Table 4. Plant characteristics and flower potential of 30 chrysanthemum cultivars grown in 6-inch containers (Spring, 1985).

Cultivar	No. of daminozide applications[z]	Plant height (inches)	Plant diameter (inches)	Number laterals per cutting	Number buds per lateral	Flower potential[y]
Alert	2	18.4 a[x]	16.8 a-f	8.7 a	8.0 b-g	69.6
Candlelight	2	13.8 c-h	14.8 efg	7.5 a-d	5.3 h	39.8
Cirbronze	2	13.7 a-h	16.2 a-g	6.6 b-f	7.3 d-h	48.2
Circus	2	14.4 b-g	15.7 c-g	6.6 b-f	7.0 e-h	46.2
Echo	2	15.1 b-e	17.4 a-e	7.8 abc	11.3 a	88.1
Excel	2	12.3 g-j	14.4 fg	5.8 d-h	8.3 b-f	48.1
Fascination	2	13.8 c-h	15.6 c-g	7.1 a-e	10.0 abc	71.0
Fiesta	2	12.8 d-i	16.4 a-g	5.6 e-h	7.7 c-h	43.1
Firebrand	2	13.5 c-h	15.6 c-g	4.2 h	7.3 d-h	30.7
Firelight	1	10.2 jk	14.8 efg	6.3 c-g	8.3 b-f	52.3
Free Spirit	2	12.1 g-j	15.5 d-g	5.7 d-h	7.7 c-h	43.9
Frosty	2	13.1 d-i	14.7 efg	4.8 fgh	10.3 ab	49.4
Hopscotch	2	15.6 bc	18.3 abc	5.6 e-h	6.7 e-h	37.5
Illini Harvest	2	15.1 b-e	17.4 a-e	7.1 a-e	9.7 a-d	68.9
Illini Prairie	2	14.1 c-g	12.4 a-e	5.0 fgh	10.0 abc	50.0
Illini Sparkler	2	11.4 h-k	15.6 c-g	6.2 c-g	8.3 b-f	51.5
Illini Summer	2	9.0 k	13.8 g	5.8 d-h	12.0 a	69.6
Illini Sunset	2	12.7 f-i	18.9 a	6.3 c-g	10.3 ab	64.9
Illini Windmill	2	13.0 d-i	16.7 a-f	4.2 h	8.7 b-e	36.5
Limelight	2	12.1 g-j	14.9 d-g	4.3 h	7.7 c-h	33.1
Pert	1	12.6 f-j	16.6 a-f	6.2 c-g	9.7 a-d	60.1
Powerhouse	2	11.1 ijk	14.8 efg	4.7 gh	7.3 d-h	34.3
Songster	2	15.2 bcd	18.5 ab	8.6 a	9.7 a-d	83.4
Spark	1	12.8 d-i	15.4 d-g	8.2 ab	10.3 ab	84.5
Stoplight	2	15.1 b-e	17.6 a-d	5.4 e-h	7.0 e-h	37.8
Sunburst Spirit	2	12.3 g-j	15.7 c-g	7.8 abc	8.3 b-f	64.7
Sunlight	2	12.8 d-i	16.1 b-g	5.5 e-h	8.0 b-g	44.0
Surf	2	12.5 f-j	17.2 a-e	5.5 e-h	5.7 gh	31.4
Twilight	2	14.9 b-f	15.5 d-g	4.9 fgh	7.7 c-h	37.7
Ultralight	2	16.8 ab	16.7 a-f	5.3 e-h	6.0 fgh	31.8

[z]Daminozide applied at 2500 ppm with 0.85 ounces per pot of 4 cuttings.
[y]Product of number laterals per cutting and number buds per lateral.
[x]Mean separation within columns by Duncan's multiple range test, 5% level.

Literature Cited

1. U. S. Dept. Agr. 1985. Floriculture crops. 1984 summary and intentions for 1985. U. S. Dept. Agr. Stat. Reporting Serv. SpCr 6-1 (85).
2. Waters, W. E. and C. A. Conover. 1969. Chrysanthemum production in Florida. Fla. Agr. Expt. Sta. Bul. 730.
3. Wilfret, G. J., F. J. Marousky, and J. C. Raulston. 1973. Evaluation of chrysanthemum cultivars as single-plant pots for mass market sales. Proc. Fla. State Hort. Soc. 86:391-395.
4. Wilfret, G. J. and B. K. Harbaugh. 1979. Minipot garden chrysanthemums: cultivar characteristics and consumer preferences. Proc. Fla. State Hort. Soc. 92:317-319.

*Proc. Fla. State Hort. Soc. 98:*127-130. 1985.

HYBRID CALLA LILIES: A POTENTIAL NEW CROP FOR FLORIDA

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Abstract. **Hybrid calla lilies (*Zantedeschia* spp) developed in New Zealand have potential to be grown in Florida both as a field grown cut flower or as a pot plant. Limited observations and experiments have shown that the colored calla lilies can be effectively grown in the field in Florida. Tubers should be planted in winter or early spring and flowers mature 60 to 70 days after planting. Each tuber produces up to 3 flowers in one season from a single growing point. Tubers with multiple growing points can produce more than 3 flowers each season. Paclobutrazol is effective in controlling height of calla lilies when grown as a flowering pot plant. Cultural suggestions, harvesting technique, and post harvest handling of the flower are discussed.**

The Florida climate is unique in the continental U.S.A., having summers tropical in nature and winters similar to mild temperate regions. Although there are distinct disadvantages to this type of climate, it also has advantages for calla (*Zantedeschia* spp) culture. Callas have tremendous commercial value, but surprisingly have not been grown

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commercially for tuber production and export. Calla lilies are tropical plants that flower in early summer. They have storage organs (tubers) similar in size to caladiums and have also attractive foliage and inflorescences. Optimum growth is with cool night temperatures, and growth habits and fertility requirements are similar to caladiums. They do not tolerate hard freezes although they survive cold nights down to 1° C. The potential of calla lilies in Florida for commercial tuber production, cut flowers, pot flowers, and even as landscape specimens is unlimited.

Classification

Calla lily belongs to the arum family and is known by a variety of names such as arum lily; pig lily; calla lily; aronskelk; richardia; cape arum; black-eyed arums; yellow arums; and in South Africa as varkeblomme, varkore, and aronskelke. There is some confusion with their classification and nomenclature in the literature. The classification used herein is that of Letty (6) who describes 6 species of *Zantedeschia* and 2 subspecies. The genus was originally restricted to that part of the African continent extending from Cape Province to Eastern Orange Free State, Natal, Lesotho, Swaziland, Transvaal, Rhodesia, Malawi, Zambia, and Angola; but, recently some species were discovered in northern Nigeria. The plants grow in marshy places, on grassy slopes, or even at forest margins. The species fall into 2 distinct sections: 1) evergreen (those whose leaves do not die down in winter months) and 2) decidious (those whose leaves die down in winter).

The species according to Letty (6):

Z. aethiopica is evergreen and is the common white calla lily. This is the species that easily naturalized in New Zealand and Australia. It is grown in northern greenhouses as a cut flower and flowers in spring and summer.

Z. rehmannii is deciduous narrow lanceolate leaves. Color ranges from yellow to lemon yellow and it flowers in summer.

Z. jucunda is deciduous and has yellow inflorescences. Its distribution is restricted to several areas in Africa. It flowers in summer and used as a landscape plant, but is not widely used commercially.

Z. elliottiana is deciduous, yellow colored, and very robust and tall (up to 60 cm). It has a monopodial growth habit and blooms in the summer. This species has not been recorded with certainty in the wild state and is suspected of being hybrid in origin.

Z. Pentlandii is deciduous and usually white, but there are cream, ivory, pale greenish yellow, or yellow forms. It blooms in the summer and is robust and tall (up to 60 cm) with monopodial growth habit.

Z. albomaculata is deciduous and not widely used commercially. It grows very tall (75 cm) and has a color range from creamy to straw colored to pale yellow. It is greenish at the base of the spathe and sometimes has an open tubular spathe. Subspecies macrocarpa and valida are similar in growth habit but differ in the shape and texture of leaves.

Hybrid Zantedeschias

The development of longer lasting, better quality *Zantedeschia* inflorescenes was not actively pursued until recently and was pioneered in New Zealand. New color forms and growth habits were mainly developed by amateur gardeners in New Zealand and each of them had different objectives in mind. The commercial objectives, i.e. productivity; longer and stiffer stems; time to flower; uniformity; larger spathes; and more colorful types, have not been seriously worked on until recently. New Zealand's interest in the crop mushroomed after growers realized its potential export market to neighboring countries, e.g. Australia, Japan, and Southeast Asian countries. Japan is one of the leading importers of *Zantedeschia* from New Zealand. New Zealand growers promptly started an organized program for breeding better hybrid cultivars which involves both research personnel from the government and from the agriculture university. Tissue culture laboratories provided large quantities of these new *Zantedeschia* clones for local exporters to grow.

Most of the *Zantedeschia* that are hybridized, commercially developed, and used for cut flower purposes belong to the species *Z. Elliottiana.* It has the desired attributes for cut flower purposes, colorful yellow and dark yellow spathes; long and stiff stems; perfect trumpet shaped inflorescence; high productivity; and a long lasting postharvest life. *Zantedeschia rehmanni* is also grown commercially. It naturally produces multiple stems from one tuber, smaller size plants, and smaller size flowers (although more numerous). Although not suitable for export grade cut flowers, it is an excellent landscape perennial or pot flowering plant. Plants fill the container rapidly and the foliage has interesting color variegated patterns of dark green with white spots or streaks. The colorful inflorescences come in shades of creamy yellow, pink, dark pink, and maroon, hence a wide variety of color combinations are readily available to the trade.

Progressive growers have started a rigorous selection program and outstanding clones are being tissue cultured. The resulting plantlets can be shipped in small containers as active growing specimens or they are allowed to grow in controlled environment greenhouses for 4 months and dormancy is induced. The marble sized tubers are then exported or shipped to growers in New Zealand to grow for another year or two, after which the dormant 2-year-old tubers are shipped overseas for forcing.

Potentials for Florida

Imports of traditional flowers from South America and the Caribbean countries have reduced the floriculture industry in the U.S. Florida has been the most affected, losing markets in the Northeast and Midwest. One such crop for example is chrysanthemums. Imports directly affect Florida growers and have reduced the number of Florida chrysanthemum growers from 34 in 1975, with a total acreage of 1710 acres valued at $12.3 million in sales to only 10 growers in 1982 with a total of 250 acres valued at $6.35 million in sales (13). These figures have decreased further in 1985. Production of miniature carnations, standard chrysanthemums, etc., are declining also. However, new crops to replace the traditional ones are gradually being grown and markets are being developed, i.e. gerberas, snapdragons, tuberoses, Asiatic hybrid lilies, Dutch iris, etc. The colorful calla lily is another crop that needs to be introduced, tried, and grown in Florida for the cut flower industry. Environmental conditions in central and south

Florida are favorable for growing this crop during the fall, winter, and early spring months. These plants grow well in the same high organic soils where caladiums are grown. Hence, for caladium growers there would be no additional capital investment necessary to produce this crop with respect to harvesting, cleaning equipment, etc. They flower during spring (February through May) when the demand for flowers is high. Each stem can produce up to 3 flowers within a 6 week period. The plant itself has leaf patterns of clones with white streaks and can be used as indoor pot or patio plants or even landscape specimens. Tuber production can be combined with flower production, with the resulting tubers sold for forcing. Calla lilies therefore, have the potential to become a major crop for Florida producers. It is certainly one crop that merits serious consideration and needs to be promoted as one of the alternative crops for Florida producers to grow.

Production

Calla lilies grow from tubers similar to caladiums and flower in 3 years from seeds, in 2 years from tissue cultured marble sized tubers, and in the same season from 2-year-old tubers. Flowering from 2-year-old tubers, takes 60 to 70 days from time of planting with up to 3 flowers per tuber when a cut flower type cultivar is used. The cut cultivars, i.e. selections of *Z. elliotiana,* usually have a monopodial growth habit (one stem per tuber) when 2-year-old tubers are planted. One flower develops after 2 or 3 leaves have matured. Another flower will mature 2 to 3 weeks later followed by another one at the same interval similar to the 2nd flower. Following flower harvest, plants should be kept under good growing conditions to increase tuber size. When tubers are left in the ground, they develop several eyes, and next year's growth will result in plants with several stems. If allowed to remain in the ground, a clump of plants will develop. When tubers are harvested and separated into sections, each section should contain one growing point. The sections should be cleaned, stored dry at 5-10° C for 6-12 weeks, and replanted the following season. A better production method would be to dig tubers annually, and to cure and store them until ready for sale or replanting the next season. Replanting should be timed for flowering to coincide with major holidays (Easter, Mother's Day) where flowers can be marketed at a premium price.

Another species, *Z. rehmanni* is an excellent pot crop and has a smaller growth habit and produces smaller size inflorescences on shorter stems than *Z. elliottiana.* The plant is sympodial, and 2-year-old tubers produce multiple stems and flowers.

Zantedeschia plants respond favorably to growth regulating chemicals. Work on growth regulation of *Zantedeschia* by chemicals has shown that height can be reduced by the use of paclobutrazol at either 2, 4, or 8 mg ai per 15-cm pot when applied as soon as the shoots begin to emerge (9). This growth regulator worked on *Z. elliottiana* and *Z. rehmannii,* reducing petiole and blade length but not leaf width. Treated plants appeared more rounded and had darker green leaves. Scape length was also reduced. No phytotoxic symptoms nor delay in flowering was observed with drenches of paclobutrazol. Gibberellic acid can also be used to increase production of tubers and increase stem number per tuber for *Z. elliottina* and *Z. rehmannii.* Gibberellic acid is applied at 50 to 100 ppm as a 30-minute tuber dip or as tuber spray at 100 ppm prior to planting. More consistent results were obtained using the 30-minute dip (10). There are some unresolved questions as to what gibberellic acid will do to flowering of *Zantedeschia.* Dr. Ohteki (7) claimed that gibberellic acid dip accelerated flowering by as much as 3 weeks. Cohen (3) found a slight delay in flowering; whereas, Tjia *et al* (10) found no significant differences in time to flower following gibberellic acid treatments, as a dip or spray. Giberellic acid treatment did supress apical dominance and cause multiple stems to develop on *Z. elliottiana* and an increase in the number of multiple stems on *Z. rehmanni.* Gibberellic acid treatments are beneficial to increase the number of stems and thereby increase tuber production and flower number. Increasing stems from multiple stem *Z. rehmanni* did not necessarily increase the number of flowers since competition for nutrition and light became a limiting factor. GA treatments produce a fuller pot plant of *Z. rehmanni.*

Disease and Insects. There is limited information on diseases and insects on *Zantedeschia* grown in Florida. Erwinia soft rots cause plants to turn yellow and decline rapidly (4). The causal organism is *Erwinia carotovora* var *aroideae.* Alternaria leaf spot causes concentric yellow necrotic spots on leaves and flowers. The affected tissue turns brown and dies. Causal organisms are *Alternaria* spp (8). Xanthomonas Causes watersoaked appearance on leaves (5). During wet weather, a soft rot usually occurs. Under dry conditions, the lesion becomes necrotic and turns brown. The necrotic tissue may become torn or partly drop out.

Harvesting

It has been suggested that the best way to harvest *Zantedeschia* is to pull the flowering scape from the plant and place it as quickly as possible in water (1, 2). It is thought that this results in flowers with longer stems and prevents split stems from developing and this is now becoming standard practice. It prevents flowers from wilting, which is important because according to some reports (1, 2) it is difficult to rehydrate flowers. Studies at Massey University indicate that wilted flowers do rehydrate with no impairment to keeping quality (12). Actually, the practice of pulling stems has been shown to be not advantageous at all except for having longer scapes (12). A better method is to cut the stems as far down the plant as possible. Cutting stems has the advantage of not disturbing the primordia of the next flower, which is located adjacent to the first flower. Carelessly pulling the stem can damage or remove the next flower primordia. Inflorescences should be harvested when the spathes are fully open and about 1 day before the flowers shed pollen. They should not be harvested earlier as no further development will occur.

Postharvest Handling

The most troublesome problems with postharvest handling of *Zantedeschia* is split stem and stem rolling. Stems of *Zantedeschia* flowers, once harvested and placed in water, absorb water rapidly and split at the base ends. In severe cases the stems continue to split, with the ends rolling (Fig. 1). However, this can be prevented by adding 40 g of sugar/liter and 100 ppm 8-hydroxyquinoline citrate (8). Freshly harvested flowers should be pulsed in this sol-

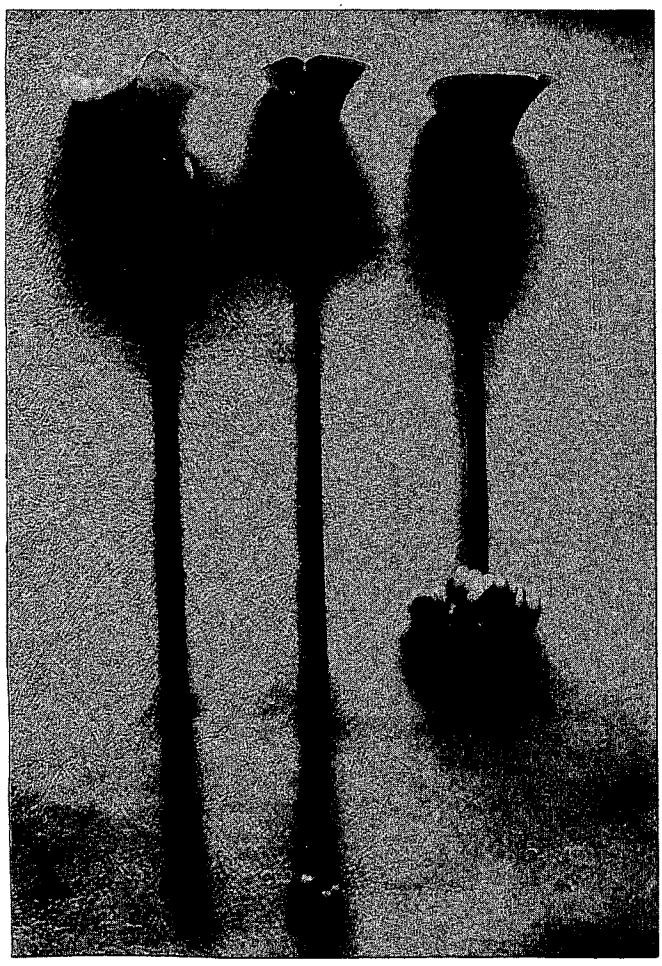

Fig. 1. Stem splits (center) and stem rolling (right) of *Zantedeschia elliottiana* following harvest (cut) and placed directly in clean water.

ution for 8 to 12 hours. Flowers placed in this solution should be hardened in the cool storage facility overnight (5 to 10° C). Stems should be wiped dry prior to packing and the flowers should be shipped dry in boxes.

The postharvest life of *Zantedeschia* is similar to the more traditional flowers e.g. roses, snapdragons, tulips, and gerberas. There is a *Zantedeschia* clone with keeping quality of up to 3 weeks but the majority of calla flowers available have a postharvest life of 6-7 days once removed from cold storage.

Zantedeschia plants still have the potential of an even longer postharvest life since colored calla lilies do not deteriorate as rapidly as do other flowers. The limitations are that in some clones the spathe gradually turns green and cups, although the inflorescences still appear fresh. No commercial preservatives or silver thiosulphate seem to be able to increase the *Zantedeschia* keeping quality (11). Were it not for these drawbacks the postharvest life of calla lilies could be increased significantly, especially if the greening of the spathe can be prevented or delayed assuming greening of spathes is used as the criterion to signify the end of useful vase life.

Conclusion

Zantedeschia spp. and hybrids have great potential for growing commercially in Florida either from seed, tissue culture plantlets, 1-year tubers, or 2-year ready to flower tubers for production of tubers, cut flowers, pot plants, or landscape plants. Production can be easily adapted to caladium producer practices. They grow well under high organic soils with moist conditions. Plants are very tolerant to herbicides and flowers do not deteriorate rapidly in the field despite heavy rain showers. Plants flower during the time in late spring when the demand for cut flowers is high. Each stem can potentially produce 3 flowers each season.

LITERATURE CITED

1. Amos, J. 1984. Zantedeschias are flowers of the '80's. N.Z. Fruit & Produce (Nov.-Dec.):51-53.
2. Brett, B. 1983. Hybrid Zantedeschia—The colored callas—N.Z. Commercial Hort. (Dec.):20-21.
3. Cohen, D. 1983. Micropropagation of Zantedeschia Hybrids. Proc. Intl. Plant Propagation Soc. New Zealand Region. (In press)
4. Fresa, R. Regnik F.Z. de. 1971. Soft rot of rhizomes in calla plants. Centro Invest. Cienc. Agron., INTA, Castelar, Argentina, Revista de Investigaciones Agropecuarias 5, 8, 2:53-61.
5. Jonbert, J. J. and S. J. Truter. 1972. A variety of *Xanthomonas campestris* pathogenic to *Zantedeschia aethiopica.* Netherlands J. Plant Path. 78(5):212-217.
6. Letty, C. 1973. The genus *Zantedeschia.* Bothalia 11, 1 & 2:5-26.
7. Ohteki, T. 1982. Cut flower production—Japanese techniques Zantedeschia, Eucharis, Gentiana. Tech. Bul. 1. Hort. Res. Ctr. Levin, New Zealand.
8. Tjia, B. and K. A. Funnell. 1985. *Zantedeschia aethiopica.* Control of stem split and alternaria flower spot following harvest. N.Z. Commercial Hort.(Apr):28-29.
9. Tjia, B. and B. R. McKay. 1985. Growth regulators effect on growth and flowering of *Zantedeschia rehmannii.* HortScience 20:126. (Abstr.)
10. Tjia B., C. J. Stanley, K. A. Funnell, and D. Cohen. 1985. Flowering of *Zantedeschia:* Effect of gibberellic acid dips and sprays. HortScience 20:126. (Abstr.)
11. Tjia B. 1985. Postharvest studies of cut *Zantedeschia* inflorescences. Proc. III Post Harvest Symposium. ISHS The Netherlands. (In Press)
12. Tjia, B. and K. A. Funnell. 1985. *Zantedeschia*: Recommendations–Harvesting on and pre-shipment. N.Z. Commercial Hort. (May):25.
13. Waters, W. E. and J. W. Prevatt. 1983. A description of the scape, magnitude and challenges facing the Florida Floriculture Industry in the 1980's. Bradenton Res. Rpt. 1983-18.