% above the zero K control and 78% higher than farmer practice. A 25% reduction in K input (treatment 3) generated a marginally lower net income of US$7,544/ha. We reason that the further addition of 457 kg of K_2O to increase banana yield by 1,300 kg and net income by $188 (equal to 2.8 kg banana and $0.41 for each extra kg of K_2O added) is justified based on the small land holdings per farm and the overriding need to maximize farm income. The 50% reduction in P input (treatment 5 vs. treatment 3) generated a much less desirable effect as profits were 30% higher under the high P, mid K treatment.

Banana growth, yield, and quality response to P and K highlight major limiting factors to maximum economic yield for plantations in Guangxi. Optimal application rate was determined to be 1,016-355-1,832 kg N-P_2O_5-K_2O/ha, which should be generally recommended to growers in the province unless specific soil test data indicate otherwise. BC

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