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.

Abstract. In field studies with potatoes, cantaloupes, and tomatoes, using S sources banded in the soil, highest yields were obtained with (NH₄)₂SO₄. Yields with urea-formaldehyde and sulfur-coated urea were similar to each other, and less than those from urea. Nitrogen absorption, as determined by NO₃⁻ 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 (NH₄)₂SO₄ 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 (NH₄)₂SO₄ or NH₄H₂PO₄, and anhydrous and aqua ammonia has resulted in toxicities if placed close to the plant. On course-textured, alkaline calcareous, and had pH values between 7.6 and 8.0. Fertilizers were applied in bands at the time of planting. Data are presented on dissolution rates of 1% per day were better for extended growth than rates 5 to 6 times higher.

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 S 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 NO3 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
(NH4)2SO4 yielded higher than those receiving Nitroform or
SCU (Table 1). The yield from (NH4)2SO4 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
lb. rate.

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

<table>
<thead>
<tr>
<th>Year of test</th>
<th>Lb. of N/A</th>
<th>(NH4)2SO4</th>
<th>Nitroform</th>
<th>Sulfur-coated urea</th>
<th>Urea</th>
</tr>
</thead>
<tbody>
<tr>
<td>1966</td>
<td>0</td>
<td>108 a</td>
<td>108 a</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>120</td>
<td>400 cd</td>
<td>300 b</td>
<td>382 c</td>
<td></td>
</tr>
<tr>
<td></td>
<td>240</td>
<td>422 d</td>
<td>360 c</td>
<td>431 d</td>
<td></td>
</tr>
<tr>
<td>1967</td>
<td>60</td>
<td>119 a</td>
<td>119 a</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>120</td>
<td>284 e</td>
<td>185 b</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>240</td>
<td>354 f</td>
<td>205 c</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>1968</td>
<td>60</td>
<td>204 a</td>
<td>204 a</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>120</td>
<td>346 de</td>
<td>243 b</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>240</td>
<td>444 f</td>
<td>278 c</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>1970</td>
<td>0</td>
<td>118 a</td>
<td>118 a</td>
<td>118 a</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>60</td>
<td>414 fg</td>
<td>292 b</td>
<td>350 d</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>120</td>
<td>465 g</td>
<td>301 bc</td>
<td>420 fg</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>240</td>
<td>567 h</td>
<td>402 ef</td>
<td>414 fg</td>
<td>529 h</td>
</tr>
</tbody>
</table>

2 Means with different letters for each experiment are significantly
different at the 5% level.

In 1967, various ratios of (NH4)2SO4 and Nitroform were also
tested (data not presented). At the 120-lb. N rate the yield from
(NH4)2SO4 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 (NH4)2SO4 and from the mixture of (NH4)2SO4 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
(NH4)2SO4 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
and 120 lb. rates.

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
(NH4)2SO4 at the 240-lb. N rate was not significantly different
from that at 120 lb. Yields from (NH4)2SO4 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.

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

<table>
<thead>
<tr>
<th>Cultivar</th>
<th>Lb. of N/A</th>
<th>(NH4)2SO4</th>
<th>Sulfur-coated urea</th>
<th>Urea</th>
</tr>
</thead>
<tbody>
<tr>
<td>White Rose</td>
<td>0</td>
<td>172 a</td>
<td>172 a</td>
<td>172 a</td>
</tr>
<tr>
<td>60</td>
<td>257 cd</td>
<td>235 bc</td>
<td>219 b</td>
<td></td>
</tr>
<tr>
<td>120</td>
<td>272 d</td>
<td>269 d</td>
<td>255 cd</td>
<td></td>
</tr>
<tr>
<td>240</td>
<td>310 e</td>
<td>240 bc</td>
<td>237 bc</td>
<td></td>
</tr>
<tr>
<td>Kennebec</td>
<td>0</td>
<td>246 a</td>
<td>246 a</td>
<td>246 a</td>
</tr>
<tr>
<td>120</td>
<td>343 b</td>
<td>325 b</td>
<td>339 b</td>
<td></td>
</tr>
</tbody>
</table>

2 Means with different letters are significantly different at the 5% level.

in 1968 and 1970 urea resulted in higher yields than SCU. The
yield from SCU was slightly higher than Nitroform at the 60
lb. rate.

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

<table>
<thead>
<tr>
<th>Source of N</th>
<th>Total yield per acre (cwt)2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Source of nitrogen (NH4)2SO4</td>
<td>Urea</td>
</tr>
<tr>
<td>0</td>
<td>182 a</td>
</tr>
<tr>
<td>60</td>
<td>339 d</td>
</tr>
<tr>
<td>120</td>
<td>399 h</td>
</tr>
<tr>
<td>240</td>
<td>416 h</td>
</tr>
</tbody>
</table>

2 Means with different letters are significantly different at the 5% level.

4th sampling (5/22/70): (plants nearly mature)  
Nitroform  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)  
Nitroform  tr  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)  
Nitroform  tr  tr  170  1995  13795
Urea  tr  tr  1490  11125
Sulfur-coated urea  tr  tr  tr  170
Nitroform  tr  tr  tr  tr

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$_4$)$_2$SO$_4$ 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$_4$)$_2$SO$_4$ 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$_4$)$_2$SO$_4$ 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$_4$)$_2$SO$_4$

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$_4$)$_2$SO$_4$, urea, and SCU at the 60-lb. N/A rate. In general, highest yields were obtained with (NH$_4$)$_2$SO$_4$, followed in order by urea, SCU, and Nitroform.

In the 1967 trials, petiole analyses showed much higher NO$_3^-$ accumulation from (NH$_4$)$_2$SO$_4$ 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$_4$)$_2$SO$_4$. In the 1970 test, absorption of NO$_3^-$ from (NH$_4$)$_2$SO$_4$ 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$_4$)$_2$SO$_4$.

Cantaloupes. In the 1967 test, (NH$_4$)$_2$SO$_4$ 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, absorption of NO$_3^-$ from (NH$_4$)$_2$SO$_4$ 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$_4$)$_2$SO$_4$.

Tomatoes. Nitrogen from the 3 sources at either the 100 or 200 lb. rate increased yields significantly (Table 8). Yields with either (NH$_4$)$_2$SO$_4$ 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$_4$)$_2$SO$_4$ 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$_4$)$_2$SO$_4$ at the 200-lb. N/A rate.

Soil nitrification. In the early part of the season the availability of N from Nitroform was much less from (NH$_4$)$_2$SO$_4$ 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 (NH$_4$)$_2$SO$_4$ at the 200-lb. N/A rate. The slow rate of N transformation from Nitroform after 60 days 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$_4$)$_2$SO$_4$ 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

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

<table>
<thead>
<tr>
<th>Source of N</th>
<th>Total N absorption (lb./A - tops and tubers)</th>
<th>Lb. N/A applied</th>
</tr>
</thead>
<tbody>
<tr>
<td>(NH$_4$)$_2$SO$_4$</td>
<td>29.6</td>
<td>85.1</td>
</tr>
<tr>
<td>(NH$_4$)$_2$SO$_4$</td>
<td>29.6</td>
<td>76.3</td>
</tr>
<tr>
<td>Nitroform</td>
<td>29.6</td>
<td>51.3</td>
</tr>
</tbody>
</table>


<table>
<thead>
<tr>
<th>Source of nitrogen</th>
<th>Total yield per acre (cwt)²</th>
<th>Lb. N applied per acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>(NH$_4$)$_2$SO$_4$</td>
<td>266 a</td>
<td>372 c</td>
</tr>
<tr>
<td>(NH$_4$)$_2$SO$_4$</td>
<td>266 a</td>
<td>347 bc</td>
</tr>
<tr>
<td>Nitroform</td>
<td>266 a</td>
<td>286 a</td>
</tr>
</tbody>
</table>

### Table 8. Effect of rate and source of N on tomato yields and NO$_3^-$ concn in dried petiole tissue, Davis, 1967.

<table>
<thead>
<tr>
<th>Source of N</th>
<th>Lb. N/A</th>
<th>Yield (tons/A)²</th>
<th>Ppm NO$_3^-$N in petiole tissue</th>
</tr>
</thead>
<tbody>
<tr>
<td>(NH$_4$)$_2$SO$_4$</td>
<td>100</td>
<td>44.0 c</td>
<td>8360</td>
</tr>
<tr>
<td>(NH$_4$)$_2$SO$_4$</td>
<td>200</td>
<td>43.6 c</td>
<td>11970</td>
</tr>
<tr>
<td>Urea</td>
<td>100</td>
<td>44.9 c</td>
<td>10900</td>
</tr>
<tr>
<td>Urea</td>
<td>200</td>
<td>46.1 c</td>
<td>11470</td>
</tr>
<tr>
<td>Nitroform</td>
<td>100</td>
<td>39.6 b</td>
<td>9490</td>
</tr>
<tr>
<td>Nitroform</td>
<td>200</td>
<td>42.8 bc</td>
<td>10300</td>
</tr>
</tbody>
</table>

²Means with different letters are significantly different at the 5% level.

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

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

Julian C. Crane and M. M. Nelson

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 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 (NH₄)₂SO₄ were slightly better than with urea. In these experiments significant differences were noted in 3 comparisons within 8 experiments.

Literature Cited