

Balanced Fertilization Increases Garlic Yield in Anhui

By Li Lujiu, Guo Xisheng, Zhang Qingsong, Xia Hongmin, and Zhang Lin

Field experiments with garlic show that rational use of potassium (K) greatly promoted garlic growth and yield. Balanced fertilization is shown to improve crop value by a large margin, with farm income being enhanced considerably.

A high-yielding garlic crop demands large amounts of nutrients, especially nitrogen (N) and K. Garlic is particularly sensitive to low soil K supply. Based on traditional practice, garlic growers in southeast China tend to rely on fertilizer sources that contain only N and phosphorus (P)—resulting in steadily declining available soil K levels. Potassium uptake imbalance relative to N can predispose the crop to serious disease and insect damage. In addition to loss of garlic shoot and clove yields, crop quality is also lower, reducing the viability of this cash crop alternative. Balanced fertilization technology improves both nutrient management practices by farmers and eliminates the effect of K deficiency on garlic production. Educational activities to promote this practice are being pursued.

The effect of K application on garlic... from left to right: zero K₂O application, 150 kg/ha, and 300 kg/ha.

This article outlines results from field trials conducted at three sites in Lai'an County, Anhui Province. Soil properties of the top 20 cm of soil are provided in **Table 1**. Six combinations of N and K, applied with 90 kg P₂O₅/ha, were tested at one paddy site in Shuikou and at two sites at Xin'an, one a paddy soil (Xin'an - 1), the other a dryland soil (Xin'an - 2). Fertilizers included urea, diammonium phosphate (DAP), and potassium chloride (KCl). All P and K were applied basally with 60% of the N. The remaining N was topdressed at mid-season. The local variety "Lai'an white garlic" was sown at the end of September at a density of 600,000 plants/ha. Garlic shoots and cloves were harvested in early and late May, respectively.

Potassium had an obvious growth-promoting effect on garlic (**Table 2**). Plant height, number of leaves, stem circumference, the



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

Site	pH	O.M.,%	Available soil nutrients, mg/kg									
			K	N	P	S	B	Cu	Fe	Mn	Zn	
Shuikou (1998-1999)	6.2	0.45	58.6	41.9	8.9	49.2	0.06	7.5	133.2	42.9	1.8	
Xin'an - 1 (2000-2001)	6.1	0.54	58.7	17.4	5.8	63.0	0.00	3.3	99.0	46.0	1.2	
Xin'an - 2 (2000-2001)	6.3	0.51	74.3	30.9	7.0	52.9	0.00	2.0	49.4	27.7	1.0	

length and diameter of garlic bolts, weight of garlic bolts and cloves, and top growth weight per plant substantially increased with N and K. The majority of highest values resulted with N-

P_2O_5 - K_2O rates of 375-90-300 kg/ha. Field notes indicated that leaf color was more vibrant, plant growth was vigorous and robust, and garlic shoots and cloves were visually larger when K was supplied.

As with crop growth, increasing the K application significantly raised yield (Table 3). At Shuikou, under the low N rate, K increased shoot yield by 121 to 156% and clove yield by 45 to 71% compared to the zero K control (farmer practice). Potassium used in combination with the higher N rate produced 103 to 127% higher shoot yields and 11 to 36% higher clove yields. At Xin'an, the range of yield increases for all treatments was 18 to 33% for shoots and 38 to 56% for cloves on paddy soil, and 24 to 29% (shoots) and 35 to 43% (cloves) on dry land.

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Table 2. Effect of NPK treatments on growth characteristics of garlic, Anhui.¹

Treatments ²	Plant height, cm	Number of leaves	Stem circumference, cm	Shoot length, cm	Shoot diameter, cm	Shoot weight, g	Weight	
							of top growth, g	Clove weight, g
$N_{300}K_0$	77.6	4.30	3.66	39.0	0.47	8.0	46.6	13.0
$N_{300}K_{150}$	88.0	5.16	4.43	59.1	0.64	14.7	68.7	16.0
$N_{300}K_{300}$	91.4	5.23	4.66	64.0	0.69	16.6	80.0	17.5
$N_{375}K_0$	83.3	4.56	3.80	40.8	0.51	9.3	53.6	13.8
$N_{375}K_{150}$	88.6	5.20	4.43	59.0	0.65	14.6	73.5	16.5
$N_{375}K_{300}$	93.2	5.30	4.60	63.8	0.70	15.6	82.0	16.3

¹The average of the three sites.
² Phosphorus was supplied at 90 kg P_2O_5 /ha.

Table 3. Garlic yield response and economic benefit from NPK application, Anhui.

Site	Treatments ¹	Yield increase						Income ² increase, US\$/ha
		Yield, t/ha		t/ha		%		
		Shoot	Clove	Shoot	Clove	Shoot	Clove	
Shuikou	$N_{300}K_0$	2.11	4.53	—	—	—	—	—
	$N_{300}K_{150}$	4.66**	6.55**	2.55	2.02	121	45	647
	$N_{300}K_{300}$	5.39**	7.75**	3.28	3.22	156	71	908
	$N_{375}K_0$	2.31	5.39	—	—	—	—	—
	$N_{375}K_{150}$	4.69**	6.00*	2.38	0.61	103	11	449
	$N_{375}K_{300}$	5.24**	7.35**	2.93	1.96	127	36	699
Xin'an - 1 (Paddy field)	$N_{300}K_0$	6.99	9.30	—	—	—	—	—
	$N_{300}K_{150}$	8.27**	13.1**	1.28	3.84	18	41	666
	$N_{300}K_{300}$	9.15**	14.5**	2.16	5.20	31	56	969
	$N_{375}K_0$	7.50	10.3	—	—	—	—	—
	$N_{375}K_{150}$	9.56**	14.3**	2.06	3.93	28	38	801
	$N_{375}K_{300}$	9.96**	15.3**	2.46	5.00	33	48	946
Xin'an - 2 (Dryland)	$N_{300}K_0$	7.06	10.4	—	—	—	—	—
	$N_{300}K_{150}$	8.80**	14.0**	1.74	3.63	25	35	714
	$N_{300}K_{300}$	9.10**	14.8**	2.04	4.40	29	43	858
	$N_{375}K_0$	7.46	11.4	—	—	—	—	—
	$N_{375}K_{150}$	9.26**	15.5**	1.80	4.14	24	36	786
	$N_{375}K_{300}$	9.63**	15.8**	2.17	4.40	29	39	876

¹Phosphorus was supplied at 90 kg P_2O_5 /ha.
²Prices: garlic bolts and cloves = 1.30 and 1.00 Yuan/kg, K_2O = 2.33 Yuan/kg.
*, ** Difference significant at the 5% or 1% level, respectively.

Bangladesh, India, Indonesia, Myanmar, and Vietnam. **BC**

Dr. Witt is Director, PPI/PPIC-IPI Southeast Asia Program, Singapore; e-mail: cwitt@ppi-ppic-ipi.org. Dr. Dobermann is Professor at the University of Nebraska. Dr. Buresh is Soil Scientist at the International Rice Research Institute (IRRI), Los Baños, Philippines. Dr. Abdulrachman is Agronomist at the Research Institute for Rice, Sukamandi, Indonesia. Mr. Gines is Agronomist at the Philippine Rice Research Institute, Maligaya, Philippines. Dr. Nagarajan is a Soil Scientist at the Soil and Water Management Research Institute, Tamil Nadu, India. Dr. Ramanathan is Director of Research, Tamil Nadu Rice Research Institute, Coimbatore, India. Dr. Tan is Agronomist at the Cuu Long Delta Rice Research Institute, Omon, Vietnam. Prof. Wang is Soil Scientist at the Zhejiang University, Hangzhou, P.R. China.

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References

- Dobermann, A., C. Witt, S. Abdulrachman, H.C. Gines, R. Nagarajan, T.T. Son, P.S. Tan, G.H. Wang, N.V. Chien, V.T.K. Thoa, C.V. Phung, P. Stalin, P. Muthukrishnan, V. Ravi, M. Babu, G.C. Simbahan, M.A. Adviento, V. Bartolome. 2003. *Agron.J.* 95:924-935.
- Fairhurst, T. and C. Witt. (ed.) 2002. *Rice: A practical guide to nutrient management*. Singapore and Makati City: Potash & Phosphate Institute, Potash & Phosphate Institute of Canada (PPI/PPIC) and International Rice Research Institute (IRRI). p 1-89.
- Witt, C., R.J. Buresh, V. Balasubramanian, D. Dawe, A. Dobermann. 2002. *Better Crops Int.* 16-2:10-17.
- Witt C. and A. Dobermann. 2004. *In* Dobermann, A., C. Witt, D. Dawe, editors. *Increasing productivity of intensive rice systems through site-specific nutrient management*. Enfield, NH (USA) and Los Baños (Philippines): Science Publishers, Inc., and International Rice Research Institute (IRRI). p. 1-420.

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The highest shoot and clove yields were obtained with 300-90-300 kg/ha at Shuikou. The two sites at Xin'an had much higher yield potential and achieved much higher relative yields under all treatments. Both sites at Xin'an suggest a potential for even higher yields given the good performance of the highest N/highest K combination, which produced very large yields and profits.

The economics of garlic production were greatly improved with addition of 150 kg K₂O/ha, at both N rates. However, the data clearly show that 300 kg K₂O/ha applied with N at rates of 300 to 375 kg/ha, regardless of site, provide the best return to farmers.

The effects of widespread adoption of balanced fertilization in garlic production systems in Southeast China could have immense economic impact. **Results point to consistently large and profitable responses to rational NPK rates and no doubt enhance this production system in the eyes of farmers searching for viable cash cropping options.** **BC**

The authors are with the Soil and Fertilizer Institute, Anhui Academy of Agricultural Science, Hefei 230031 China. E-mail: lilujiu@yahoo.com.cn.