'NELLIE WHITE' EASTER LILY FERTILIZER AND GROWTH MEDIA STUDIES[1]

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Fertilizer regime effects on growth and incidence of leaf scorch in 'Croft' and 'Ace' Easter lilies have been investigated at the University of Minnesota (5,6). Leaf scorch refers to the development of half-moon shaped, tan, necrotic areas on the leaf margins of the outer ends of the leaves. Leaf scorch is a physiological condition which is encouraged by low soil pH, low calcium and nitrogen, and high phosphorus levels in the soil (3,4,5). The application of a mix of 1 part ammonium sulfate and 4 parts sodium nitrate was more effective than other N fertilizers in controlling leaf scorch in 'Croft' lilies (5). The 'Ace' cultivar which replaced 'Croft' on the local market was less susceptible to leaf scorch. Widmer (6) studied the effects of 13 different fertilizer treatments including slow release ammonium nitrate on 'Ace' plants. He concluded that the best quality plants were fertilized every 2 weeks with a mixture of 1 part ammonium sulfate and 4 parts sodium nitrate at the rate of 1 ounce per 2 gallons of water. The second best plants received applications of potassium nitrate alternated with calcium nitrate.

Kiplinger, et al. (2) reported that 'Ace' lilies fertilized with slow release fertilizers, Osmocote or MagAmp, developed into satisfactory quality plants.

In 1971-73, fertilizer studies were conducted with the cultivar 'Nellie White', which currently represents a large share of the crop in the Upper Midwest. The objective of the studies was to determine what fertilizer regimes and growth media were optimal for plant development and flowering of this cultivar.

Materials and Methods

'Nellie White' bulbs, 7-8 inches in circumference in 1971-72 and 8-9 inches in circumference in 1972-73, were grown in 6-inch plastic pots. All bulbs were shipped to St. Paul, MN by refrigerated truck. Bulbs were held at 70°F. from receipt until potting. Soil mixes were steam pasteurized prior to potting but before adding slow release fertilizers. The controlled temperature forcing method of placing potted noncooled bulbs at 60°F. for 21 days and then for 6 weeks at 40°F. in 1971-72, or 4 weeks at 40° F. in 1972-73, was used. The potted bulbs were then forced in greenhouses at a 60° F. night temperature starting December 15, 1971 and December 22, 1972, respectively. Fungicide drenches were applied monthly.

In the 1971-72 study, bulbs were planted in a 2 soil:1 moss peat mix with a 6.2 pH, or a 1 soil:1 moss peat:1 perlite mix with a 5.4 pH. Treatments included slow release fertilizer incorporated in the potting mix and regular applications of soluble fertilizers (table 1). All soils for both years, except the nutrient enriched moss peat had superphosphate mixed in at the rate of 1

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Table 1. Fertilizers applied to Nellie White Easter lilies in 2 forcing seasons.

Treatment 1971-72[y]	Number 1972-73[x]	Fertilizer	Rate of application[z]	Time of application
1	-	unfertilized control		
2,11	1,I,2,II	Osmocote 19-0-20.5	7 oz/bushel of soil	in potting mix
3	3,III	Osmocote 19-0-20.5 + 25-0-25	3.5 oz/bushel + 1 oz/9 gal water (200 ppm N)	in potting mix every watering
4,12	4,IV	MagAmp 7-40-6	12 oz/bushel of soil	in potting mix
5	5,V	MagAmp 7-40-6 + 25-0-25	6 oz/bushel of soil 1 oz/9 gal water (200 ppm N)	in potting mix every watering
6	6,VI	25-0-25	1 oz/3 gal water (600 ppm N) 1 oz/9 gal water (200 ppm N)	first watering every watering thereafter
7	7,VII	25-0-25	1 oz/3 gal water (600 ppm N)	weekly
8,13	8,VIII	1 part ammonium sulfate and 4 parts sodium nitrate plus potassium chloride (0-0-60)	1 oz/2 gal water 1 oz/3 gal water	every 2 weeks in between weeks until buds 1/2" long, then ammonium sulfate-sodium nitrate mix only
9,14	9,IX	calcium nitrate and potassium nitrate, then calcium nitrate only	1 oz/4 gal water 1 oz/8 gal water 1 oz/3 gal water	weekly until buds 1/2" long, weekly thereafter
10	10,X	sodium nitrate and potassium nitrate, then sodium nitrate only	1 oz/4 gal water 1 oz/8 gal water 1 oz/3 gal water	weekly until buds 1/2" long, weekly thereafter
	11,XI[w]	Peat #1	moss peat with nutrients included	in potting mix
	12,XII[w]	Peat #1 + treatment #9	moss peat with nutrients included see 9 above	in potting mix weekly
	13,XIII[w]	1/2 Peat 0 + 1/2 Peat #2 and treatment #9	moss peat with no nutrients moss peat with about double the added nutrients of Peat #1 see above	in potting mix in potting mix weekly
	14,XIV[w]	Peat #2	moss peat with about double the added nutrients of Peat #1	in potting mix

[z] Solutions applied at rate of an average thorough watering.

[y] In 1971-72 study, treatments 1-10 were conducted on bulbs potted in a 2 soil:1 peat mix and treatments 11-14 were in a 1 soil:1 peat:1 perlite mix.

[x] In 1972-73 study, treatments 1-14 (except 1) represented one bulb source and treatments I-XIV (except I) represented another bulb source. Treatments 1-10 were in a 1 soil:1 peat:1 perlite mix and treatments I-XIV were in a 2 soil: 2 peat:1 rice hulls mix.

[w] Peat #1 and #2 were commercial products consisting of nutrient enriched sphagnum moss peat. Peat #2 had approximately twice the nutrient level of Peat #1, but the contents are not identical.

Table 2. Fertilizer and growth medium effects on 'Nellie White' lilies grown from 7-8 inch bulbs in 1971-72. Values are means of 15 bulbs per treatment.

Treatment	Soil[z] mix ratio	Days to[y] first flower	Flower number	Plant height (cm)	Plant diameter at mid-pt. (cm)	Condition[w] of base 1-3(3=best)	Foliage color 1-3(3=best)	Roots Quantity 1-3(3=best)	Roots Color 1-3(3=best)
1 - control	2:1	183 ab[v]	4.1 abc[v]	21.0 ab[v]	22.8 [v]	1.7 ab[v]	2.3 a[v]	2.1 abc[v]	2.3 c[v]
2 - Osm @ 7 oz/bu	2:1	184 ab	3.7 a	21.7 ab	22.4	2.9 ef	3.0 b	2.0 abc	2.1 abc
3 - Osm @ 3.5 oz/bu + 25-0-25	2:1	183 ab	4.1 abc	19.6 a	22.1	3.0 f	3.0 b	1.5 a	1.7 ab
4 - Mag @ 12 oz/bu	2:1	180 a	4.9 cd	22.6 ab	25.7	2.6 def	2.9 b	2.2 abc	2.0 abc
5 - Mag @ 6 oz/bu + 25-0-25	2:1	180 a	4.7 bcd	22.1 ab	24.5	2.6 def	3.0 b	1.9 abc	2.1 abc
6 - 25-0-25 every watering	2:1	186 b	4.5 abcd	22.1 ab	24.0	2.9 ef	3.0 b	1.8 ab	2.1 abc
7 - 25-0-25 @ 1 oz/3 gal wkly	2:1	183 ab	4.8 bcd	21.1 ab	24.4	2.3 a-f	3.0 b	1.8 ab	1.7 ab
8 - ammon. sul. & sod. nitr. + pot. nitr.	2:1	184 ab	4.9 cd	19.0 a	23.1	2.1 abcd	3.0 b	1.8 ab	1.9 abc
9 - cal. nitr. & pot. nitr.	2:1	182 a	4.7 bcd	21.1 ab	24.1	2.0 abc	2.6 ab	1.8 ab	1.8 ab
10 - sod. nitr. & pot. nitr.	2:1	183 ab	4.5 abcd	19.9 a	23.7	1.6 a	2.3 a	2.0 abc	1.7 ab
11 - same as #2	1:1:1	182 a	4.9 cd	22.3 ab	26.0	2.7 def	3.0 b	2.3 abc	1.7 ab
12 - same as #4	1:1:1	186 b	4.4 abcd	24.8 b	26.6	2.4 b-f	2.9 b	2.7 bc	2.3 c
13 - same as #8	1:1:1	190 bc	4.5 abcd	22.5 ab	25.3	2.5 c-f	2.9 b	2.3 abc	2.0 abc
14 - same as #9	1:1:1	195 c	5.2 d	24.2 b	22.9	2.1 abcd	2.7 ab	2.7 bc	2.2 bc
Significance level		5%	5%	1%	NS	1%	1%	1%	1%

[z] 2 soil:1 peat; 1 soil:1 peat:1 perlite.
[y] calculated from date of potting, Oct. 13, 1971.
[x] plant ht. measured from pot rim to base of flower pedicel.
[w] condition of base determined by amount of dried and/or short leaves.
[v] means followed by the same letter do not differ significantly, Duncan's multiple range test.

Table 3. Fertilizer and growth medium effects on 'Nellie White' lilies from 8-9 inch bulbs in 1972-73 study. Bulbs from Source A grown in a soil:peat:perlite mix or in nutrient enriched moss peat. Values are means of 12 bulbs per treatment.

Plant characteristic / Treatment	Days to[z] first flower	Flower number	Plant[y] height (cm)	Plant diameter at mid-pt. (cm)	Leaf number	Roots Quantity 1-3(3=best)	Roots Color 1-3(3=best)	Foliage color 1-3(3=best)	Floral trumpet length (cm)
1 - Osm. @ 7 oz/bu	155 abc[x]	7.9 abcd[x]	31.9 bcd[x]	28.0 ab[x]	98 [x]	2.4 [x]	1.5 e[x]	3.0 e[x]	15.1 bc[x]
2 - Osm. @ 7 oz/bu	155 abc	8.6 bcd	33.2 d	28.2 ab	96	2.0	1.5 e	2.5 d	15.1 bc
3 - Osm. @ 3.5 oz/bu + 25-0-25	152 a	8.9 cd	30.2 abcd	29.4 bc	101	2.2	1.1 f	2.9 e	14.6 ab
4 - Mag @ 12 oz/bu	155 abc	8.8 cd	32.9 cd	31.5 d	98	2.5	2.2 cd	2.5 d	15.7 c
5 - Mag @ 6 oz/bu + 25-0-25	158 cd	8.3 bcd	33.1 d	29.4 bc	102	2.7	1.9 de	3.0 e	15.2 bc
6 - 25-0-25 every watering	155 abc	9.0 cd	33.3 d	30.8 cd	104	2.5	1.1 f	3.0 e	14.2 a
7 - 25-0-25 @ 1 oz/ 3 gal wkly	154 abc	7.9 abcd	32.4 cd	27.8 ab	106	2.6	1.1 f	3.0 e	14.8 ab
8 - ammon. sulf. & sod. nitr. +	157 bcd	9.2 d	30.2 abcd	28.3 ab	104	2.5	1.8 e	3.0 e	15.0 bc
9 - cal. nitr. & pot. nitr.	153 ab	8.9 cd	33.0 d	28.3 ab	100	2.5	1.8 e	2.8 e	14.8 ab
10 - sod. nitr. & pot. nitr.	159 cd	8.1 abcd	30.4 abcd	29.3 bc	102	2.5	1.5 e	3.0 e	15.0 bc
11 - Peat #1	152 a	7.8 abcd	32.2 cd	29.2 bc	98	2.7	2.9 a	1.2 a	14.8 ab
12 - Peat #1 + trt. #9	157 bcd	7.5 abc	28.3 ab	27.5 ab	95	2.6	2.7 ab	1.7 b	14.5 ab
13 - 1/2 moss peat, 1/2 Peat #2	160 d	6.7 a	27.0 a	27.0 a	98	2.6	2.7 ab	2.1 c	15.1 bc
14 - Peat #2	159 cd	7.1 ab	29.2 abc	28.0 ab	97	2.3	2.4 bc	1.9 bc	14.6 ab
Significance level	1%	5%	5%	1%	NS	NS	1%	1%	5%

[z] calculated from date of potting, Oct. 31, 1972.

[y] measured from pot rim to base of flower pedicel.

[x] means followed by the same letter do not differ significantly, Duncan's multiple range test.

Table 4. Fertilizer and growth medium effects on 'Nellie White' lilies from 8-9 inch bulbs in 1972-73 study. Bulbs from Source B grown in a 2 soil:2 peat:1 rice hull mix or in a nutrient enriched moss peat. Values are means of 12 bulbs per treatment.

Plant characteristic / Treatment	Days to first flower[z]	Flower number	Plant height (cm)[y]	Plant diameter at mid-pt. (cm)	Leaf number	Roots Quantity 1-3(3=best)	Roots Color 1-3(3=best)	Foliage color 1-3(3=best)	Floral trumpet length (cm)
I - Osm. @ 7 oz/bu	156 [x]	7.7 bc[x]	26.9 bc[x]	26.1 bc[x]	93 abcd[x]	2.0 c[x]	1.4 f[x]	3.0 d[x]	14.4 ab[x]
II - Osm. @ 7 oz/bu	156	7.6 bc	27.3 bcd	26.2 bc	94 bcd	2.6 ab	1.9 dc	3.0 d	14.0 a
III - Osm. @ 3.5 oz/ bu + 25-0-25	155	8.0 bc	27.4 bcd	26.4 cd	92 abcd	2.7 a	1.2 c	3.0 d	14.7 ab
IV - Mag @ 12 oz/bu	158	7.1 bc	28.8 cd	28.6 e	86 ab	2.7 a	2.1 cd	2.8 d	15.6 c
V - Mag @ 6 oz/bu + 25-0-25	155	8.4 c	25.9 abc	28.3 e	94 abcd	2.7 a	1.5 ef	3.0 d	14.3 ab
VI - 25-0-25 every watering	154	7.4 bc	29.8 d	27.9 de	96 cd	2.4 bc	1.5 ef	3.0 d	14.6 ab
VII - 25-0-25 @ 1 oz/ 3 gal wkly	158	7.3 bc	27.8 bcd	26.7 cd	98 d	2.8 a	1.4 f	3.0 d	13.9 a
VIII - ammon. sul. & sod. nitr.+	159	7.6 bc	27.1 bcd	24.5 a	95 cd	2.1 c	1.5 ef	3.0 d	14.3 ab
IX - cal. nitr. & pot. nitr.	157	7.3 bc	26.4 abc	24.4 a	93 abcd	1.9 c	1.4 f	3.0 d	14.3 ab
X - sod. nitr. & pot. nitr.	156	7.6 bc	27.2 bcd	24.8 ab	94 bcd	2.4 abc	1.3 f	3.0 d	14.4 ab
XI - Peat #1	157	7.3 bc	27.3 bcd	23.6 a	90 abcd	2.6 ab	2.4 bc	1.7 a	14.9 b
XII - Peat #1 + trt. #9	159	6.7 b	26.6 abc	23.5 a	85 a	2.2 bc	2.7 ab	2.0 b	14.0 a
XIII - 1/2 moss peat, 1/2 Peat #2	156	6.6 b	24.1 a	23.8 a	86 ab	2.1 c	3.0 a	2.3 c	14.1 ab
XIV - Peat #2	160	5.2 a	24.9 ab	23.2 a	88 abc	2.0 c	2.6 ab	2.3 c	14.0 a
Significance level	NS	1%	5%	1%	5%	1%	1%	1%	1%

[z] measured from date of potting, Oct. 31, 1972

[x] measured from pot rim to base of flower pedicel

[x] means followed by the same letter do not differ significantly, Duncan's multiple range test

Table 5. Comparison of treatments 2-10 and II-X (1972-73 study). Block significance indicates significant differences due to soil mix while treatment significance indicates significant differences occurring over all treatments regardless of soil mix.

Plant characteristic	Block significance	Treatment significance
Days to first flower	1.70^{NS}	1.15^{NS}
Flower number	15.5^{**}	1^{NS}
Plant height	71.72^{**}	1.48^{NS}
Plant diameter at mid-pt.	48.31^{**}	4.74^{*}
Leaf number	76.13^{**}	4.43^{*}
Root quantity	1^{NS}	3.43^{*}
Root color	1^{NS}	1^{NS}
Foliage color	4.66^{NS}	2.35^{NS}
Floral trumpet length	8.05^{*}	2.29^{NS}

NS = No significance.

* = statistical significance at 5% level.

** = statistical significance at 1% level.

ounce per bushel (2 1/2 pounds per 100 square feet). There were 3 replicates of 5 plants each per treatment. By January 10, 1972 all shoots had emerged and fertilizer applications were started.

In the 1972-73 study, bulbs from 2 sources (A and B) were potted in 2 soil mixes. Source A bulbs (treatments 1-10) were potted in a 1 soil:1 moss peat: 1 perlite mix with a 6.0 pH and source B bulbs (treatments I-X) were potted in a 2 soil:2 moss peat:1 rice hulls mix (table 1) with a 5.6 pH. There were also 4 different fertilizer treatments with nutrient enriched moss peat media. For all treatments there were 3 replicates of 4 plants each. Fertilizer applications were begun on January 17, 1973 when shoots had emerged.

Because two bulb sources (A and B) and two soil mixes (in addition to moss peats) were used in this study, bulbs from the "other" source were used in treatments 1 and I of each soil mix. Then treatments 1, I and 2, II were fertilized similarly to determine whether any differences in plant response were related to soil mix or bulb source.

Well water with a 7.8 pH was used for irrigation in the 1971-72 study and city water with a pH about 7.0 was used in the 1972-73 study.

Soil tests were conducted at the initiation and termination of the experiments. Plants were observed regularly during the studies and key data were recorded primarily at the termination of the studies.

Results

All plants except those in the nutrient enriched moss peats were of salable quality. Leaf scorch was not a problem in any of the studies.

1971-72 Study. Although no consistent, significant differences in growth responses to soil type were evident, some points are worthy of comment. Plants grown in the 1:1:1 soil mix often bloomed later and tended to be taller and broader with more flowers and smaller root systems (table 2).

All factors considered, the best plants in the 2:1 soil were those fertilized with MagAmp (Tr. 5) with or (Tr. 4) without 25-0-25, (Tr. 7) 25-0-25 weekly, (Tr. 8) ammonium sulfate-sodium nitrate mix with potassium chloride and (Tr. 9) calcium-potassium nitrate. In the 1:1:1 mix, the best plants were those fertilized with (Tr. 11) Osmocote only.

1972-73 Study. Generally the plants grown in moss peat were of smaller diameter, had fewer flowers, poorer foliage color and better root color than plants grown in the soil mixes (tables 3,4).

Few significant differences in plant responses within a soil mix were noted. However, plants in the soil:peat:perlite mix (Tr. 1,2 - table 3) had more flowers and leaves, longer floral trumpets and were taller and broader than plants in the soil:peat:rice hull mix (Tr. I,II - table 4). Response variations could be attributed to soil mix differences and not to bulb sources. Analysis of data from Tr. 2 to 10, II to X (table 5) further confirmed these findings.

Also, differences in plant diameter, leaf number, and root quantity were a response to fertilizer treatment regardless of soil mix.

The best plants grown in the soil-peat-perlite mix, all plant responses considered, were those fertilized with (Tr. 3) Osmocote plus 25-0-25, (Tr. 6) 25-0-25 with every watering, (Tr. 8) the ammonium sulfate-sodium nitrate mix with muriate of potash and (Tr. 9) calcium and potassium nitrate. In the soil:peat: rice hull mix, the best plants were those fertilized with (Tr. II) Osmocote only, (Tr. III) Osmocote plus 25-0-25, (Tr. V) MagAmp + 25-0-25, (Tr. VIII) ammonium sulfate-sodium nitrate mix with muriate of potash and (Tr. X) the sodium and potassium nitrate mix.

Discussion and Conclusions

The greenhouse forcer usually desires rapid uniform flowering; many long trumpeted flowers; stocky, relatively short plants with many dark green leaves, and abundant, healthy roots. Many of these qualities are controlled by bulb treatment prior to potting; however, nutrition and growth medium used can also have significant effects.

Although plants grown in the nutrient-enriched, moss-peat media were not of desired quality, moss peat is usually a highly satisfactory growth medium (7). Even though the roots were the whitest, poor lily plant top growth indicated that the nutrient supply was probably inadequate or unbalanced.

While Einert (1) reported delayed flowering and higher flower counts on Ace plants grown in a medium containing rice hulls, plants in this study grown in the rice hull soil mix had lower flower counts and flowered without delay. These plants were less desirable than plants grown in the soil:peat:perlite mix, however. The difference in results might be attributed to differences in quantities of rice hulls used. Einert used a quantity equal to the soil or peat, and we used half that quantity in our mix.

Satisfactory plants were grown in both the 2 soil:1 moss peat and the 1 soil: 1 moss peat:1 perlite media with a tendency toward stronger plants and more flowers in the 1:1:1 mix.

Any of the fertilizer regimes used in treatments 2 through 10 provided salable plants. No regime provided the best results for all characters evaluated. Once good quality, properly prepared bulbs are obtained, the forcer should strive to provide an appropriate medium for one's conditions to obtain the best growth and minimal root rot development. Then, select an appropriate fertilizer regime. One must realize that although some differences in plant responses seen in the tables are relatively small, they do show trends which might be magnified in different greenhouse environments. The appropriate regime will vary with conditions in one's range and one's objectives. For example, is there trouble with short plants, tall plants, too alkaline a soil and/or water supply, too acid soil and/or water supply, etc.

Both slow release fertilizer mixed in the potting soil and regular applications of soluble fertilizers provided satisfactory plants.

Slow Release Fertilizer. Osmocote alone or a half application plus 25-0-25 with every watering provided good plants with a preference for the combination treatment. Soil pH increased 0.5 units from 6.2 at the start with a water supply pH of 7.8. With a neutral (pH 7.0) water supply, the pH dropped roughly 1.0 units from 6.5.

The two MagAmp treatments provided similar plant responses and had the best floral trumpet length. With an alkaline water supply and MagAmp only, soil pH increased 0.8 units and with the MagAmp plus 25-0-25 it did not change. With a neutral water supply, soil pH dropped 0.6 and 1.0 units, respectively.

When a slow release fertilizer is used we would generally recommend incorporation at the half rate, supplemented by soluble fertilizer applications. This system allows the forcer to alter soil nutrient levels, if necessary, while the full rate of slow release fertilizer does not permit manipulation.

Soluble Fertilizers. The 25-0-25 plants (every watering or weekly) had acceptable flower counts, full plant bases, and the best foliage color. They were also relatively tall and for the weekly fertilizer treatment, narrow. Soil pH increased 0.5 units with an alkaline water supply and decreased 1.0 unit with a neutral water supply.

Plants fertilized with the ammonium sulfate-sodium nitrate mix alternating with potassium chloride had the most flowers, were short, had full plant bases, rich green foliage color and good floral trumpet length. The plants were also among the narrowest. Soil pH increased 1.0 unit with an alkaline water supply, but decreased 0.5 units with a neutral water supply.

Fertilization with calcium and potassium nitrate resulted in plants with acceptable flower number, full plant bases and dark green foliage color. The plants were also relatively tall, narrow, and had fair floral trumpet length. Soil pH increased 1.3 units with an alkaline water supply and remained unchanged with a neutral water supply.

Plants fertilized with sodium and potassium nitrate were short, fairly broad with fairly dark green foliage color and acceptable floral tube length. They were also lower in floral number and had open plant bases. Soil pH increased 1.8 units with an alkaline water supply and 0.5 units with a neutral water supply.

The soluble fertilizer treatments above are discussed with the most acidic fertilizer first and each one thereafter is progressively less acidic or more alkaline.

Summary

1. 'Nellie White' Easter lilies were forced in several growth media under various fertilizer regimes. All plants except those grown in the nutrient enriched peat media were of salable quality.

2. Bulbs from different sources reacted similarly in this study.

3. Plant response to fertilizer treatments varied with the growth medium used.

4. The most appropriate fertilizer treatment will vary depending on the needs and objectives of individual forcers.

5. Both slow release fertilizer mixed in the potting soil and regular applications of soluble fertilizers provided satisfactory growth.

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