Soil Phosphorus Status and Crop Response in Major Cropping Systems of Guangxi

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A cropping system-specific analysis of past and present phosphorus (P) fertilizer management practices and their impact on current soil P status and crop response to P in Guangxi Province shows that calling for reduced P application rates is clearly unjustified if sustained crop production is truly desired.

Research indicates that P is one of the main plant nutrients limiting crop growth in the subtropical region of southern China. Those soils have inherently low P levels due to intense soil weathering and soil adsorption, as well as a prolonged period of cropping without attention to nutrient balance. Thus, it is especially important to re-examine the soil P status and crop response to applied P fertilizer for high yielding systems in Guangxi.

Fertilization trials and demonstrations are conducted in rice, the major crop in Guangxi Province.

Agricultural Production Systems in Guangxi

The main cropping systems of the lowland soils in Guangxi are rice-rice-winter fallow, rice-rice-vegetable, and rice-rice-green manure. The main cropping systems of the uplands are corn-soybean, corn-sweet potato, peanut-sweet potato, and sugarcane. Rice production in Guangxi is mainly distributed in the central and western regions. The total area of lowland rice is 1.52 million hectares (M ha), of which the rice-rice-fallow cropping system occupies about 1.22 M ha or 80% of the total.

The rice-rice-vegetable cropping system utilizes 0.23 M ha, accounting for 15%, while the rice-rice-green manure cropping system only occupies approximately 0.08 M ha, or 5% of the total (**Table 1**). Upland soils of Guangxi are mainly distributed in the western and central regions. Sugarcane is mainly grown in central and southern Guangxi, while the corn-soybean cropping system predominates in western Guangxi (**Table 2**).

Table 1. Area and distribution of lowland rice in Guangxi.

System	Area, 10,000 ha	Distribution
Early rice-late rice-winter fallow	121.5	Central, West
Early rice-late rice-vegetable	22.8	East, South
Early rice-late rice-green manure	7.6	South, North

Table 2. Area and distribution of major upland cropping systems in Guangxi.

System	Area, 10,000 ha	Distribution
Corn-soybean	31.1	West, Central
Corn-sweet potato	5.2	West, Central
Peanut-sweet potato	21.7	Central, South
Sugarcane	54.9	Central, South

Average fertilizer application rates as well as the N:P:K ratios for rice, corn, sweet potato, soybean, peanut, and sugarcane are explained in **Table 3**. Sugarcane receives the most plant nutrients, followed by corn and rice.

Table 3. Fertilizer application rates (kg/ha) for selected crops in Guangxi.

Crop	N	P_2O_5	K_2O	N: P_2O_5: K_2O
Rice	159.7	62.5	76.2	1: 0.39: 0.48
Corn	169.3	69.0	70.2	1: 0.41: 0.41
Tuber	54.2	43.9	36.6	1: 0.81: 0.68
Soybean	53.1	52.9	47.1	1: 1.00: 0.89
Peanut	53.0	55.3	53.2	1: 1.04: 1.00
Sugarcane	168.5	85.8	115.4	1: 0.51: 0.68

Phosphorus Status of Various Soils and Cropping Systems in Guangxi

Lowland soils. The average total P content of lowland soils ranges between 0.14 and 1.07 g/kg, although the majority of soil P is neither soluble nor plant available. Availability of soil P will vary greatly in lowland systems due to the influence of past fertilizer management and ranges from 0.4 to 22 mg/kg. Results from several years of investigation indicate that average available soil P contents, before the early and late rice seasons, were low, 7.6 and 7.1 mg/kg, respectively. Thus, P is one of the main yield-limiting nutrients for lowland rice. Lowland field trials throughout Guangxi showed that P fertilization can increase available soil P contents from 0.6 to 6.0 mg/kg (**Table 4**).

Table 4. Effect of P application on available soil P in paddy soils, Guangxi.

	Available P, mg/kg	
Site	NK	NPK
Central (Binyang)	5.0	11.0
East (Wuzhou)	5.3	5.9
West (Debao)	2.0	3.5
South (Hepu)	1.1	3.0

Upland soils. Phosphorus status of upland soils was lower than that of lowland soils. Total soil P content for upland soils ranged between 0.17 and 1.0 g/kg, with the range of available soil P being slightly wider than lowland soils (**Table 5**).

Table 5. Typical soil P content in corn-soybean cropping systems, Guangxi.

		Available P, mg/kg	
Crop	Total P, g/kg	Range	Average
Before corn planting	0.17-1.0	0.44-22	6.8
Before soybean planting		0.4-16	4.5

- Examination of 37 corn-soybean cropping system trials found that although average available soil P levels were highest at 6.8 mg/kg, just prior to corn planting, thereafter the system underwent a significant decrease. Thus, after corn harvest, average available soil P levels were lowest at 4.5 mg/kg. The low availability prior to soybean planting jeopardizes the yield opportunity.
- In 107 typical sugarcane growing regions, P content was 0.4 to 20.7 mg/kg with an average of 6.7 mg/kg. Data showed that if stalk yield was high, the uptake of plant nutrients was also high.
- Banana has been traditionally planted in upland soils, although recently plantations have shifted to paddy soils. Nineteen field trials conducted in paddy soils planted to banana had available soil P levels between 1 and 46 mg/kg, averaging about 9.1 mg/kg.
- Pineapple soils had low available soil P, ranging between 0.4 and 13 mg/kg, and had the lowest average of all soils at 2.9 mg/kg with 15 field trials (**Table 6**).

Table 6. Status of soil P content in sugarcane, banana, and pineapple growing regions, Guangxi.

Crop	Total P, g/kg	Available P, mg/kg	Average, mg/kg
Sugarcane	0.16-0.95	0.4-6.7	6.7
Banana	0.15-0.99	0.4-20	4.0
Pineapple	0.11-0.81	0.4-5.7	1.3

Table 7. Effect of P application on rice yield and profit, Guangxi.

Measurement	NK	NPK
Yield, kg/ha	7,220	8,350
Yield increase, kg/ha	—	1,130
Percent yield increase	—	16
Grain yield increase per kg of P_2O_5, kg/ha	—	19
Increased profit, Yuan/ha	—	566

Pineapple is shown with fertilized plots at left and back, and check plot at right front.

Crop Response to Phosphorus Fertilizer

Rice cropping systems. Applying P fertilizer to rice increased yield significantly, averaging about 1,130 kg/ha higher (16%). This improved yield raised profitability by 566 Yuan/ha (US$68/ha). One kg of P_2O_5 was shown to increase rice yield by 19 kg (**Table 7**).

Corn-soybean cropping system. Phosphorus fertilizer increased corn yield between 700 and 1,040 kg/ha. Given the 2.3 mg/kg decrease in available soil P, as measured after harvesting the corn crop, it is apparent that not enough P is being added to compensate for uptake and removal. In fact, P fertilizer application rates ranged only between 38 and 75 kg P_2O_5/ha, which is now proven to be an unsustainable practice for high yield, high quality corn production in southern China. Response of late-planted soybeans to P fertilizer application was more significant than for corn. Phosphorus application increased yield by an average of 340 kg/ha, or 56%. Average increase in profit for the corn-soybean cropping system (**Table 8**) was 1,170 Yuan/ha (US$142/ha).

Sugarcane. Sugarcane yield increased markedly when P was applied at rates between 38 and 75 kg P_2O_5/ha. The average sugarcane yield achieved by applying 38 kg P_2O_5/ha (with adequate N and K) was 4,730 kg/ha (8%) higher than the average yield obtained with N and K application alone. Plots receiving 75 kg P_2O_5/ha produced 12.7 t/ha (20%) more than plots receiving N and K alone. Sugarcane profitability was increased between 947 and 2,530 Yuan/ha or US$115 and US$306/ha (**Table 9**). Past research on maximum economic yield in sugarcane has indicated a potential near 115 t/ha using NPK applications rates of 345-120-450 kg N-P_2O_5-K_2O/ha (Guangxi SFI and PPIC, 1996).

Table 8. Effect of P application on the corn-soybean cropping system, Guangxi.

Measurement	NK	NPK
Corn yield, kg/ha	4,280	4,980
Yield increase, kg/ha	—	700
Percent yield increase	—	16
Soybean yield, kg/ha	610	950
Yield increase, kg/ha	—	340
Percent yield increase	—	56
Inc. profit of corn + soybean, Yuan/ha	—	1,170

Table 9. Effect of P application on sugarcane yield and profit, Guangxi[1].

Measurement	NK	NP_1K	NP_2K
Yield, kg/ha	63,000	67,700	75,700
Yield increase, kg/ha	—	4,730	12,700
Percent yield increase	—	8	20
Inc. profit, Yuan/ha	—	947	2,530

[1] NP_1K=38 kg P_2O_5/ha; NP_2K=75 kg P_2O_5/ha

Conclusions

A wide range of experimental results shows a strong relationship between crop response to P fertilizer additions and available soil P status in a variety of soils. The various cropping systems of Guangxi Province currently are based on soils with low available P contents. Application of P fertilizer to these systems and soils resulted in very significant and profitable yield increases. If P is omitted from common farmer practice, crop yield and profits suffer. These trials point to the continuing need to test higher P application rates as in most cases the response curve for P was linear. Hence, a maximum yield and profitability could not be defined. In such studies it will also be necessary to test the P response curves using higher rates of N, K, and other deficient plant nutrients based on soil test information. While some scientists in China have suggested P application rates could be reduced in certain areas, this does not apply to the vast majority of cropping systems in Guangxi. **BCI**

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Sugarcane...*continued from page 21)*

(**Table 2**). After harvest, the minor differences in available soil P among treatments indicates the P uptake and use-efficiency is substantially improved when adequate and balanced fertilizers are applied to sugarcane. **BCI**

Table 2. Effect of soil P levels on the nutrient content of sugarcane leaf at mature stage and post harvest soil P level, BSRI farm, Ishurdi, Bangladesh.

Soil P levels,	Leaf, %			Soil P[1],
ppm	P	K	S	ppm
T_1- 8	0.09	1.88	0.09	9
T_2-14	0.09	1.95	0.11	12
T_3-20	0.09	1.95	0.11	13
T_4-26	0.10	1.98	0.11	11
T_5-32	0.11	2.00	0.12	13
T_6-38	0.10	1.88	0.10	11

[1]After harvest

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