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LIME AND PHOSPHATE EFFECTS ON EASTER LILIES, LILIUM LONGIFLORUM THUNB.[1]

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Greenhouse-forced Easter lilies have displayed a variety of undesirable leaf patterns over the last 30 years. Symptoms include leaf tip chlorosis and necrosis (tip burn), necrotic blotches scattered on the leaves, half moon necrotic patterns on leaf margins (leaf scorch), and dried or necrotic lower foliage.

In 1949, Stuart (18) reported that "leaf burn was first observed at Beltsville on Croft lilies during the 1945-46 forcing season". Necrotic semicircular areas developed on leaf margins near the leaf tips and often spread to the leaf tips in a short time. The symptoms were similar to injury from botrytis and from nicotine fumigation, but often these two factors were not involved.

Seeley and de Cardona Velaquez in 1952 (16) defined two types of leaf burn (a) semi-circular, brown necrotic areas on leaf margins within 1 1/2-inches of the leaf tip and (b) dying back of leaf tips up to 3/4-inch. Widmer (24) and Marousky and Woltz (10) mentioned the drying of lower foliage. Apparently little is known about the causes of scattered necrotic blotches on the leaves.

The incidence of the various symptoms has varied by cultivar grown (25). 'Croft' has been the most susceptible, 'Ace' has been more resistant, and 'Nellie White' the most resistant.

More studied have been directed toward determining the causes of leaf scorch than toward any of the other symptoms. Possible causes include an inadequate nitrogen supply (8, 13, 15, 18, 22, 23); an excess of ammonium nitrogen (20); inadequate lime, low calcium and low pH (2, 5, 13, 18); nutrient imbalances (5, 12, 16, 17, 18, 19, 21); moisture stress (5, 18); root rot; (1) too much phosphorus fertilizer (3, 20); lithium toxicity (6); and fluorine toxicity (10). Because of the superphosphate-lime-fluorine-leaf scorch interaction, several sources have recommended adding lime and eliminating superphosphate in lily potting soils.

Our studies were conducted to determine the response of Ace and Nellie White lilies, forced into bloom under Minnesota growing conditions, to varied levels of pulverized limestone and superphosphate incorporated in the potting soil.

Lime Study

Ace (A) and Nellie White (NW) bulbs, 7-8 inches in circumference, were potted in 6-inch plastic pots on November 3, 1975. A steam pasteurized 1:1:1 (loam:peat moss:sand) soil mix was used. Superphosphate (0-20-0) was incorporated in the soil at 1 1/2 lb. per yd., one-half the rate recommended for most crops. Pulverized dolomitic limestone was added to the soil at the rate of 0, 12, 24, 48 and 96 lb. per cu. yd. to provide five treatments. There were 12 plants (3 replications of 4 plants) per cultivar in each treatment.

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A modified CTF method used involved potting unprecooled bulbs and subjecting them to 62°F (16.7°C) for 21 days, 40°F (4.5°C) for 7 days and 35°F (1.7°C) for 14 days, prior to transfer to a 62°F (16.7°C) night temperature greenhouse for forcing. The pots were moved to the greenhouse earlier than originally planned because a large number of bulbs had sprouted. They were lighted with 25 foot candles of incandescent light from 10 p.m. to 3 a.m. for 3 weeks starting January 7, 1976. Thus, a total of 6 weeks of cold and long days were provided.

A routine alkaline fertilizer program was initiated on December 23, 1975 when all shoots had emerged. A nutrient solution containing 1 oz. calcium nitrate and 1/2 oz. potassium nitrate/4 gal. water was applied weekly until flower buds were 1/2-inch long (February 24), then calcium nitrate only at 1 oz./3 gal. weekly. Appropriate fungicide drenches were also applied.

Soil was analyzed biweekly during the study. Foliar samples for analysis were taken from the uppermost mature leaves at flowering, unless otherwise noted, for nutrient element analyses.

Results and Discussion

Table 1 shows plant responses to the varied rates of limestone added. As the rate increased beyond 12 lb./cu.yd., A plants were shorter (up to 7.7 cm) and narrower while NW plants showed no significant differences. Both cultivars tended to bloom later in the 0 and highest rate treatments with a maximum difference of 6 days. Flowers of NW only showed a consistent trend to longer (maximum 0.8 cm) floral tubes with increasing lime rates. Flower number did not vary significantly between treatments. Leaf tip-burn of NW (figure 1) increased significantly and undesirably with increases in lime. Leaf scorch was evident on A plants only, but not seriously enough to affect plant appearance. Foliage of NW plants was significantly paler at the highest lime rate. Roots were relatively similar in all treatments except that NW plants given no limestone, had fewer roots, and A plants had lower quality at the 96 lb. rate. Dried lower foliage was not a problem in this study.

Cultivar differences independent of treatment mostly favored NW which averaged 5 cm wider plants, 0.5 more flowers per plant, slightly longer flower tubes, better foliage color and root systems, and no leaf scorch but significant tip-burn.

Soil analysis on February 7, 1976 showed a pH range from 6.6 - 7.0 and calcium from 62 - 108 ppm. On April 10 when the plants were in bloom the pH ranged from 7.2 - 7.6 and calcium from 64 - 136 ppm reflecting the quantity of lime applied. Other nutrient levels were maintained in a medium range except for those of potassium which decreased gradually in March and April. The initial unlimed potting soil pH was 6.3 and the irrigation water was neutral with an average fluorine level of 1.2 ppm.

Foliar nutrient content at flowering (table 2) showed that individual element levels were usually higher when lime was added to the potting soil. Exceptions were phosphorus which was similar or slightly lower and copper and magnesium which were lower in A plants only. In most instances, adding lime dramatically increased manganese and boron content. Boron alone showed a progressive increase in proportion to the quantity of lime provided. Boron levels in NW were up to 1/3 higher than in A plants. Boron levels were closely correlated to the degree of foliar tip-burn, especially in NW. Kohl and Oertli (9) found the greatest boron concentration in lily tips. Thus boron toxicity, possibly aggregated by elevated manganese levels was the probable cause of the tip burn.

Dunham and Crossan (5) reported less lily leaf injury with increasing calcium levels. Mastalerz (11) found that overliming induced boron deficiency in carnations. Such reports appear to be in sharp contrast to the boron toxicity tip-burn conclusion. However, Chichilo and Whittaker (4) reported that Minnesota limestone contained 4 - 14 (average 8) ppm boron and 370 - 1420 (average 970) ppm manganese. A sample of the original limestone used in our study was not available for analysis when this report was written, but the facts strongly indicate that excessive boron possibly aided by high manganese in the lime, rather than the lime itself, was the primary cause of the tip-burn.

Fluorine levels in the lily foliage were usually higher when lime was added to the soil, but not always in proportion to the quantity of lime used (table 2). Fluorine content of NW plants which showed no leaf scorch was higher than that of A plants which did show some leaf scorch, though severity was not in direct proportion to fluorine content.

Gill (7) grew L. longiflorum "Georgia" lilies outdoors and noted that adding dolomite to the soil had little effect on growth and flowering.

Superphosphate Study

The bulbs were from the same source and were handled similarly to those in the lime study. Superphosphate (0-20-0) was mixed in the potting soil at the rate of 0, 1 1/2, 3, 6, and 12 lb./cu.yd. The 3 lb. rate is commonly used for most florist crops. No lime was added. There were 12 plants (3 replicates of 4 plants) per cultivar in each treatment.

Fertilizer applications began on December 23, 1975 when all shoots had emerged. A neutral mix of 1 part ammonium sulfate and 4 parts sodium nitrate was applied at 1 oz./2 gal. water every second week, potassium chloride at 1 oz./3 gal. water was applied until flower buds were 1 1/2-inch long.

Results and Discussion

Table 3 shows plant responses to varied levels of superphosphate (SP) in the potting soil. Plants with SP additions in the soil were significantly shorter, especially NW. The NW plants in higher SP treatments required up to 7 days more to bloom. Flower count was highest for both cultivars in the 1 1/2 lb. SP treatment. Interestingly, Gill (7) growing L. longiflorum "Georgia" outdoors also found that more flowers were produced when superphosphate was added to the soil before planting. There were 1.2 fewer flowers per plant for A and 1.1 less for NW when no SP was added to the soil. With additions of SP greater than 1 1/2 lb., flower count was lower although not always significantly so. Degree of tip-burn, although not conspicuous, was greatest on plants in the 1 1/2 lb. SP treatment. Leaf scorch was not present in significant quantity.

Treatments had a negligible effect on plant width, flower tube length, foliage color, and root quantity and quality. Dried lower foliage was not a factor in this study.

Cultivar differences, independent of treatment, were similar to those noted in the lime study.

Soil analysis on February 7 indicated that as the soil SP levels, increased pH levels decreased from 6.8 - 5.7, soluble salt readings (1-5) rose from 35 - 84 and phosphorus levels increased from 6 - 27 + ppm. By April 10, the pH ranged from 7.4 - 6.3, soluble salts from 5 - 25 and phosphorus from 4 - 21 ppm. Other nutrient levels were maintained in a medium range and in some instances were medium-low at the finish.

Table 4 shows foliar nutrient content at maturity. Phosphorus levels were progressively higher with increases of SP in the soil. Aluminum, manganese, copper, zinc, and fluorine were usually higher and calcium, magnesium, nitrogen, and sodium were usually lower in plants grown in SP amended soil, than in 0 SP soil. Other elements followed no specific pattern.

While fluorine levels (table 4) were usually appreciably higher when SP was added to the soil, the 3 lb. treatment readings were higher than were the 6 and 12 lb. treatment readings. By contrast, phosphorus levels increased progressively in proportion to the quantity of SP used. Leaf scorch in A, although limited, generally increased with higher SP rates (table 3). Lower (lowest fully developed green leaves) but not upper (uppermost fully developed leaves) leaf samples appeared to provide an appropriate indication of plant fluorine content. Although fluorine levels were higher in NW than in A plants, leaf scorch present in NW was minimal. Thus, we concluded that (a) the amount of fluorine present in normal application rates of SP was not adequate to cause any significant amount of leaf scorch in A or NW under our growing conditions and (b) the influence of fluorine on leaf scorch may be altered or controlled by numerous cultural factors.

Conclusions

In this area if the starting soil has a pH of 6.0, or higher and the irrigation water is slightly acid, neutral or alkaline, there appears to be no need for the addition of limestone to the soil of properly forced Easter lilies. Shorter plants may develop (A) if lime is added, but possible disadvantages include the development of narrower plants (A), wider plants (NW), fewer flowers (A), tip-burn (NW), paler foliage color, and other possible problems caused by impurities in the limestone. Boron toxicity was an obvious cause of undesirable leaf tip-burn in this study.

Phosphorus is recognized as an essential element for lily growth (14). Incorporating superphosphate in an Easter lily potting soil which contains no more than a bare minimum of available phosphorus is recommended at 1 1/2 lb/cu.yd. of soil. Plants grown in soil enriched with SP at this rate produced 1.2 (A) and 1.1 (NW) more flowers per plant. Plant response in other respects was slight and did not make plants less attractive or salable. Adding larger quantities of SP was less beneficial.

Fluorine was not a primary cause of undesirable plant symptoms under the conditions encountered in these studies.

Table 1. Plant reaction to varied levels of lime in the potting soil (each figure represents the mean of 12 plants).

Cultivar	Lb. limestone per cu.yd. soil	Plant Height (cm)	Plant Width (cm)	Days to flower[1]	Flowers Tube length(cm)	Flowers Number per plant	Tip burn severity (1-5)[2]	Leaf scorch no. of leaves	Foliage color (1-3)[3]	Roots Quantity (1-5)[4]	Roots Quality (1-5)[4]
Ace	None	31.6^{c}[5]	25.9^{c}	137^{bc}	13.4^{a}	5.4^{a}	3.4^{a}	2.2^{ab}	2.4^{a}	2.6^{a}	3.0^{b}
	12	30.4^{c}	24.7^{bc}	133^{ab}	12.9^{a}	5.4^{a}	3.8^{a}	2.3^{b}	2.7^{a}	3.1^{ab}	3.1^{b}
	24	27.7^{b}	25.3^{bc}	132^{a}	13.3^{a}	5.6^{a}	4.1^{a}	3.5^{b}	2.3^{a}	3.6^{ab}	3.0^{b}
	48	28.3^{b}	23.2^{ab}	133^{ab}	12.8^{a}	4.7^{a}	4.0^{a}	0.1^{a}	2.2^{a}	3.2^{ab}	2.8^{b}
	96	23.9^{a}	21.4^{a}	138^{c}	12.6^{a}	4.9^{a}	3.9^{a}	0.1^{a}	2.1^{a}	2.8^{ab}	2.3^{a}
Nellie White	None	26.8^{a}	26.0^{a}	137^{b}	12.9^{a}	5.5^{a}	2.7^{a}	0	2.8^{b}	3.4^{a}	3.2^{ab}
	12	31.8^{b}	29.4^{b}	131^{a}	13.2^{a}	5.9^{a}	3.8^{b}	0	2.8^{b}	4.1^{b}	4.0^{b}
	24	27.9^{ab}	30.7^{b}	134^{ab}	13.4^{a}	5.7^{a}	3.9^{b}	0	2.8^{b}	4.1^{b}	3.4^{ab}
	48	30.3^{ab}	30.7^{b}	131^{a}	13.5^{a}	5.7^{a}	4.6^{bc}	0	2.7^{b}	4.1^{b}	3.1^{a}
	96	28.7^{ab}	29.8^{bc}	137^{b}	13.7^{a}	5.9^{a}	5.0^{c}	0	2.3^{a}	4.4^{b}	3.9^{b}

1 Days in greenhouse after CTF treatment
2 0 = no tip burn, 5 = maximum burn
3 3 = best green color
4 5 = most roots, best quality
5 Means not followed by the same letter differ significantly at the 5 percent level

Table 2. Nutrient content[1] at time of bloom of lilies grown in soil with varied additions of limestone

Element	Ace: Lb. lime added/cu.yd. 0	12	24	48	96	Nellie White: Lb. lime added/cu.yd. 0	12	24	48	96
Nitrogen %	2.41	2.87	2.76	2.64	2.69	2.45	2.35	2.77	2.50	2.63
Phosphorus %	0.31	0.31	0.29	0.29	0.27	0.29	0.29	0.29	0.28	0.28
Potassium %	3.84	5.09	4.65	4.84	5.45	3.96	3.76	6.76	4.31	4.15
Calcium %	2.47	2.86	2.86	2.57	2.59	3.83	3.88	4.11	4.49	4.11
Magnesium %	1.43	1.13	1.24	0.99	0.95	1.50	2.04	1.44	2.01	1.63
Sodium %	0.12	0.10	0.14	0.23	0.17	0.35	0.23	0.40	0.32	0.28
Aluminum ppm	71	83	67	62	93	100	125	377	160	139
Iron ppm	95	108	99	103	88	100	110	126	108	103
Zinc ppm	40	52	50	51	46	33	43	84	48	39
Copper ppm	6.0	5.0	2.8	2.3	5.0	2.5	2.2	4.2	8	2.5
Manganese ppm	81	116	108	274	189	198	108	96	318	236
Boron ppm	50	74	92	124	186	51	88	107	198	292
Fluorine ppm										
Lower leaves										
April 9	38	55	47	45	67	47	45	72	49	148
May 5	47	28	35	42	38	53	47	40	43	62
Upper leaves										
May 5	25	28	13	21	15	26	22	21	21	32

[1]Uppermost mature leaves unless otherwise noted; analyzed by University of Minnesota Research Analytical Laboratory.

Table 3. Plant response to varied levels of superphosphate in the potting soil (each figure represents the mean of 12 plants.

Cultivar	Lb. superphosphate per cu.yd. soil	Plant Height (cm)	Plant Width (cm)	Days to flower[1]	Flowers Tube length(cm)	Flowers Number per plant	Tip burn severity (1-5)[2]	Leaf scorch no. of leaves	Foliage color (1-3)[3]	Roots Quantity (1-5)[4]	Roots Quality (1-5)[4]
Ace	None	27.0^{ab5}	21.9^{a}	136^{a}	12.6^{a}	4.3^{a}	1.5^{a}	0^{a}	2.3^{a}	3.0^{a}	2.3^{a}
	1½	29.1^{b}	24.2^{b}	137^{a}	13.1^{a}	5.5^{b}	2.6^{b}	0.6^{a}	2.6^{ab}	3.0^{a}	2.9^{b}
	3	25.2^{a}	22.4^{ab}	139^{a}	13.0^{a}	5.0^{ab}	1.9^{ab}	1.8^{a}	2.7^{ab}	3.2^{a}	2.8^{b}
	6	26.0^{a}	20.6^{a}	137^{a}	12.4^{a}	4.7^{ab}	1.2^{a}	0.3^{a}	2.8^{ab}	3.0^{a}	3.0^{b}
	12	25.1^{a}	21.6^{a}	137^{a}	12.8^{a}	4.6^{ab}	1.1^{a}	2.8^{a}	2.9^{b}	2.9^{a}	2.9^{b}
Nellie White	None	28.9^{bc}	28.9^{a}	133^{a}	13.5^{ab}	5.5^{ab}	1.3^{a}	0	2.7^{a}	4.2^{a}	3.3^{a}
	1½	30.0^{c}	28.3^{a}	133^{a}	13.2^{a}	6.6^{b}	2.2^{c}	0	2.6^{a}	4.1^{a}	3.4^{a}
	3	24.9^{ab}	29.3^{a}	139^{bc}	13.8^{b}	5.6^{ab}	1.3^{ab}	0	3.0^{a}	4.3^{a}	3.5^{a}
	6	25.4^{ab}	30.0^{a}	140^{c}	13.7^{ab}	5.4^{ab}	1.1^{a}	0.1	3.0^{a}	4.5^{a}	3.8^{a}
	12	23.1^{a}	28.0^{a}	135^{ab}	13.7^{ab}	4.5^{a}	1.1^{a}	0	3.0^{a}	4.1^{a}	3.4^{2}

1 Days in greenhouse after CTF treatment
2 0 = no tip burn, 5 = maximum burn
3 3 = best green color
4 5 = most roots, best quality
5 Means not followed by the same letter differ significantly at the 5 percent level

Table 4. Nutrient content[1] at time of bloom of lilies grown in soil with varied additions of superphosphate.

Element	Ace 0	Ace 1½	Ace 3	Ace 6	Ace 12	Nellie White 0	Nellie White 1½	Nellie White 3	Nellie White 6	Nellie White 12
	Lb. SP added/cu.yd.					Lb. SP added/cu.yd.				
Nitrogen %	2.85	2.68	2.90	2.78	2.67	2.79	2.61	2.69	2.59	2.59
Phosphorus %	0.31	0.31	0.41	0.42	0.47	0.27	0.32	0.36	0.44	-
Potassium %	7.38	6.50	7.17	7.44	6.35	7.15	5.80	7.17	8.25	-
Calcium %	1.90	1.62	1.78	1.67	1.59	2.87	2.24	2.53	2.60	-
Magnesium %	0.85	0.65	0.77	0.71	0.55	1.20	0.87	1.02	1.00	-
Sodium %	1.37	0.84	0.92	1.11	0.99	1.88	1.48	1.63	1.58	-
Aluminum ppm	58	345	81	49	96	85	86	93	233	-
Iron ppm	110	102	141	111	111	119	110	126	125	-
Zinc ppm	41	48	59	56	78	40	39	53	67	-
Copper ppm	low	low	43	2.8	6.1	2.2	low	3.5	5.1	-
Manganese ppm	255	108	423	479	467	254	76	546	528	-
Boron ppm	55	49	58	60	54	48	46	61	61	-
Fluorine ppm										
Lower leaves										
April 9	70	104	122	53	104	55	55	222	171	130
May 5	43	38	53	51	43	48	35	45	51	55
Upper leaves										
May 5	16	13	15	17	15	13	22	16	27	26

[1]Uppermost mature leaves unless otherwise noted; analyzed by University of Minnesota Research Analytical Laboratory.

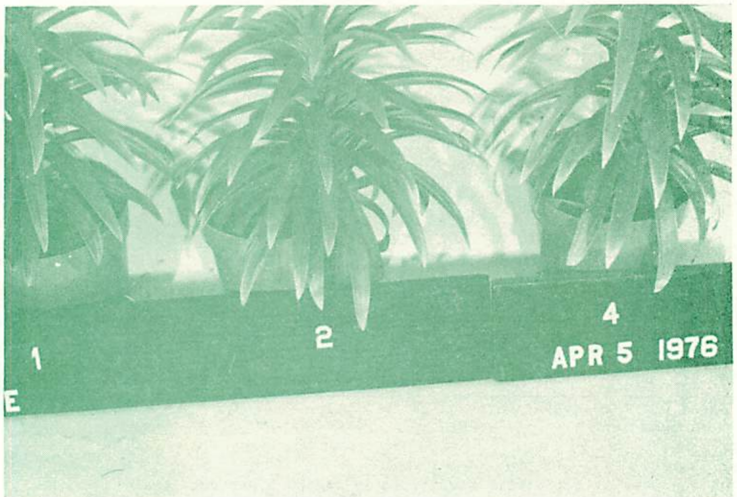

Figure 1. Typical tip-burn on Nellie White lilies grown in soil to which 48(2) and 96(4) lb. dolomitic limestone had been added per cu.yd.

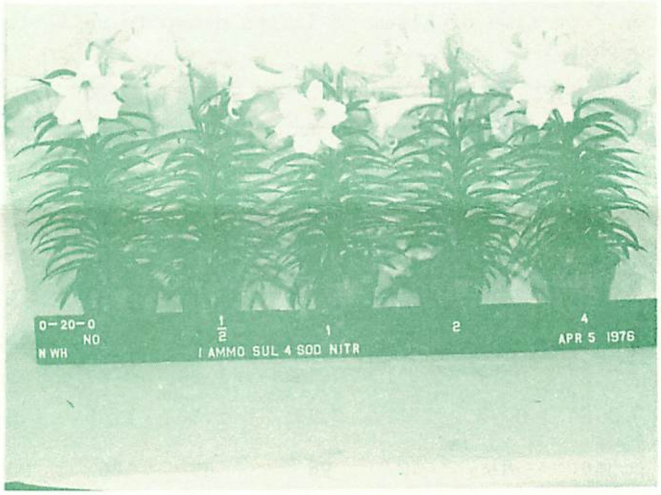

Figure 2. Nellie White lilies grown in soil to which 0(no), 1 1/2(1/2), 3(1), 6(2) and 12(4) lb. superphosphate (0-20-0) had been added per cu.yd.