Ginger Response to Potassium in Anhui Province

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The Huaibei plain in Anhui Province of Southeastern China is a major ginger production center. Ginger is a high income alternative for farmers and three years of research suggest a large opportunity cost when omitting potassium (K) from fertilizer recommendations.

Ginger is a root crop that is highly valued by China's people for its strong flavor and reported health benefits. Agronomically, ginger takes up large amounts of nutrients. One crop can absorb about 400 kg nitrogen (N)/ha, 145 kg P_2O_5/ha, and 950 kg K_2O/ha from the soil. This especially high K requirement makes ginger sensitive to low soil K supply. Nonetheless, ginger growers in southeastern China tend to rely on fertilizer sources that contain only N and phosphorus (P). As a result, available soil K levels in the region's ginger fields are dropping steadily and K imbalances have predisposed the crop to serious disease and insect damage.

Close-up view of ginger root tubers.

In addition to loss of root yield, crop quality is also reduced. Because K supply is inadequate, farm income is suboptimal and is reducing the viability of this normally highly remunerative crop. Proof regarding the benefits of balanced fertilization was needed in order to change fertilizer management practices and the cost (or lost income) of soil K deficiency on ginger production.

Replicated randomized complete block design (RCBD) small plot trials were conducted at three sites in Linquan County, Anhui. Basic soil properties for the sites are provided in **Table 1**. Six combinations of N and K were selected for trials at the Yangji and Tanpeng locations, while seven NK treatments were tested at the 'Farm' site (**Table 3**). The fertilizers used were urea, diammonium phosphate, and potassium chloride. Phosphorus was supplied at 90 kg P_2O_5/ha. All P and K were

Table 1. Basic soil properties of the three study sites, Anhui, China

Year/Site	pH	O.M., %	Available nutrients, mg/kg								
			K	N	P	S	B	Cu	Fe	Mn	Zn
1999/Yangji	6.1	0.82	66.5	26.4	8.6	14.2	0.32	1.9	12.2	11.0	1.9
2000/Tanpeng	6.4	0.57	70.4	12.0	24.9	8.8	nil	1.3	21.3	1.9	0.9
2001/Farm	6.2	0.57	77.2	15.0	40.1	3.6	0.48	2.9	84.3	83.3	1.5

applied basally, along with 60% of the N rate. The remaining N was top-dressed in two split applications. The local "lion-head" variety was germinated at the beginning of April, transplanted within the first 10 days in May at a planting density of 106,000 plants/ha, and harvested at the end of October.

Table 2. Effect of selected NPK treatments on growth characteristics of ginger, Anhui, China.

Treatments	Plant height, cm: Mid-growth stage	Plant height, cm: Harvest stage	Stem circumference, cm: Mid-growth stage	Stem circumference, cm: Harvest stage	No. of branches: Mid-growth stage	No. of branches: Harvest stage	Weight of top growth, g	Weight of tubers, g
Low N								
$N_{300}K_0$	43.5	61.8	5.0	5.1	6.1	6.3	75.0	329.3
$N_{300}K_{150}$	52.3	83.1	5.1	5.7	6.8	7.8	119.0	610.7
$N_{300}K_{300}$	54.0	86.9	5.3	6.6	7.8	9.6	130.0	609.0
Mid N								
$N_{375}K_{150}$	51.1	75.4	5.2	5.6	8.6	8.0	150.0	609.6
$N_{375}K_{300}$	54.2	80.2	6.5	6.6	8.3	8.4	176.0	548.5
$N_{375}K_{450}$	60.8	83.8	6.8	6.3	10.6	10.6	176.0	657.1

Phosphorus was supplied at 90 kg P_2O_5/ha.

Effect of K Application on Ginger Plant Growth

Potassium has an obvious growth promoting effect on ginger (**Table 2**). Plant height, stem circumference, number of branches, and tuber weight per plant greatly increased with increasing rates of N and K with the majority of high values resulting with 375-90-450 kg N-P_2O_5-K_2O/ha. Field notes indicated that leaf color was more vibrant and plant growth was vigorous and robust when K was supplied. Enhanced resistance to plant disease and insect infestation was also noted. For example, burnt leaf disease typically afflicts plants in the latter stages of growth, but was rarely observed when fertilized with NPK. Hence, the rates and frequencies of crop protection chemicals were substantially lowered for the period of study. As a result, profitability was increased.

Table 3. Yield response and economic benefit from NPK application in ginger, Anhui, China.

Year/Site	Treatments	Yield, t/ha	Increase, t/ha	Yield increase, %	Income increase, US$/ha
Yangji 1999	Low N				
	$N_{300}K_0$	39.9	-	-	-
	$N_{300}K_{150}$	53.3	13.4	34^{**}	1,608
	$N_{300}K_{300}$	52.8	12.9	32^{**}	1,548
	Mid N				
	$N_{375}K_{150}$	50.3	10.4	26^{**}	1,248
	$N_{375}K_{300}$	51.9	12.0	30^{**}	1,440
	$N_{375}K_{450}$	58.6	18.7	47^{**}	2,244
Tanpeng 2000	Low N				
	$N_{300}K_0$	32.0	-	-	-
	$N_{300}K_{150}$	39.2	7.2	22^{*}	864
	$N_{300}K_{300}$	42.3	10.3	32^{**}	1,238
	Mid N				
	$N_{375}K_{150}$	38.2	6.2	19^{*}	744
	$N_{375}K_{300}$	39.7	7.7	24^{*}	924
	$N_{375}K_{450}$	43.2	11.2	35^{**}	1,344
'Farm' 2001	Mid N				
	$N_{375}K_0$	31.2	-	-	-
	$N_{375}K_{375}$	42.9	11.7	38^{**}	1,404
	$N_{375}K_{450}$	43.2	12.0	39^{**}	1,440
	$N_{375}K_{525}$	42.9	11.7	38^{**}	1,404
	High N				
	$N_{450}K_{375}$	43.7	12.5	40^{**}	1,500
	$N_{450}K_{450}$	44.0	12.8	41^{**}	1,536
	$N_{450}K_{525}$	41.9	10.7	35^{**}	1,284

Phosphorus was supplied at 90 kg P_2O_5/ha.
*, ** Differences significant at the 5% and 1% level, respectively.

Ginger yield comparison.

Ginger Yield Response to K

As with crop growth characters, K fertilizer significantly affected yield (**Table 3**). At Yangji (1999), treatments increased tuber yields by 26 to 47% (34% average). At Tanpeng (2000), the range was 19 to 35% (27% average). At the 'Farm' site (2001), the range was 35 to 41% (38% average). In 1999 and 2000, yields stagnated as N rate was increased from the low to mid range and K was increased from 150 to 300 kg K_2O/ha. A better yield was achieved when the mid N level was combined with high K_2O (450 kg/ha), an indication of improved N to K balance. Mid N rate results in 2001 tended to agree with the two previous years and suggest no yield benefit from K application rates beyond 450 kg K_2O/ha. The high N regime tested in 2001 provided no clear evidence of a yield advantage beyond results obtained using the set of mid N treatments.

Farmer weighing harvested ginger tubers.

Ginger Production Economics

Based solely on the yield advantage, the economics of ginger production were greatly improved with balanced fertilization (**Table 3**). Compared to the farmer practice at Yangji and Tanpeng, income was increased by US$744 to US$2,244/ha, proving the value of investing in rational quantities of N, P, and K fertilizers. Maximum benefit at these sites was obtained with the mid N rate (375 kg N/ha) used in combination with 450 kg K_2O/ha. At the 'Farm' site, the high N rate along with 450 kg K_2O/ha proved most profitable. This result suggests a possible N limitation at the two other study sites. Inadequate and imbalanced nutrient input is allowing soil K deficiency to prevail in the ginger production areas of southeastern China and is the main barrier for growers to break through in order to move closer to maximum economic yield.

Rational use of K promotes ginger growth and tuber yield. The impact of balanced fertilization on the long-term viability of ginger production is clearly demonstrated in this research.

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