Fertilizing summer-planted strawberries in California's Central Coast

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Many growers in California's Central Coast area keep strawberry fields for two years of production. Nitrogen needs and nutrient removal by strawberries during the full two years had not previously been studied in California.

Strawberries require frequent irrigation on a well-drained soil for maximum production. It is not unusual for a grower to apply 4 to 5 feet of water per acre annually when furrow-irrigating and 3 feet per acre when using drip tubes. Rainfall from November to April averages 20 inches. Frequent irrigation, use of plastic mulch over the bed, and a long growing season make it difficult to fertilize this crop properly with nitrogen. Too much nitrogen can cause poor fruit quality, excessive plant growth that makes harvesting more expensive, and an increase in the number of runners on some varieties.

Experiments

This study, covering four years and two varieties (Tioga and Aiko), each harvested over two production years, was designed to determine the amount of nitrogen removed from the soil in the harvested fruit and plant parts of summer-planted strawberries under normal cultural practices and various nitrogen rates. The quantities of phosphorus (P), potassium (K), calcium (Ca), and magnesium (Mg) contained in the fruit and plant parts were also determined. The soils in our experimental plots were high in these four minerals, so no attempt was made to test application rates of these nutrients. Before planting, 1,000 pounds of 0-20-20 and 1,000 pounds of lime were applied over each experimental area.

The study included Agriform (21-4-8) as a slow-release nitrogen material. Nitrapyrin, a material used to block bacterial oxidation of ammonium, was used in part of the ammonium sulfate treatments.

For both varieties, nitrogen fertilizers were sidedressed into the bed in four equal units in September, late October, early February, and early April in each production year. Ammonium sulfate was applied at 75, 150, and 225 pounds actual nitrogen per acre. The same rates of nitrogen as ammonium sulfate were used in combination with nitrapyrin. Agriform was applied in an amount to supply 75 pounds of nitrogen per acre.

All runners and leaf prunings were collected from each plot and analyzed for nutrient content. Fruits were harvested and weighed weekly; samples were composited on a monthly basis and frozen.

The Tioga variety was planted on August 7, 1975, in fumigated Watsonville loam soil at 21,500 plants per acre. Plants were set in a single row on a 40-inch bed and furrow-irrigated.

Aiko was chosen as a second variety because of its long harvest period, high yield, and increasing popularity with growers. This variety was planted in fumigated Watsonville loam soil on September 2, 1977, using 28,000 plants per acre. Plants were planted in a double row per bed and drip irrigated.

Results and discussion

The total nitrogen level was significantly lower in both Tioga and Aiko fruit coming from nonfertilized plots than from all other treatments (tables 1 and 2). Fruit from the plot receiving 75 pounds of nitrogen per acre without nitrapyrin had a significantly lower percentage of nitrogen than that in other treatments and, except in the second-year Aiko harvest, was significantly higher in percentage of nitrogen than fruit receiving no nitrogen (table 3).

Within each year, no significant differences in level of nitrogen occurred among the other treatments. The P, K, Ca, and Mg contents of the fruit within each year, between each picking, and among the different fertilizer rates were not significantly different from each other.

The zero nitrogen plots produced significantly lower weights of leaves and runners in both varieties than all other treatments (table 4). The 75-pound-per-acre rate of nitrogen without nitrapyrin produced significantly lower leaf and runner weights than the other nitrogen treatments in the Tioga experiments but higher weights in the Aiko experiments. Weights of runners and leaves in remaining treatments were not significantly different from each other. Levels of all minerals analyzed in leaf and runner prunings were not significantly different among treatments within the same variety.

Conclusions

Nitrapyrin mixed with ammonium sulfate significantly increased yield in both varieties at 75 pounds nitrogen per acre and in Tioga at 150 pounds per acre, when compared with no nitrogen or with the same rate of ammonium sulfate alone. Agriform supplying nitrogen at 75 pounds per acre, resulted in significantly higher Tioga strawberry yields than were obtained in nonfertilized plots and in those receiving 75 and 150 pounds of nitrogen per acre without nitrapyrin.

Increasing nitrogen rates above 75 pounds per acre in the Aiko experiments did not significantly increase yield or nitrogen uptake into leaves, runners or fruits. Nitrogen removal in pruning and in the harvested berries over a two-harvest season was about 267 pounds per acre in Tioga and 277 in Aiko.

The major differences between the two varieties were that Tioga removed roughly twice as much nitrogen in leaves and runners, and Aiko yielded more fruit. Tioga is a more vigorous variety that produces many more runners than Aiko after the first crop is picked. Nitrogen levels were lower in Aiko fruit than in Tioga in the first year of production but were about the same in fruit of both varieties in the second year of harvest.

Strawberries tend to need a constant supply of nitrogen during their active growing season, as is evident from the constant level of nitrogen in the fruit throughout the harvest period. For this reason, a slow release fertilizer, such as Agriform, or addition of a material, such as nitrapyrin, that slows bacterial conversion of ammonium increases efficiency of nitrogen use.

Ammonium has a positive charge that helps it adsorb onto the negative clay particle until bacteria in the soil oxidize it to the negative-charged nitrate-ion form of nitrogen. This form is easily leached by water, because it is not adsorbed to the clay particles. A number of nitrogen fertility tests indicate that Aiko needs 20 to 30 percent more nitrogen than Tioga to produce a near maximum yield. Aiko, with its semi-dwarfed plant habit, has a smaller root system, which is less able to explore and remove nitrogen

TABLE 1. Tioga Strawberry Fruit Yield and Total Nutrient Content as Related to Various Fertilizer Treatments

Treatments		First-year harvest, 1975-76						Second-year harvest, 1976-77					
			Total nutrients removed						Total nutrients removed				
Total N applied	Nitrapyrin a.i.*	Yield†	N†	P	K	Ca	Mg	Yield†	N†	P	K	Ca	Mg
lb/a	*lb/a*	*trays/a*	*lb/a*	*lb/a*	*lb/a*	*lb/a*	*lb/a*	*trays/a*	*lb/a*	*lb/a*	*lb/a*	*lb/a*	*lb/a*
0	0.0	5,333 a	89.6 a	19.8	115.2	35.2	12.2	3,008 a	50 a	11.7	67.7	19.6	7.1
75	0.0	5,667 b	100.6 b	21.0	122.4	37.4	12.9	3,356 b	54 b	12.7	73.3	21.4	7.7
75	0.5	6,033 c	108.6 c	22.4	130.3	39.8	13.8	3,426 c	55.2 b	13.0	74.8	21.6	7.9
75‡	0.0	6,066 c	109.2 c	22.6	131.0	40.0	13.8	3,484 c	54.5 b	12.8	73.9	21.4	7.8
150	0.0	5,733 b	103.2 b	21.3	123.8	37.8	13.1	3,374 b	54.3 b	12.8	73.7	21.3	7.8
150	0.5	6,103 c	112.2 c	23.1	134.6	41.4	14.2	3,600 d	58.0 c	13.7	78.7	22.8	8.3
225	0.0	6,033 c	108.2 c	22.4	130.3	39.8	13.7	3,496 c	56.2 b	13.3	76.3	22.1	8.0
225	0.5	6,067 c	109.2 c	22.6	131.0	40.0	13.8	3,462 c	56.8 c	13.6	78.4	22.7	8.3

*a.i. = active ingredient.
†Numbers not followed by a common letter are significantly different at the 5 percent level.
‡Agriform. In all other treatments (NH_4) SO_4 was used as source of nitrogen (N).

TABLE 2. Aiko Strawberry Fruit Yield and Total Nutrient Content as Related to Various Fertilizer Treatments.

Treatments		First-year harvest, 1977-78						Second-year harvest, 1978-79					
			Total nutrients removed						Total nutrients removed				
Total N applied	Nitrapyrin a.i.*	Yield†	N†	P	K	Ca	Mg	Yield†	N†	P	K	Ca	Mg
lb/a	*lb/a*	*trays/a*	*lb/a*	*lb/a*	*lb/a*	*lb/a*	*lb/a*	*trays/a*	*lb/a*	*lb/a*	*lb/a*	*lb/a*	*lb/a*
0	0.0	6,348 a	65.7 a	21.9	116.8	36.5	13.9	5,966 a	71.6 a	15.0	100.2	28.6	14.3
75	0.0	7,048 b	84.0 b	25.8	137.6	43.0	16.3	6,506 b	90.5 b	18.1	105.6	30.2	15.1
75	0.5	7,656 c	105.6 c	26.4	140.8	44.0	16.7	6,766 c	108.9 c	18.7	108.9	31.1	15.6
75‡	0.0	8,022 c	110.6 c	29.4	156.8	49.9	18.6	6,730 c	108.4 c	18.6	108.4	31.0	15.5
150	0.0	7,623 c	105.2 c	26.3	140.3	43.8	16.6	6,800 c	109.5 c	18.8	109.5	31.3	15.6
150	0.5	7,722 c	106.6 c	26.6	142.1	44.4	16.9	6,800 c	109.5 c	18.8	109.5	31.3	15.6
225	0.0	7,874 c	101.8 c	25.4	135.7	42.4	16.1	6,739 c	108.7 c	18.1	105.3	30.1	15.0
225	0.5	7,906 c	108.4 c	27.6	147.2	46.0	17.5	6,713 c	108.1 c	18.5	108.1	30.9	15.4

*a.i. = active ingredient.
†Numbers not followed by a common letter are significantly different at the 5 percent level.
‡Agriform. In all other treatments (NH_4) SO_4 was used as source of nitrogen (N).

TABLE 3. Level of Nutrients in the Fruit

Treatments (N/acre)	Nitrogen†	Phosphorus		Potassium		Calcium		Magnesium	
		Range	Average	Range	Average	Range	Average	Range	Average
	%	%	%	%	%	%	%	%	%
TIOGA									
0	.14 a								
75 lb*	.146 b	.019–.024	.021	.16–.19	.18	.051–.057	.055	.018–.021	.019
All others	.15 c								
AIKO first year									
0	.083 a								
75 lb*	.089 b	.03–.04	.03	.14–.18	.16	.05–.05	.05	.017–.021	.019
All others	.094 c								
AIKO second year									
0	.137 a								
75 lb*	.140 ab	.02–.03	.024	.11–.16	.14	.03–.06	.04	.02–.02	.02
All others	.147 c								

*Without nitrapyrin.
†Numbers not followed by a common letter are significantly different at the 5 percent level.

TABLE 4. Strawberry Nutrient Removal by Leaves and Runners, Total of Two Harvest Years

Treatments	Dry wt.†	Nutrient removal					Percentage				
		N†	P	K	Ca	Mg	N	P	K	Ca	Mg
	lb/a	*lb/a*	*lb/a*	*lb/a*	*lb/a*	*lb/a*	%	%	%	%	%
TIOGA											
0	6,405 a	89.0 a	13.4	66.6	84.5	28.2	1.40	.21	1.04	1.32	.44
75 lb*	6,534 b	93.4 b	13.7	67.9	86.2	28.7	1.43	.21	1.04	1.32	.44
All others	7,052 c	100.1 c	14.8	73.3	93.1	31.0	1.42	.21	1.04	1.32	.44
AIKO											
0	2,800 a	38.5 a	4.3	40.0	38.6	12.6	1.37	.15	1.42	1.37	.45
75 lb*	3,600 c	49.8 c	5.9	50.0	49.2	15.0	1.38	.16	1.38	1.36	.41
All others	3,400 b	45.7 b	5.1	47.0	42.3	12.8	1.34	.15	1.38	1.24	.37

*Without nitrapyrin.
†Numbers not followed by a common letter are significantly different at the 5 percent level.

from a larger volume of soil.

Levels of other nutrients were constant over the entire picking season, regardless of the nitrogen rate used. Phosphate, potassium, and calcium are held in the soil and are not readily leached below the root system of strawberries under normal farming practices. Aiko tends to have lower phosphorus and higher potassium levels in the vegetative portion of the plant than Tioga.

Because strawberry roots are sensitive to salt, all preplant fertilizers should be broadcast after the fields have been leveled. The fields then should be thoroughly disced and bedded up. A method of slot-fertilization for winter-planted strawberries has been worked out by Victor Voth, U.C. pomologist in southern California, which is effective in stimulating growth during the short, cool days of winter.

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