homogenization procedure is probably related to reduced intimacy between the enzyme, cofactors, and substrate, the requirement for diffusion of reaction products out of the intact cells and the possibility of further metabolism of nitrate.

With blueberry roots, we observed by the infusion method nitrate reductase activities of 48 ± 18 mμ moles NO_2^- formed per hour. This observation was made with plants grown at pH 4 with NO_3 nutrition. This value is of the same order of magnitude as that found by Townsend (17) under similar conditions.

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High Intensity Supplementary Lighting Increases Yields of Greenhouse Roses[1]

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Abstract. Flower yields from October to May increased with the duration of supplementary lighting. Lighting improved flower yields by increasing bottom breaks, stimulating axillary shoot development after flower removal, and slightly reducing the days from cut-to-cut. Development of additional axillary buds was the principal factor in the improved branching of lighted plants. Excessive plant branching from supplementary lighting during a 7-month flowering period reduced significantly flower stem length, node number, and fresh wt of cvs. Shocking Pink and Red American Beauty. The 6.2 w/ft^2 of incandescent light after the high intensity lighting period improved the flower quality of 'Forever Yours' but not of 'Red American Beauty'. Plants lighted 9, 12, or 21 hr daily had fewer blind stems than unlighted plants.

Low winter light reduces greenhouse rose plant growth and flower yield. The capacity to regulate light, as achieved for other environmental factors, is necessary for the full control of plant growth in greenhouses. Supplementary high intensity lighting, above 10 watts/ft^2, has caused improved seed germination and faster seedling growth of gloxinia and cineraria during winter (10). African violets (11), begonia (2), cyclamen (9), gloxinia (10), and stock (4) flowered much earlier when they received supplementary high intensity lighting. Lighting during dark seasons increased the numbers of cuttings from stock plants of chrysanthemum (3) and foliage plants (6). Winter rose yields have been increased 24% by lighting nightly overhead for 5 hr with W.S. Gro-Lux lamps at 21 lamp watts/ft^2 (1). 'Better Times' roses lighted continuously from Feb. 1st to May 30th with W.S. Gro-Lux lamps at 32 lamp watts/ft^2 had yield increases over unlighted plants of 96% from lamps placed between the plants and 46% when overhead. Reduction of stem lengths and fresh wt of cut roses by supplementary lighting was attributed to flower injury from contact with hot lamp surfaces (8).

Our study was conducted to determine the extent and nature of the effect of supplementary lighting on winter growth and flowering of greenhouse roses.

Materials and Methods

One hundred ninety-two dormant plants each of rose cvs. Forever Yours and Shocking Pink were planted in adjacent 54-ft, 42-inch width, V-bottom ground benches April 15, 1969. The benches were sub-divided into 6 plots of 32 plants immediately after planting, and 6-ft opaque partitions were placed between plots and at bench ends. Four plots were randomly selected to receive supplemental lighting nightly and the remaining 2 were unlighted. Two, 4 by 8 ft, metal frame fixtures, each mounting six, 96-inch, 105 w, W.S. Gro-Lux lamps, were placed vertically in each lighted replication between interior rows 1-2 and 3-4. A black sateen cloth hung vertically was pulled in the aisle between the benches nightly. Plant spacing and the cultural practices followed were those recommended for roses (8).

Lighting treatments began Dec. 15, 1969, and discontinued May 1, 1970. Plots were randomly selected to receive: (a) no supplementary lighting, (b) 8 hr of supplamantary lighting

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Table 1. Effect of high intensity supplementary lighting on the growth and flowering of greenhouse roses. Means of 64 plants of each cultivar lighted Dec. 15, 1969 to May 1, 1970 or Sept. 1, 1970 to May 1, 1971.

Treatment	Flowers per plant	Days to flower	Nodes per flower	Stem length (cm)	Fresh wt (g)	Basal breaks per plant
			1969-70 (Jan. through April flowering period)			
			Forever Yours			
Unlighted	7.5a[z]	38.6a[z]	6.9a[z]	41.8a[z]	16.4a[z]	0.00a[z]
Lighted 8 hr	10.5ab	37.1a	6.0ab	37.7ab	14.2a	0.55a
Lighted 20 hr	12.1b	37.0a	5.5b	33.9b	13.1a	1.75b
			Shocking Pink			
Unlighted	5.8a	40.9a	5.9a	41.9a	17.1a	0.05a
Lighted 8 hr	6.6a	39.6a	5.6a	39.2a	16.7a	0.50a
Lighted 20 hr	7.2a	35.0b	4.4b	28.3b	12.7b	1.00b
			1970-71 (Oct. through April flowering period)			
			Forever Yours			
Unlighted	19.8a	35.8a	8.5a	43.5a	15.9a	0.00a
Lighted 12 hr	31.9b	34.3a	8.1a	40.8a	14.9a	0.35ab
Lighted 21 hr	40.1b	33.1a	7.8a	39.3a	16.5a	0.86b
			Red American Beauty			
Unlighted	12.2a	37.9a	7.4a	48.8a	15.7a	0.00a
Lighted 9 hr	26.0b	35.3ab	6.0ab	38.5b	13.7a	0.18ab
Lighted 21 hr	35.4b	33.8b	4.5b	33.3b	6.2b	0.31b
			Electra			
Unlighted	14.5a	39.3a	6.5a	48.3a	17.5a	0.14a
Lighted 9 hr	26.3b	37.6a	7.2a	46.0a	18.0a	0.40a
Lighted 12 hr	25.3b	37.5a	7.2a	44.2a	16.8a	0.92b

[z]Means within columns followed by the same letter are not significantly different at the 5% level by Duncan's Multiple Range Test.

daily from 6 PM to 2 AM, or (c) 20 hr of supplementary lighting daily from 6 AM to 2 AM. Lighted plots received 31.3 lamp watts/ft^2 at plant level from W.S. Gro-Lux lamps supplementing seasonal daylight intensities. The bench of 'Forever Yours' were cut-back to an 18-inch height June 18, 1970.

April 17, 1970, 192 dormant rose plants each of cvs. Electra and Red American Beauty were planted in adjoining benches; 6 plots were developed in each bench and randomly assigned

Table 2. Flowering stem numbers per plant and percentages of blind shoots for unlighted plants and those receiving high intensity supplemental lighting during 12 daylight hr, 9 hr nightly or 21 hr daily. Data for 64 plants per treatment for September 1, 1970 to May 1, 1971 lighting period.

Treatment	Month: Sept.	Nov.	Jan.	Mar.	May
			1970-71 Flowering stem no./plant		
			Forever Yours		
Unlighted	3.4a[z]	3.3a[z]	3.1a[z]	3.5a[z]	3.8a[z]
Lighted 12 hr	2.9a	4.2ab	4.5b	5.6b	5.5b
Lighted 21 hr	3.3a	4.7b	5.8c	6.6b	6.9c
			Red American Beauty		
Unlighted	2.6a	2.7a	2.0a	2.9a	3.7a
Lighted 9 hr	3.2b	3.9b	4.2b	4.7b	5.1b
Lighted 21 hr	2.3a	3.6ab	5.9b	7.6c	9.0c
			Electra		
Unlighted	3.7a	4.0a	3.6a	4.1a	4.5a
Lighted 9 hr	3.5a	4.7a	5.8b	6.2b	6.0b
Lighted 12 hr	4.1a	5.2a	5.5b	6.1b	6.0b
			1970-71 Percentages of blind shoots		
			Forever Yours		
Unlighted	11.7a	13.1a	22.4a	27.2a	25.5a
Lighted 12 hr	19.3b	20.6b	25.7a	28.0a	28.3a
Lighted 21 hr	14.5ab	16.0ab	20.4a	21.6b	18.2b
			Red American Beauty		
Unlighted	14.5a	25.2a	42.7a	48.9a	37.1a
Lighted 9 hr	12.1a	20.6a	31.8b	34.0b	31.6ab
Lighted 21 hr	15.3a	22.2a	30.4b	31.1b	26.9b
			Electra		
Unlighted	17.8a	21.1a	32.6a	41.8a	39.4a
Lighted 9 hr	16.2a	14.5b	26.3b	33.4b	34.1ab
Lighted 12 hr	20.4a	18.8ab	27.1b	32.9b	31.6b

[z]Means within columns followed by the same letter are not significantly different at the 5% level by Duncan's Multiple Range Test.

treatments. Gro-Lux W.S. fluorescent lamps were placed vertically in each lighted replication between interior rows 1-2 and 3-4 prior to the development of the dormant vegetative buds. Two 100-watt incandescent lamps were kept 2 ft above the rose plants in each lighted plot and these provided light from 2 to 4 AM nightly. Interior rows 2 and 3 of rose plants in the lighted replications were spaced 8 inches apart to allow a spacing of 14 inches between rows 1-2 and 3-4. Plant spacing in the unlighted replications was as recommended (7). Lighting the selected replications of newly planted and cut-back rose cultivars was begun when the shoots were 2 inches long and expanding leaves were visible and continued until May 1, 1971. Each rose cultivar had 3 treatments with 2 replicated plots. Comparisons among unlighted plots and those lighted for 9 hr nightly (6 PM to 3 AM) or 12 hr each day (6 AM to 6 PM) were made using cv. Electra. 'Red American Beauty' was unlighted, lighted 9 hr nightly or lighted 21 hr daily (6 AM to 3 AM). Plots of cut-back 'Forever Yours' roses were unlighted or lighted 12 or 21 hr. All lighted plots also received 6.2 watts/ft^2 of incandescent light from 2 to 4 AM nightly. Each lighting fixture was controlled by a time clock. Cultural practices for dormant and cut-back rose plants were followed as recommended by Langhans (7).

We measured flower yield; days required for a return to flowering of individual stems; the length, number of nodes, and fresh wt of each flower; and the number of bottom breaks. Additional counts were made in the second experiment of the number of developing axillary buds after cutting each rose and the nature of the branches (flowering or blind). All data were analyzed statistically by Duncan's Multiple Range Test.

Results

Rose yield and days to flower. Flower numbers per plant were significantly higher during the 7-month flowering period for those receiving 9, 12, or 21 hr of supplementary lighting than for non-lighted plants. Plants receiving 21 hr of lighting consistently had higher monthly yields than those lighted 9 or 12 hr (Fig. 1). Plants receiving supplementary lighting during 12 hr day (6 AM to 6 PM) had yields similar to those lighting 9 hr nightly (6 PM to 3 AM). Flower yields from plants lighted 20 or 21 hr daily were consistently higher than those from plants lighted only during the daylight hr or at night (Table 1).

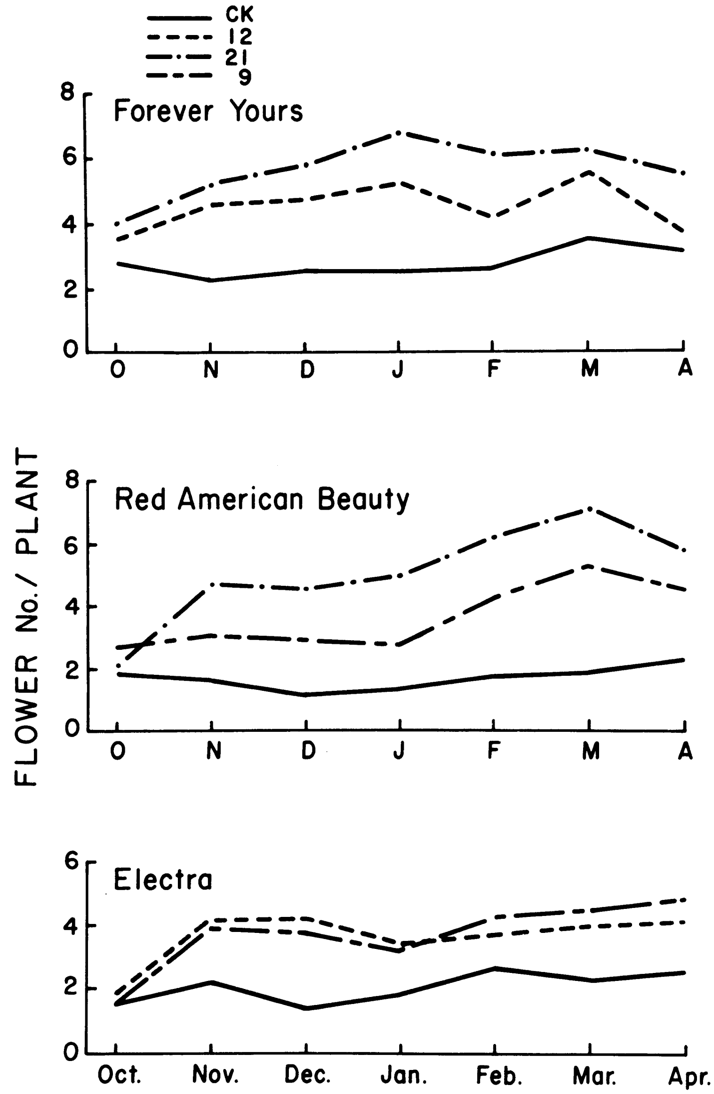

Fig. 1. Supplementary lighting for 9, 12 or 21 hr daily increased flower yield for 3 rose cultivars.

Stems from lighted plants flowered again in fewer days than from unlighted plants of the same cultivars, but the differences were small and generally nonsignificant. Plants of 'Shocking Pink' and 'Red American Beauty' were exceptions and these cultivars required fewer days from cut-to-cut from lighting and differences were significant.

Numbers of flowering and blind stems. Large and generally significant increases occurred in the numbers of flowering branches on plants receiving high intensity supplementary lighting for 9, 12, or 21 hr (Table 2). Numbers of flowering stems on unlighted plants increased only slightly during the 7-month period. The largest numbers of flowering branches developed on plants lighted 21 hr daily with smaller but similar numbers on plants lighted 9 or 12 hr (Table 2). The numbers of flowering stems on lighted plants of the 3 cultivars progressively increased from September to March, but declined in May from a gradual cut-back begun April 15th. Larger numbers of bottom breaks developed on lighted plants which contributed to the increased numbers of flowering stems (Table 1). The percentages of blind stems increased for all cultivars during the winter, but were smaller on lighted plants (Table 2).

Flower stem length, node number, and fresh wt. Significant reductions in stem lengths of cut flowers from cvs. Forever Yours and Shocking Pink resulted from lighting 8 or 21 hr daily (Table 1). Flower stems of lighted 'Forever Yours' and 'Electra' roses were shorter than those of unlighted plants even with additional low intensity incandescent light from 2 to 4 AM, but differences were smaller and non-significant (Table 1). Flowers from plants of 'Red American Beauty' lighted 9 or 21 hr with added incandescent light had large and significant reductions in stem length similar to those of 'Shocking Pink' the previous year (Table 1).

Node numbers for flowering stems were reduced significantly by lighting 21 hr daily for both cultivars during 1969-70 (Table 1). Node numbers of flowers from lighted plants with added incandescent light were like unlighted plants for 'Forever Yours' and 'Electra', but flowers from similarly lighted plants of 'Red American Beauty' had large reductions in node number. Differences in flower fresh wt were found only for 'Shocking Pink' and 'Red American Beauty' where high intensity supplementary lighting for 20 or 21 hr significantly reduced flower stem length and node number.

Discussion

Flower yields from October to May were increased proportionately to the duration of lighting with W.S. Gro-Lux lamps at 31 watts/ft^2. Lighting improved flower yields by increasing bottom break production, stimulating the development of more axillary buds after flowers were removed, and reducing slightly the days needed from cut-to-cut. The development of additional axillary buds was the principal factor in the improved production of lighted plants. The cause of light stimulation of the development of additional axillary buds was not determined.

Rose cultivars varied in their response to high intensity supplemental lighting. 'Shocking Pink' and 'Red American Beauty' normally produce no bottom breaks during mid-winter and branch poorly. Some bottom breaks developed when plants are given supplementary light, but lighting also resulted in the development of an excessive number of light wt stems with low numbers of nodes from axillary buds. No attempt was made in this study to remove some stems for improved quality.

'Forever Yours' plants lighted for 8 or 21 hr daily during 1969-70 had significant reductions in stem length and node number. When the same plants were lighted 12 or 21 hr during 1970-71, but given 2 hr of additional light from incandescent lamps at the end of the normal lighting period, the reductions in stem length and node number were reduced, becoming non-significant. The addition of incandescent light for 2 hr after the lighting period had no similar effect on 'Red American Beauty' during 1970-71. Mastalerz (8) reported that continuous lighting of 'Better Times' roses with W.S. Gro-Lux lamps caused reduced stem length with lower flower fresh wt than for unlighted plants. He attributed this to injury from hot lamp surfaces. The reduced stem length, node number, and fresh wt found in our study was probably due to a larger number of stems on lighted plants. The results were inconclusive regarding the value of lighting with incandescent lamps after the termination of the lighting period, since 'Forever Yours' and 'Electra' were benefitted but not 'Red American Beauty'. The flowering stems of lighted 'Forever Yours' and 'Electra' were observed to be longer in an area beneath each incandescent lamp than in other parts of the same plot. Possibly a higher incandescent light intensity or lamps providing a higher ratio of far red light to visible red would have been more beneficial.

Kamp (5) reported that shading had no effect on the number of blind shoots. The percentages of blind stems in our study increased for both unlighted and lighted plants during the winter indicating light was not a factor for the control of stem blindness. However, the lower percentage of blind shoots on lighted plants during winter indicated that light did provide some indirect benefit that allowed some stems to flower that morphologically were similar to blind shoots and might otherwise have been blind. These flowers increased rose yields 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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