Diagnosing nutrient needs of garlic

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Phosphorus and zinc fertilizers are rarely required. Only moderate amounts of nitrogen are needed for top yields.

Most of the garlic grown commercially in the United States is produced in California. About 80 percent of California garlic is produced for processing into dehydrated flakes, granules, or powders. This garlic is usually grown under contract with dehydrator companies, which plant the fields using their own seed cloves, and harvest the crops with their machines and crews. Dehydrator companies also provide technical advice and guidance to garlic growers on fertilization, irrigation, and pest and disease control.

Until our studies began in 1979, there had been very little research to determine fertilizer requirements of garlic and to establish levels of nutrient deficiency and sufficiency in garlic leaf tissue for diagnosing the crop's nutrient status. These studies consisted of ten replicated field fertilizer experiments conducted in the Salinas and San Joaquin valleys from 1979 to 1985. Three test fields were planted to the California Late variety, five fields to California Early, and two fields to virus-free California Early garlic. All were planted in the fall (October to December) and harvested the following summer (June to September). Soil samples were collected before planting, and leaf tissue samples were taken several times during the growing season for macronutrient analysis.

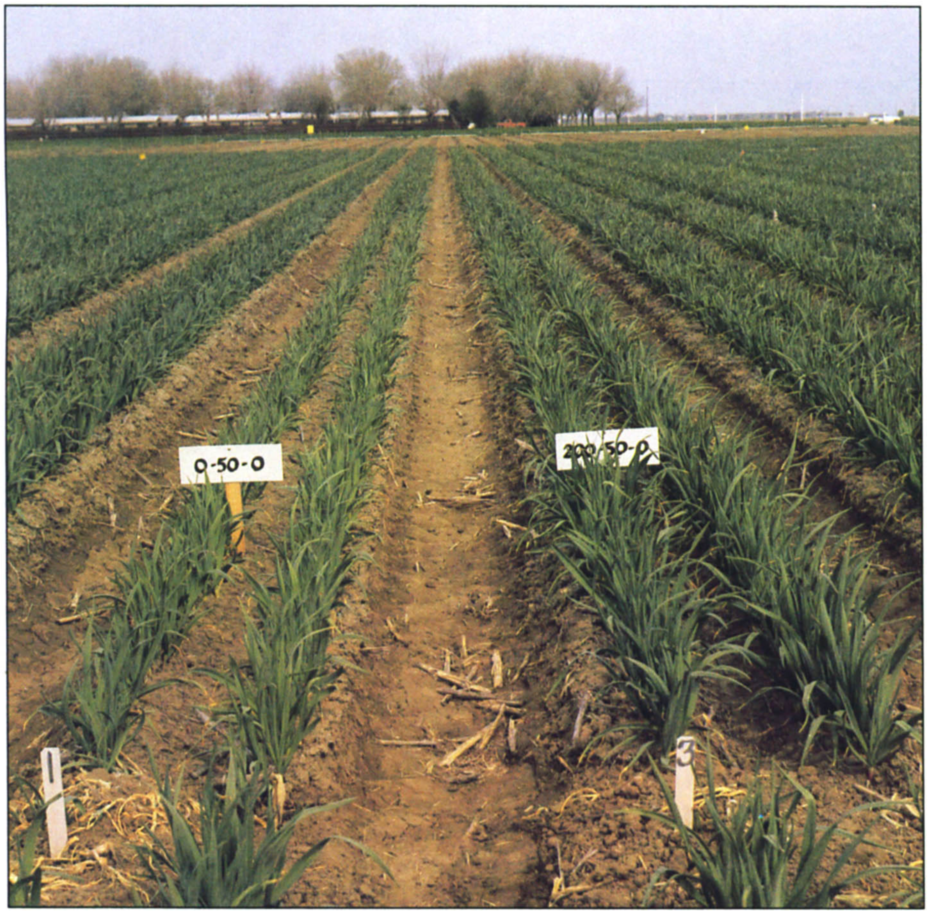
All ten fields had more than 100 parts per million (ppm) exchangeable soil potassium, which was above the known deficiency levels for most vegetable crops. The soils in all except one field would be considered very low to deficient in nitrate-nitrogen for vegetables. Except for the Kern, Fresno, and Monterey County experiments, all fields had phosphate-phosphorus levels below 8 ppm and would be considered deficient for many crops. All were slightly alkaline, averaging 7.6 in pH, except the coarse-textured, slightly acid soil in Monterey County.

Despite very low concentrations of available phosphorus in seven soils and zinc in four fields, there was no significant yield response to phosphorus or zinc fertilizer applications. Nitrogen applications of 100 pounds per acre or more, however, increased garlic yields in all but one of the ten experiments (table 1). Rates of nitrogen above 100 pounds per acre significantly increased yields in four of ten experiments. One of these four was on gravelly sandy loam in Monterey County. Two of the four were planted with virus-free California Early Garlic cloves, which generally produced higher yields than all others at comparable nitrogen rates.

Total solids in garlic cloves, one measure of quality, were unaffected by phosphorus, potassium, and zinc application. Nitrogen at 100 pounds per acre significantly increased total solids in three experiments, but caused a reduction in one experiment (table 2). Higher nitrogen rates (generally above 100 pounds per acre) tended to reduce total solids.

The analysis of plant tissue data, representing total nitrogen, acetic-acid-soluble phosphate-phosphorus, and potassium in both California Early and California Late garlic leaf samples provided a basis for compiling the garlic leaf analysis guide in table 3. Three sampling times were chosen, based on physiological growth stages, since both nitrogen and phosphorus concentrations in garlic leaves decline fairly rapidly before plants start to bulb and continue to decrease until bulbs are nearly mature.

Values in the guide should be regarded as estimates that may eventually change or be verified as accurate as more field experiments are conducted. Nitrogen values in the guide are probably more precise than phosphorus or potassium values, because nine of the ten field experiments had yield responses and leaf nitrogen increases resulting from nitrogen application. There were no significant yield responses from phosphorus application, although mid- and late-season levels of phosphate-phosphorus were generally higher where phosphorus was applied.



Nitrogen increased garlic yield in nine of ten field experiments. This photo, taken at the UC West Side Field Station in 1985, shows the effects of applying 200 pounds of nitrogen per acre (rows at right); area on the left received no nitrogen.

TABLE 1. Influence of nitrogen fertilizer application on garlic yield in 10 field experiments

	Garlic yield†										
Nitrogen fertilizer application rate*	**Kern 1-79**	**WSFS 2-80**	**Fresno 3-80**	**Monterey 4-80**	**WSFS 5-80**	**WSFS 6-81**	**Fresno 7-81**	**WSFS 8-83**	**WSFS 9-83**	**WSFS 10-85**	**Average 10 expts.**
lb N per acre					*tons per acre*						
0	3.7	5.3	8.0	7.7	3.4	4.0	5.4	6.0	9.4	6.7	6.0
100	6.5	9.2	9.3	10.8	6.3	6.4	7.2	8.7	11.4	13.1	8.9
200	7.3	9.7	8.5	11.8	7.9	7.9	7.7	8.2	11.7	14.3	9.5
300	6.6	9.0	8.4	12.7	6.7	9.0	7.7	8.4	13.1	15.3	9.7
400	7.8	10.3	8.7	12.0	8.9	9.2	7.1	8.4	11.8	15.6	10.0
500	7.6	9.0	7.6	12.6	7.0	8.0	7.0	8.7	11.1	15.4	9.4
LSD 5% level	2.2	1.5	ns	1.2	2.0	1.5	0.6	1.2	1.8	0.9	—

* Phosphorus fertilizer was applied before planting at the rate of 50 lb P per acre as treble superphosphate (0-45-0).
† The garlic variety in experiments 3-80, 4-80, and 5-80 was California Late. All other experiments were cropped to California Early garlic except 9-83 and 10-85 which were planted to virus-free California Early garlic.

TABLE 2. Influence of nitrogen fertilizer application on total solids content of garlic bulbs

	Total solids content†										
Nitrogen fertilizer application rate*	**Kern 1-79**	**WSFS 2-80**	**Fresno 3-80**	**Monterey 4-80**	**WSFS 5-80**	**WSFS 6-81**	**Fresno 7-81**	**WSFS 8-83**	**WSFS 9-83**	**WSFS 10-85**	**Average 10 expts.**
lb N per acre					*% dry matter*						
0	36.6	42.2	—	40.7	43.9	40.7	40.7	41.0	41.1	42.7	41.1
100	37.8	42.0	—	42.5	43.6	41.2	39.5	40.7	41.2	44.1	41.4
200	37.5	41.2	—	40.9	42.4	40.8	39.0	40.6	40.5	43.9	40.8
300	37.2	40.7	—	40.2	42.0	40.4	38.8	39.6	40.4	42.6	40.2
400	37.2	39.8	—	40.2	41.3	39.7	—	39.7	40.1	42.6	40.1
500	37.0	39.6	—	40.0	41.4	39.3	—	39.1	39.8	42.8	39.9
LSD 5% level	0.8	1.1	—	1.5	1.3	0.9	0.7	0.5	0.7	0.8	—

* See table 1 (*).
† See table 1 (†).

TABLE 3 Garlic leaf analysis guide for diagnosing crop nutrient status

	Nutrient level		
Sampling time and nutrient*	**Deficient**	**Intermediate**	**Sufficient**
Early season (pre-bulbing)			
Total N, %	4	4-5	5
PO_4-P, ppm	2000	2000-3000	3000
Soluble K, %	3	3-4	4
Midseason (bulbing)			
Total N, %	3	3-4	4
PO_4-P, ppm	2000	2000-3000	3000
Soluble K, %	2	2-3	3
Late season (post-bulbing)			
Total N, %	2	2-3	3
PO_4-P, ppm	2000	2000-3000	3000
Soluble K, %	1	1-2	2

* Plant part sampled was newest fully elongated leaf.

Potassium application had little or no effect on garlic yield or on leaf levels of soluble potassium. This finding might be explained by the soil analyses, which showed adequate levels of available potassium in the ten fields.

This five-year study of garlic mineral nutrition has shown that responses of the California Early and California Late varieties to fertilizer application are moderate. Because garlic has an excellent capacity to forage for, or efficiency in utilization of, phosphorus and zinc in soils, their application should be required very rarely and only where soils are extremely low in available forms of these nutrients. The addition 100 to 200 pounds of nitrogen per acre should be sufficient for garlic, since most yield responses in these studies leveled off at these rates, even though some of the soils had very low nitrate-nitrogen levels. High-yielding crops grown from virus-free garlic cloves were more responsive to higher rates of nitrogen and may benefit from application of as much as 300 pounds of nitrogen per acre.

Plant tissue analyses should be used in conjunction with soil analyses to help manage garlic fertilizer programs. Our guide (table 3) lists deficient, intermediate, and sufficient levels of total nitrogen, phosphate-phosphorus, and soluble potassium to enable labs, growers, and crop advisors to interpret results of leaf analyses and thus diagnose the nutrient status of garlic crops.

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