but lowered the means of measurements for flower quality from lighted plots.

Our results indicated that high intensity supplementary lighting with W.S. Gro-Lux lamps and incandescent light at the end of the lighting period may increase winter rose yields if the proper greenhouse cultivars are selected.

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Effect of Controlled-Release Nitrogen Fertilizers on Yield and Nitrogen Absorption by Potatoes, Cantaloupes, and Tomatoes[1]

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Abstract. In field studies with potatoes, cantaloupes, and tomatoes, using N sources banded in the soil, highest yields were obtained with $(NH_4)_2SO_4$. Yields with urea-formaldehyde and sulfur-coated urea were similar to each other, and less than those from urea. Nitrogen absorption, as determined by NO_3^- concn in the petiolar tissue or total N absorption by the entire plant, was in the same sequence as yields. Controlled-release fertilizers did not increase N absorption during late growth. About 90% of the N from $(NH_4)_2SO_4$ and urea had nitrified and leached from the fertilizer band within 40 days after application. In contrast, about half of the N from urea-formaldehyde remained in the fertilizer band 120 days after application.

Numerous experiments have demonstrated the superiority of ammoniacal sources for fertilizing potatoes and other vegetables grown on alkaline calcareous soils in California (6, 7). In most experiments the highest yields were obtained with $(NH_4)_2SO_4$ or $NH_4H_2PO_4$, and anhydrous and aqua ammonia has resulted in toxicities if placed close to the plant. On course-textured, heavily irrigated soils, nitrate sources are unsatisfactory because of leaching. The inferiority of urea in comparison with $(NH_4)_2SO_4$ is often due to the formation of high concn of free ammonia and infrequently to nitrites. Injury has not been noted from the use of $(NH_4)_2SO_4$, which is physiologically acid.

The effectiveness of "controlled" or "slow-release" N fertilizers has been evaluated, using forage (1, 2, 8, 9, 10, 11) and greenhouse (3, 4) crops. Such fertilizers have given good results with broadcast applications on turf and slow-maturing crops. However, their performance with vegetables under field conditions has not been adequately determined. The results from placed or banded fertilizers on quick-growing vegetable crops might be considerably different from those obtained with broadcast applications on long-season crops.

Studies on the rate of nitrification of urea-formaldehyde have been summarized by Hays (5). After greenhouse experiments, Byrne and Lunt (3) reported that about 25% of the N from urea-formaldehyde is soluble in cold water, and the rate of mineralization of the remainder is about 6 to 7% per month. Futura, Sciaroni, and Breece (4), in studies on the rate of release of N from various sulfur-coated ureas, found that dissolution rates of 1% per day were better for extended growth than rates 5 to 6 times higher.

This paper compares results obtained with several N sources applied in bands at the time of planting. Data are presented on yields, N uptake, and N transformations in the soil.

Materials and Methods

Potato, *Solanum tuberosum* L. cv. White Rose, experiments were conducted on Hesperia fine sandy loam soil in Kern County, California for 4 years, on a Moreno fine sandy loam at Hemet 1 year, and on a Yolo fine sandy loam at Davis for 1 year. Plantings were made in February, and the crops were harvested in June or July. The fertilizers were applied at planting in bands 3 inches to each side and 2 inches below the seed piece. The cantaloupes, *Cucumis melo* L. cv. PMR45 and tomatoes, *Lycopersicon esculentum* Mill. cv. VF145, were grown at Davis on a Yolo fine sandy loam. They were planted in March and harvested in August. All soils were light to medium textured, alkaline calcareous, and had pH values between 7.6 and 7.8. Fertilizers were banded in the shoulder of the bed 6 inches from the seed and 4 inches deep. All crops received 50 lb. P and 100 lb. K per acre applied with the N fertilizers. Each plot, which was replicated 4 times, consisted of 2 rows 65 ft long. Potato rows were spaced 32 inches apart, and those for cantaloupes and tomatoes, 66 inches apart. All crops were furrow irrigated, with water supplied in amounts consistent with commercial practice.

The sulfur-coated ureas (SCU) were supplied by the

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Tennessee Valley Authority. The material used in the 1970 trials contained 35.6% N, conditioned with 1.5% diatomaceous earth, a wax coating of 3%, and a microbiocide coating of 0.25%. The dissolution rate in water was 16.8% in 5 days and 22.9% in 14 days. The SCU in the 1966 test contained 26.8% N. The urea-formaldehyde (Nitroform), supplied by the Hercules Powder Company, contained 38% total N and 24% to 28% insoluble N, and had an activity index of 40 to 50.

In all trials, petiole samples were taken 3 or more times during the growing season and analyses made, as described by Tyler et al. (12). Soil samples for N transformation studies were taken at approx 3-week intervals from fallow plots which were fertilized and irrigated the same as the plots growing the crops. The fertilizer bands were marked at time of application by adding colored pebbles with the fertilizer. At sampling, 4 cores of soil, each 8 inches long and 3 inches in diam, surrounding the fertilizer band were taken from each of 4 plots. Since the N in the Nitroform and SCU was water insoluble, total N was obtained by the Kjeldahl method, and the rate of nitrification was determined by comparing with soil not receiving the N fertilizers. The amount of N remaining in the area of placement and not leached as NO_3^- or other soluble form was used as the measure of the amount of nitrification that had occurred.

Results

Potatoes. In all tests in Kern County, plants receiving $(NH_4)_2SO_4$ yielded higher than those receiving Nitroform or SCU (Table 1). The yield from $(NH_4)_2SO_4$ was significantly higher than from urea only at the 60 lb. rate in 1970. In both 1966 and 1970 urea resulted in higher yields than SCU. The yield from SCU was slightly higher than Nitroform at the 60 and 120 lb. rates.

In 1967, various ratios of $(NH_4)_2SO_4$ and Nitroform were also tested (data not presented). At the 120-lb. N rate the yield from $(NH_4)_2SO_4$ was 354 cwt/A, as compared to 205 with Nitroform and 279 with a 50:50 mixture of the 2 forms. At the 240-lb. N rate the yields from $(NH_4)_2SO_4$ and from the mixture of $(NH_4)_2SO_4$ and Nitroform were equal.

At Hemet in 1962, yields of cv. White Rose were increased with all N sources, but higher yields were obtained with $(NH_4)_2SO_4$ than with SCU or urea, especially at the 240-lb. N rate (Table 2). At the 120-lb. N application there were no significant differences in yield of the cv. White Rose or cv. Kennebec associated with source of N.

In the 1970 experiment at Davis, results were similar to those in Kern County (Table 3). Increases in yield were obtained from all N sources at all rates of application, with highest yields occurring at the highest rates, except that yield from $(NH_4)_2SO_4$ at the 240-lb. N rate was not significantly different from that at 120 lb. Yields from $(NH_4)_2SO_4$ were significantly higher than from any other source at the 60- and 120-lb. N/A rates, and were higher than from Nitroform and SCU at 240 lb. N/A. Higher yields were obtained from SCU than from Nitroform, and urea gave slightly higher yields than SCU.

Petioles from plants in all experiments were analyzed for NO_3^-, with data reported only for the 1970 test in Kern County. The results from the other experiments were similar. There was excellent agreement between NO_3^- concn in the petioles and

Table 1. Effect of source and rate of N on potato yields in Kern County during 4 years.

Year of test	Lb. of N/A	Total yield per acre (cwt)[z]			
		Source of N			
		$(NH_4)_2SO_4$	Nitro-form	Sulfur-coated urea	Urea
1966	0	108 a	–	108 a	108 a
	120	400 cd	–	300 b	382 c
	240	422 d	–	360 c	431 d
1967	0	119 a	119 a	–	–
	60	284 e	185 b	–	–
	120	354 f	205 c	–	–
	240	389 g	244 d	–	–
1968	0	204 a	204 a	–	–
	60	346 de	243 b	–	–
	120	444 f	278 c	–	–
	240	510 g	332 d	–	–
1970	0	118 a	118 a	118 a	118 a
	60	414 fg	252 b	290 bc	350 d
	120	465 g	301 bc	355 de	420 fg
	240	567 h	402 ef	414 fg	529 h

[z]Means with different letters for each experiment are significantly different at the 5% level.

Table 2. Effect of source and rate of N on potato yields, Hemet, 1962.

Cultivar	Lb. of N/A	Total yield per acre (cwt)[z]		
		Source of N		
		$(NH_4)_2SO_4$	Sulfur-coated urea	Urea
White Rose	0	172 a	172 a	172 a
	60	257 cd	235 bc	219 b
	120	272 d	269 d	255 cd
	240	310 e	240 bc	237 bc
Kennebec	0	246 a	246 a	246 a
	120	343 b	325 b	339 b

[z]Means with different letters are significantly different at the 5% level.

Table 3. Effect of source and rate of N on potato yields, Davis, 1970.

Lb. of N/A	Total yield per acre (cwt)[z]			
	Source of N			
	$(NH_4)_2SO_4$	Urea	Nitro-form	Sulfur-coated urea
0	182 a	182 a	182 a	182 a
60	339 d	303 de	251 b	284 cd
120	399 h	349 fg	274 bc	327 ef
240	416 h	392 h	329 f	365 g

[z]Means with different letters are significantly different at the 5% level.

Table 4. Effect of source and rate of N on NO_3-N in dried petioles from potato fertilizer experiment, Kern County, 1970. Planted 3/21/70 and harvested 7/13/70.

Source of nitrogen	Ppm NO_3-N in petiole (dry wt basis)			
	Lb. N per acre			
	0	60	120	240
1st sampling (4/6/70): (plants 12" tall)				
Ammonium sulfate	1325	18835	23530	26245
Urea	1325	19795	23000	26745
Sulfur-coated urea	1325	8030	9785	19315
Nitroform	1325	2385	5915	12045
2nd sampling (4/21/70): (tubers 1 in. diam.)				
Ammonium sulfate	tr	5125	14020	21420
Urea	tr	3750	9470	19025
Sulfur-coated urea	tr	2900	3500	5200
Nitroform	tr	80	150	1065
3rd sampling (5/5/70): (tubers half grown)				
Ammonium sulfate	tr	170	1995	13795
Urea	tr	tr	1490	11125
Sulfur-coated urea	tr	tr	tr	170
Nitroform	tr	tr	tr	tr
4th sampling (5/22/70): (plants nearly mature)				
Ammonium sulfate	tr	tr	450	9205
Urea	tr	80	tr	3895
Sulfur-coated urea	tr	95	115	150
Nitroform	tr	75	95	415

subsequent yields. At the first 2 samplings, there was increased NO_3^- with increased application rates with all sources of N (Table 4). At the lower rates of application, much higher NO_3^- occurred with $(NH_4)_2SO_4$ and urea than with Nitroform or SCU. At all rates, NO_3^- was higher with SCU than with Nitroform. As the plants approached maturity, only the 240-lb. N/A application of $(NH_4)_2SO_4$ and urea resulted in appreciable quantities of NO_3^- in the plants.

The efficiency of N sources was also evaluated by determining the total amount of N absorbed by the crops, including tops and tubers. In the 1967 experiment in Kern County, $(NH_4)_2SO_4$ resulted in highest N absorption at all rates of application, followed in order by urea and Nitroform (Table 5). At 120- and 240-lb. N/A rates, plants receiving $(NH_4)_2SO_4$

Table 5. Effect of source and rate of N on N recovery by potatoes, Kern County, 1967.

	Total N absorption (lb./A - tops and tubers)			
	Lb. N/A applied			
Source of N	0	60	120	240
$(NH_4)_2SO_4$	29.6	85.1	125.3	186.6
Urea	29.6	76.3	101.3	131.8
Nitroform	29.6	51.3	53.6	75.6

removed more than twice as much N as those given Nitroform. Plants fertilized with $(NH_4)_2SO_4$ recovered 80% of the N applied at 120-lb. rate and 65% of that applied at the 240-lb. N/A rate, compared to recoveries from Nitroform of 20% and 18%, respectively.

Cantaloupes. In the 1967 test, $(NH_4)_2SO_4$ and urea resulted in higher yields than Nitroform at the 100-lb. N/A application. With all sources, yields from 200 lb. N/A were not significantly different from those produced with 100 lb. N/A (Table 6). In the 1970 test, as compared to unfertilized plots, yields of cantaloupes were significantly increased by all N sources at the 120-lb. N/A rate and by $(NH_4)_2SO_4$, urea, and SCU at the 60-lb. N/A rate. In general, highest yields were obtained with $(NH_4)_2SO_4$, followed in order by urea, SCU, and Nitroform.

In the 1967 trials, petiole analyses showed much higher NO_3^- accumulation from $(NH_4)_2SO_4$ and urea than from Nitroform, with the largest differences occurring at the second sampling (Table 7). At the last sampling, the only plants containing high amounts of NO_3^- were those receiving 200 lb. N/A from urea or $(NH_4)_2SO_4$. In the 1970 test, absorption of NO_3^- from $(NH_4)_2SO_4$ and from urea was comparable, and both resulted in much higher levels of NO_3^- in the plants than occurred with Nitroform or SCU. The differences were greater at the last 2 samplings. At the last sampling, high amounts of NO_3^- were found only in plants receiving 120 lb. N/A from urea or $(NH_4)_2SO_4$.

Table 6. Effect of source of N on cantaloupe yields, Davis, 1967 and 1970.

	Total yield per acre (cwt)[z]		
	Lb. N applied per acre		
Source of nitrogen	0	100	200
1967:			
$(NH_4)_2SO_4$	266 a	372 c	362 c
Urea	266 a	347 bc	363 c
Nitroform	266 a	286 a	333 abc
	0	60	120
1970:			
$(NH_4)_2SO_4$	274 a	398 c	441 d
Urea	274 a	389 c	400 c
Sulfur-coated urea	274 a	333 b	373 c
Nitroform	274 a	300 a	331 b

[z]For each year, experiment means with different letters are significantly different at the 5% level.

Table 7. Source and rate of N and NO_3-N in petioles from cantaloupe experiment, Davis, 1967 and 1970.

		Ppm NO_3-N in petiole tissue		
Source of N	Lb. N/A	7/10/67	7/17/67	7/31/67
1967:				
Control	0	15170	2295	305
$(NH_4)_2SO_4$	100	26935	15335	3170
	200	28620	20500	9285
Urea	100	24390	15965	3155
	200	25525	20555	8915
Nitroform	100	19110	2980	595
	200	22290	5380	610
		6/20/70	7/10/70	7/29/70
1970:				
Control	0	3345	300	tr
$(NH_4)_2SO_4$	60	17490	5540	170
	120	21665	13620	2340
Urea	60	14395	8850	280
	120	18420	16565	7205
Sulfur-coated urea	60	12360	395	280
	120	15290	1700	tr
Nitroform	60	10885	tr	tr
	120	17580	1065	tr

Tomatoes. Nitrogen from the 3 sources at either the 100 or 200 lb. rate increased yields significantly (Table 8). Yields with either $(NH_4)_2SO_4$ or urea were approx the same but both exceeded those from Nitroform at the 100-lb. rate. Nitrate concn in the petioles were also higher with $(NH_4)_2SO_4$ and urea than with Nitroform, the largest differences occurring at the second sampling, when the fruit were about half-size. At the third sampling, when the fruits were approaching maturity, significant quantities of NO_3^- were found only in plants receiving $(NH_4)_2SO_4$ at the 200-lb. N/A rate.

Table 8. Effect of rate and source of N on tomato yields and NO_3^- concn in dried petiole tissue, Davis, 1967.

			Ppm NO_3-N in petiole tissue		
Source of N	Lb. N/A	Yield (tons/A)[z]	7/17	7/31	8/14
Control	0	35.7 a	8360	3080	210
$(NH_4)_2SO_4$	100	44.0 c	11970	9000	135
	200	43.6 c	12880	11110	710
Urea	100	44.9 c	11090	9490	170
	200	46.1 c	11470	11135	325
Nitroform	100	39.6 b	9490	3600	170
	200	42.8 bc	10300	4450	150

[z]Means with different letters are significantly different at the 5% level.

Soil nitrification. In the early part of the season the availability of N from Nitroform was much less from $(NH_4)_2SO_4$ or urea (Fig. 1). From an initial supply of 120 lb. N/A, less than 20% of the N from $(NH_4)_2SO_4$ and urea remained in the area of the fertilizer band 40 days after application, compared to over 60% of Nitroform. At 80 days after application, approx half of the N from Nitroform was still in place and presumably would be available for later plant use. The slow rate of N transformation from Nitroform after 60 days was reflected also in the data on plant absorption of N, there being no measurable increase in N absorption by the plants during this latter period.

The results with yields and N absorption clearly show the superiority of $(NH_4)_2SO_4$ over Nitroform and SCU when banded and used on vegetable crops that mature in less than 120 days. The rate of availability of N from Nitroform is too slow for these quick-growing crops. The relatively slow

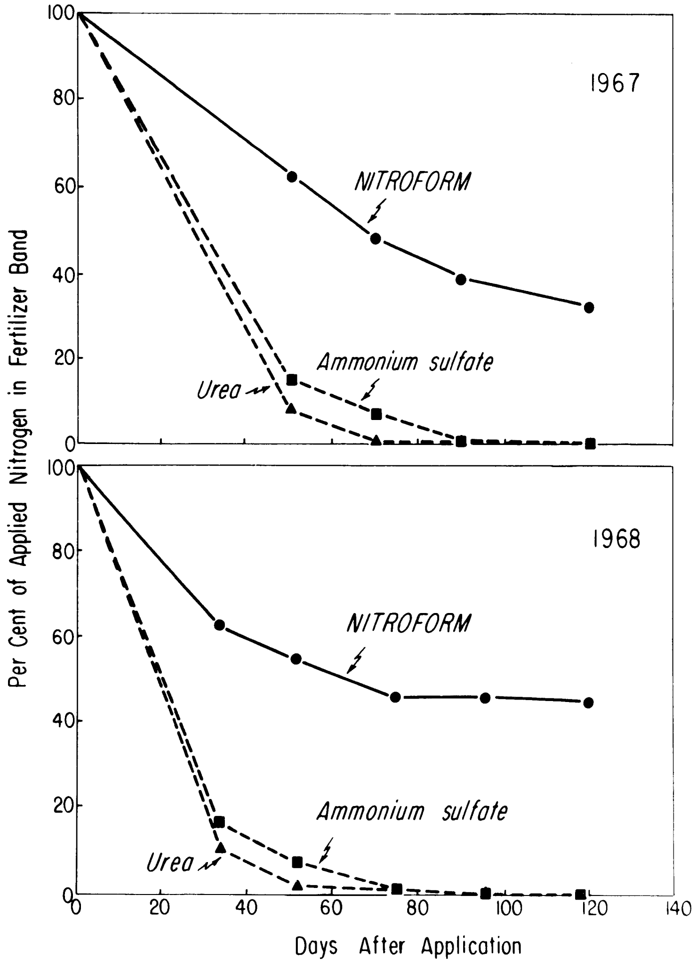

Fig. 1. Effect of source of N on the rate of leaching of N from the fertilizer band.

transformation of N from Nitroform even after 60 days makes the value of this material in vegetable fertilizer programs doubtful. As noted in previous experiments with potatoes grown on similar soils (6), the yields with $(NH_4)_2SO_4$ were slightly better than with urea. In these experiments significant differences were noted in 3 comparisons within 8 experiments.

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Effects of Crop Load, Girdling, and Auxin Application on Alternate Bearing of the Pistachio[1]

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Abstract. Alternate bearing in the pistachio, in contrast to other tree fruit species, is caused by abscission of abundant inflorescence buds during the heavy crop year. Bud abscission was found to increase as the number of nuts per branch increased. Branch girdling between the developing nuts on 1-year-old wood and the inflorescence buds on current wood reduced bud abscission to practically the same extent as that resulting from removing the young nuts from the branches. Application of para-chlorophenoxyacetic acid delayed but did not alter the degree of bud abscission. The greater the crop load in 1970, the shorter the shoot growth in length in 1971.

The pistachio (*Pistacia vera* L.) characteristically is an alternate bearer (5, 8), but the mechanism involved is unlike that of other alternate bearing tree-fruit species. Whereas other species produce relatively few flower buds during the year of a heavy crop, the pistachio produces abundant inflorescence buds every year. However, they abscise in such numbers during the summer of a heavy crop that few remain to produce a light crop the next year (2). Thus, alternate bearing in the pistachio is the result of abscission of inflorescence buds during a heavy crop year rather than lack of bud formation.

Research on other tree fruits involving various manipulative techniques relative to alternate bearing has indicated the importance of leaf area to flower bud differentiation and subsequent fruit production (1, 3, 4). For example, a greater number of leaves per fruit was required for flower bud formation on ungirdled than on girdled apple branches (4). Apparently some product of the leaves effective in flower

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