No phytotoxicity was observed on the Laurel oaks or young citrus.

Herbicide experiments conducted from 1987 through 1990 have demonstrated that fluometralin is a unique dinitroaniline herbicide exhibiting unusual pre and post-emergence activities. Relatively low water solubility, coupled with a high partition coefficient makes fluometralin a product of choice where sandy soils, frequent irrigation and high rainfall contribute to groundwater contamination concerns.

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HANDLING, STORAGE, AND GERMINATION OF FORMOSAN LILY SEED

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Abstract. **Temperature governs the days required for propagation and total percent germination of Formosan lily seed. High temperatures cause the poor germination from fall outdoor seed propagation in Florida. Highest total germination, exceeding 90%, occurred at constant 15°C or 12 hour alternating 10°-15°C, 15°-20°C or 15°-25°C. Only 24% and 43% of seeds germinated at alternating temperatures of 10°-30°C or 15°-30°C respectively. Seed germination was 4 to 8 days earlier and more uniform at 15°C constant or alternating 15°-20°C, while other temperatures reduced and delayed germination. Total germination was unchanged by seed dehydration that reduced moisture contents from 36% to 12%, however, more days were required to 50% of final germination as seed moisture contents decreased. Formosan lily seeds were tolerant of low temperature storage. Total germination was not affected when seed storage temperatures declined from 10°C to −15°C, but germination was 4 days earlier and 3 days shorter between 10% and 90% germination following low temperature seed storage. Seeds were stored without reduction in total germination for 9 months at 5°C and 11%, 52%, or 75% relative humidity, but only storage at 5°C and 52% RH did not increase the numbers of days required for 50% of final germination or the germination span as storage durations were increased.**

Formosan lily (*Lilium formosanum* L.)(Fig. 1) grow in the partial shade of Florida's landscapes and have gained use as a greenhouse plant for cut flowers and occasionally as potted plants (8). Flowering can be scheduled for any period during the spring months under greenhouse conditions (9), but in the landsape flowering normally occurs in early August. Propagated from seed, plants generally flower the first year. Seed pods should be harvested when mature and beginning to split, but before seed is shed (6). Spraying the plants with a fungicide during wet periods is recommended to prevent botrytis infection of the pods. Botrytis can spread during seed handling and curing, which reduces seed viability. Emsweller (4) reported that lily seed maturity at harvest affects the time required for germination. Formosan lily seed has been reported to have a thermodormancy requiring 5°C for 3 to 4 weeks before sowing, and a maximum germination temperature of 21°C (3). Other researchers (10) classified the Formosan lily as a species requiring germination temperatures below 25°C. Highest total germination has been reported shortly after seed harvest, because of a rapid loss in seed viability during storage (3). No recommendations for seed storage temperature of relative humidity were found in the literature. Our research objectives were to measure the effect on germination of reduced seed moisture content or temperature during seed handling, and to compare the interactions of temperature and relative humidity (RH) during long-term seed storage.

Materials and Methods

Formosan lily seeds from open and controlled crosses were collected in a Florida bulb production nursery as mature capsules dehised in Oct. 1989. With all studies, seeds were germinated in 9-cm petri dishes on Anchor blue blotter paper 100 (Anchor Paper Co., Charlotte, NC) wet with 5 ml of distilled water (dw). Treatments of four 50 seed replications were placed in dark incubators at constant 10°, 15°, 20°, 25°, or 30°C. Germination data were recorded daily during 42 days and treatment means for days to 50% of final germination and span of germination (days between 10% and 90% germination) were calculated as recommended by Furutani (5). The experimental design was a split plot with data analyzed by an analysis of variance (ANOVA) with mean separation by Duncan's multiple range test (P = 0.05) and multiple regression analysis.

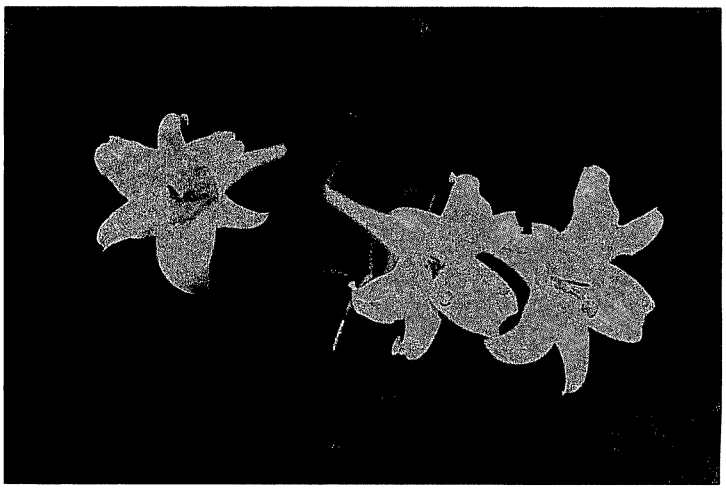

Fig. 1. Flowers of Formosan lilies enhance the summer landsapes of Florida.

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A second study was begun in Dec. 1989 to determine the effect of alternating temperatures on seed germination. Prior to the study, seeds were harvested and stored 6 weeks at 5°C and 45% RH. Treatments of four 50 seed replications were germinated in petri dishes as described previously. Germination was in incubators at 12 hr alternating temperatures of 10°-15°, 10°-30°, 15°-20°, 15°-25°, 15°-30°, or 20°-25°C. Germination data were recorded daily and percent, mean days to 50%, and span of germination were calculated. Data were analyzed by an ANOVA with mean separation by Duncan's multiple range test at P = 0.05.

Seed Moisture Content. Immediately following harvest and cleaning, seeds were placed in treatments of four 50 seed replications. The replications of each treatment were weighed individually, placed in 9-cm open petri dishes, and dehydrated for 0, 1, 3, 6, 12, 24, or 48 hr in 40°C forced draft incubators. Following dehydration, seeds of each replicate were reweighed and placed immediately in sealed screw-capped 10-ml plastic vials, 50 seeds per vial. Dehydrated and nondehydrated seeds were stored at 25°C for 1 week. Following storage, seeds were germinated and total germination, mean days for 50% germination, and germination span calculated. The experimental design was a split plot and data were analyzed using the least significant difference (LSD) at P = 0.05.

Storage Temperature. Seeds were cleaned and prepared as described previously before placing in 15 x 2.5 cm petri dishes on wire screens supported by segments of tubing 1 cm above a chemical desiccant. Constant 22% RH was maintained in the sealed petri dishes by adding 50 ml of saturated potassium acetate to the bottom of each dish (2). The refrigerated incubator was maintained at 15°C during the week of reducing the seed moisture content. Following preparation, the seeds were weighed, placed immediately in 10 ml of sealed glass vials, and immersed in polyethylene glycol-water (V/V) in controlled temperature baths (7) for 7 days at 10°, 5°, 0°, –5°, –10°, or –15°C. Bath temperatures were lowered 3°C/hr to final temperatures, held for 7 days, then increased 4°C/hr to 10°C. Following temperature treatment seeds were germinated as described previously in 15°C incubators. Daily germination counts were made of seeds with radicle protrusion through the testa and all data were analyzed using the least significant difference (LSD) at P = 0.05.

Temperature and relative humidity during seed storage. Freshly harvested seeds were cleaned and dusted with captan before storage at 11%, 52%, 75% or 95% RH at 5°C for 3, 6, or 9 months. Humidity levels of treatment were achieved as described previously, except different desiccants were used. Refrigerated incubators maintained constant 5°C during seed storage. Following storage seeds were germinated in petri dishes at 15°C, with data calculations for the rate of germination as in the previous studies. The experimental design was a randomized complete block arranged as a 3 x 4 factorial, with data analyzed by ANOVA and mean separation by Duncan's multiple range test (P = 0.05).

Results and Discussion

The initial study indicated temperature had an important effect on germination, therefore, a trend analysis was conducted using the combined data to better show the main temperature effects (Table 1). Temperature was found to influence total germination, mean days required to 50% of final germination, and germination span. At 15°C, total germination was significantly higher, and mean days to 50% of final germination and germination span were lower than at other constant temperatures (Table 1). Total germination progressively declined and mean days to 50% germination and germination span lengthened as temperatures increased above or declined below 15°C. The germination percentage trend line for temperature was significantly similar to linear, quadratic, and cubic, while the trend lines for days to 50% of final germination and germination span were similar to the quadratic (Table 1).

Table 1. Influences of temperature on the germination of Formosan lily seeds.

Temperature (°C)	Germination		
	G[y]	T_{50}[x]	T_{90}-T_{10}[w]
10	86 b[z]	28 a	26 a
15	100 a	14 b	10 c
20	80 b	22 a	16 b
25	22 c	24 a	19 b
30	0	—	—
Significance			
Linear	*	NS	NS
Quadratic	**	**	**
Cubic	*	NS	NS

[z]Mean separation in columns by Duncan's multiple range test, 5% level
[y]Percent total germination after 42 days
[x]Days to 50% of final germination
[w]Days from 10% to 90% germination
[NS,*,**]Nonsignificant or significant at P = 0.05 or 0.01, respectively; data are the means of 200 seeds.

Seeds incubated at constant 15°C had total germination similar to those at 10°-15°C, 15°-20°C or 15°-25°C, but significantly higher germination than at 10°-30°C, 15°-30°C or 20°-25°C alternating temperatures (Table 2). Constant 15°C and alternating 15°-20°C had similar days to 50% of final germination and germination spans, but the other alternating temperatures delayed germination (Table 2). The reduced germination at constant temperatures of 20°C or above (Table 1) continued when these temperatures were alternated (Table 2). Commercial lily bulb producers in Florida sow freshly harvested Formosan

Table 2. Germination of Formosan lily seed under alternating temperatures.

Alternating[y] Temp. (°C)	Germination		
	G[x]	T_{50}[w]	T_{90}-T_{10}[v]
15	98 a[z]	15 c	12 d
10-15	97 a	22 b	20 b
10-30	24 d	26 a	24 a
15-20	95 a	18 bc	13 d
15-25	92 a	21 b	16 c
15-30	43 c	23 ab	19 b
20-25	60 b	22 b	16 c

[z]Mean separation in columns by Duncan's multiple range test, 5% level
[y]Temperature alternated every 12 hr.
[x]Percent total germination after 42 days
[w]Days to 50% of final germination
[v]Days from 10% to 90% germination

lily seeds during late October or November in prepared beds in greenhouses or under Saran-covered structures. Seed germination percentages generally range from 40% to 60%. Our results attribute the low total and irregular germination of Formosan lily seeds from Oct. or Nov. propagations to fluctuations in temperature ranging from 0°C nights to 30°C days.

Germination percentages were unaffected by reducing the moisture contents of freshly harvested seed from 36% to 12% (Fig. 2). Griffith (6) recommended storing lily seeds dry to prevent fungal growth, but cautioned that excessive seed drying could reduce viability. Reducing the seed moisture content from 36% to 12% significantly increased the days required for 50% of final germination, but had no effect on the span of germination (Fig. 2). Bewley and Black (1) report that embryos severely desiccated during storage require reconstitution of seed membranes after imbibition, which delays germination.

The seeds were very tolerant of low temperatures and freezing, with no differences in total germination when seeds were stored from 10° to −15°C (Fig. 3). Days to 50% germination and days between 10% and 90% germination progressively were reduced for seeds with 21% moisture contents as temperatures declined from 10° to −15°C during 7 days storage. The thermodormancy requirement of Formosan lily seed reported by Chou (3) was believed responsible for the progressively earlier and more uniform germination as storage temperatures declined.

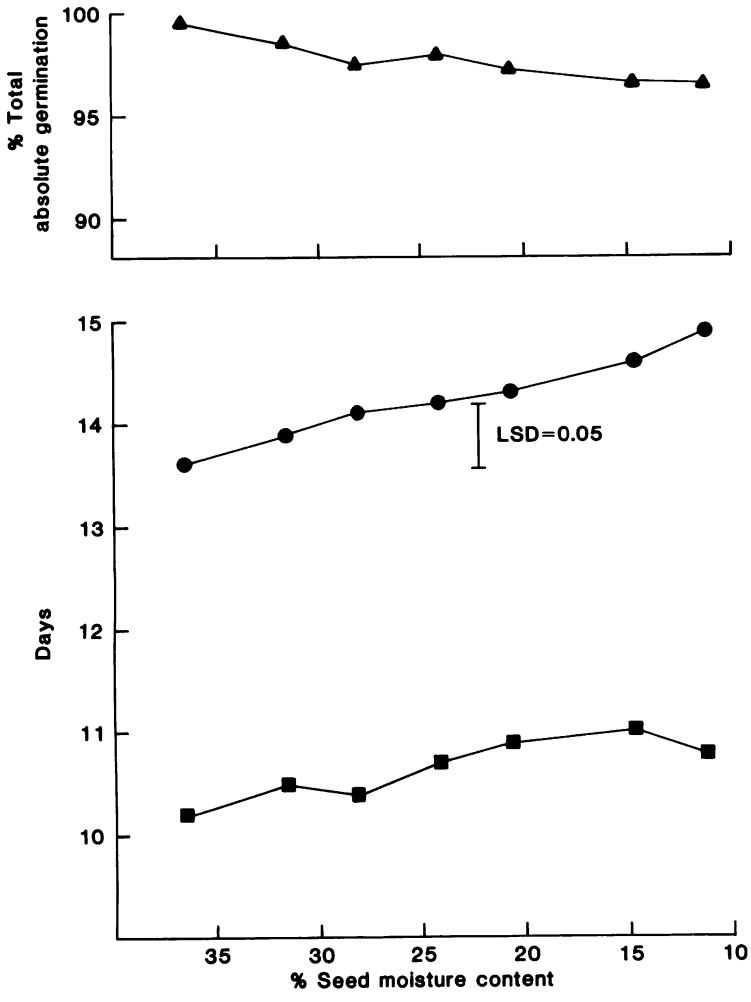

Fig. 2. Effect of seed moisture content on Formosan lily total germination (▲), days to 50% of final germination (●) and germination span (■).

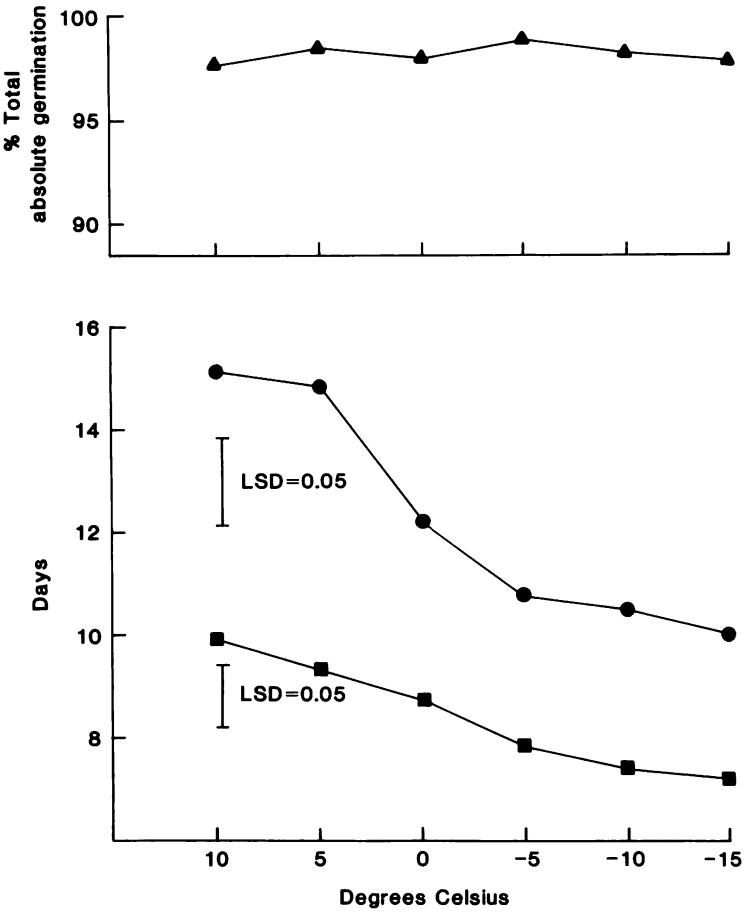

Fig. 3. Effect of seed storage temperature on Formosan lily total germination (▲), days to 50% of final germination (●), and germination span (■).

Storage of seeds for 9 months without reduction in total germination was possible at 5°C and 11%, 52%, or 75% RH (Table 3). Storage at 95% RH for longer than 3 months caused reduced germination, with total loss of viability at 9 months of storage. Seeds stored at 5°C and 52% RH generally required fewer days to achieve 50% germination and had shorter spans between 10% and 90% germination at each storage duration than the other treatments. Seeds dehydrated at 105°C after 9 months of storage at 11% RH contained 10% moisture, which was believed to cause the delay in achieving 50% germination (Table 3).

This study provides information to help explain the low germination, irregular germination, and loss of seed viability of Formosan lily seed resulting during propagation. The seed has no thermodormancy requiring 3 to 4 weeks at 5°C as previously reported (3), although low temperatures during seed storage promotes slightly earlier and more uniform germination. Low total and irregular germination were caused by improper germination temperature or inadequate RH and temperature during seed storage. Our results indicate that seeds can be stored dry for long periods in home refrigerators at 3° to 5°C and 45% RH. Florida's propagators should avoid sowing seeds until outdoor or greenhouse maximum daily temperatures remain at or below 25°C.

Table 3. Effect of relative humidity during seed storage at 5°C on germination of Formosan lily seeds. Data are the means of 400 seeds.

Seed Storage		Germination (15°C)		
Period (months)	RH (%)	Percent	T_{50}[y]	T_{90}-T_{10}[x]
0		98 a[z]	14.2 b	8.0 b
3	11	98 a	15.3 ab	8.2 b
	52	100 a	11.0 c	5.4 d
	75	99 a	14.2 b	8.9 b
	95	97 a	11.5 c	7.5 bc
6	11	96 a	16.0 ab	10.1 ab
	52	99 a	11.2 c	6.9 cd
	75	99 a	13.1 bc	8.3 b
	95	61 b	13.7 b	7.8 bc
9	11	99 a	16.5 a	12.0 a
	52	100 a	11.4 c	6.5 cd
	75	95 a	14.6 b	7.1 cd
	95	0 c	—	—

[z]Mean separation in columns by Duncan's multiple range test, 5% level.
[y]Days to 50% of final germination.
[x]Days from 10% to 90% germination.

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FERTILIZATION OF *ARAUCARIA HETEROPHYLLA* [SALISB.] FRANCO AND *CHRYSALIDOCARPUS LUTESCENS* H. WENDL

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Additional index words. electrical conductivity, pH, foliage plants.

Abstract. ***Araucaria heterophylla* (Norfolk Island pine) and *Chrysalidocarpus lutescens* (Areca palm) were placed in 15-cm plastic pots containing 6 parts Florida peat: 3 parts pine bark: 1 part builder's sand by volume on 2 June 1989 and 26 April 1989, respectively. Containers received periodic applications of Osmocote 19N-2.6P-10K 3-month release rate fertilizer at one of ten fertilizer levels (4.3, 8.6, 12.9, 17.2, 21.5, 25.8, 30.1, 34.4, 38.7 or 43.0 g/15-cm pot). Electrical conductivity (μmhos/cm) and pH of growing medium, determined by the pour-through nutrient extraction method, and plant height were recorded initially and monthly thereafter for the duration (one year) of the experiment. Plant grade was determined at 3-month intervals. Norfolk Island pine receiving fertilizer application rates of 4.3, 8.6, and 12.8 g/15 cm-pot were taller, had higher plant grades than other rates tested, and no tipburn was observed on foliage. Electrical conductivity at termination of the experiment for the leachate from these media were 286, 477, and 581 μmhos/cm and final pH readings obtained were 7.6, 5.3 and 3.4. Areca palms receiving fertilizer application rates of 25.8, 30.1, 34.4, 38.7 and 43.0 g/15-cm pot were taller and scored higher plant grades than the five lower fertilization levels tested. Electrical conductivity and pH of leachate from growth media of best quality Areca palms at termination of experiment were 671, 620, 722, 767 and 1439 μmhos/cm and 6.8, 6.9, 5.9, 6.7 and 5.7.**

Monitoring of soluble salts levels of the potting medium is now commonly used as a method of determining medium fertility (2,4,5,6,8). Four methods for measuring soluble ions in potting media currently exist, the volume:volume of water:soil method, usually 2:1, the saturated paste method, the weight:weight method (not generally used for artificial media) and the pour-through method. Although many tables suggesting soluble salts ranges for best growth of a wide variety of foliage plants have been printed in trade publications and textbooks, they mainly list the first three methods of soluble salts determination mentioned above, although the pour-through method has been used to report electrical conductivity and pH (3,9,10,11,12). The pour-through method is the easiest of the above mentioned tests for soluble salts determination to perform and thus has the most potential of being widely utilized by foliage producers in monitoring programs. The pour-through nutrient extraction method consists of pouring a measured amount of deionized water through the container medium to be tested and collection of the leachate from which soluble ion levels are then measured with a solubridge (11). Previous research with foliage plants has indicated that while many species can be grown profitably under greatly varying fertilization levels, some species require a very narrow range of fertilization levels in order to produce a salable

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