(LR #836)

STABY - OSU

Akamine 79

by Ernest K. Akamine, Theodore Goo and Robert Suehisa

Relationship between leaf darkening and chemical composition of leaves of species of protea

INTRODUCTION—The history and culture of ornamental proteas and their worldwide use as cut flowers have been published (8, 9). The vase life of some species of ornamental protea is decreased by the rapid darkening of the leaves on the flower stem (2, 4, 5). This paper reports on the relationship between the rate of leaf darkening and chemical composition of the flower stem leaves of different species of protea. Results of attempts to decrease the rate of leaf darkening by the use of some commercial floral preservatives and chemicals used for the preservation of other cut flowers (1, 3, 6, 7) are also reported.

MATERIALS AND METHODS—Sixteen species of protea were used in the investigation to determine the relationship between the rate of darkening of flower stem leaves and their chemical composition. Terminal shoots with flower buds were cut from fields at the Maui agricultural research center of the Hawaii agricultural experiment station and immediately air shipped to the laboratory in Honolulu where the investigation was conducted. For each species, two flower stems with 15 leaves each were used for chemical analyses, and one other stem with a similar number of leaves was used to determine the rate of leaf darkening.

For chemical analyses, the leaves were removed from the stem and successively washed in detergent solution, tap water and deionized water (twice). Excess surface moisture was removed with paper toweling before weighing, and the leaves were dried in a draft oven at 75 degrees Centigrade for 48 hours. After drying, the leaves were again weighed, then ground in a stainless steel Wiley mill preparatory to analyzing for various constituents. For the analysis of manganese (Mn), zinc (Zn), copper (Cu), iron (Fe), potassium (K), magnesium (Mg) and calcium (Ca), an atomic absorption spectrophotometer was used. For the analysis of nitrogen (N), phosphorus (P), boron (B), sulfur (S) and sugars (sucrose, non-reducing and total), a Technicon Autoanalyzer was used. Analyses were reported on the basis of dry weight.

The stem for determining the rate of leaf darkening was placed in a glass jar with tap water (supplemented as required) in the laboratory. Temperature ranged from 20.8 to 22.5 degrees C. and relative humidity was kept at 71 to 79 percent. Each leaf was numbered from butt to tip of the stem, and the approximate area of darkened surface as percentage of the total leaf surface area was determined daily and recorded until all leaves were completely darkened.

In other experiments, various commercial floral preservatives and chemicals were utilized in the vase water in the laboratory in attempts to decrease the rate of flower stem leaf darkening in a species of protea (Protea exima) which has one of the highest rates of leaf darkening (2).

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Species	Days to darken
Protea repens	5.3
P. macrocephala	5.3
P. exima	7.1
Leucospermum cordifolium	8.9
Leucadendron discolor	14.4
Protea obtusifolia	16.7
P. aristata	17.6
P. compacta	17.7
P. barbigera	18.1
P. cynaroides	20.1
P. laurifolia	20.6
P. lacticolor	24.3
P. neriifolia	24.7
P. suzanne	45.0
P. longifolia	**46.1**
Leucospermum tottum	a

[a]After 22 days, test was discontinued because the leaves dried out. On this day, on the average, only 4.6 percent of the leaf surface was darkened and no leaves were completely darkened.

Table 1. Average number of days for all flower stem leaves of ornamental protea species to darken completely

Leaf constituent	Correlation
Mn (ppm)	.7908[a]
Zn (ppm)	.6954[a]
N (%)	.6044[b]
Cu (ppm)	.5435
Fe (ppm)	.4737
Moisture (%)	.4108
Dry weight (%)	−.4108
P (%)	.4033
K (%)	.3398
Sucrose (%)	−.3068
Non-reducing sugars (%)	.2048
S (%)	.1847
Total sugars (%)	.1088
B (ppm)	−.0868
Mg (%)	−.0802
Ca (%)	−.0096

[a]Significant at P = .01
[b]Significant at P = .05

Table 2. Correlation (r) between flower stem leaf composition and rate of leaf darkening for 13 ornamental protea species

Floral preservatives	Days 2	4	6	8	10	12	14	16	18	20	22	24	26	28
	Average darkened leaf area (percent)													
Everbloom (20 g/l)	2.5	3.8	6.8	9.1	13.1	14.5	15.6	20.5	25.5	26.7	27.7	28.9	29.6	[illegible]
Floralife (20 g/l)	1.6	5.1	7.3	10.3	13.2	14.6	16.8	18.5	18.5	18.5	18.6	19.0	19.3	[illegible]
Roselife (20 g/l)	2.8	7.5	11.0	36.5	63.4	86.0	93.8	97.8	98.0	100.0				
Petalife (20 g/l)	5.1	5.8	6.1	6.9	7.7	8.1	8.3	8.6	8.6	8.9	8.9	9.2	9.5	[illegible]
Oasis (20 g/l)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.5	0.9	4.3	6.3	8.5	[illegible]
Sucrose (30 g/l) + 8 HQC[a] (0.2 g/l)	1.1	1.5	1.9	2.5	3.1	3.6	4.1	4.1	4.4	4.4	4.4	4.8	4.8	[illegible]
Sucrose (30 g/l) + 8 HQS[b] (0.2 g/l)	5.7	7.1	9.1	11.3	14.0	15.9	18.3	20.3	25.7	31.2	33.4	35.1	36.3	[illegible]
Sucrose (30 g/l) + $AgNO_3$ (.05 g/l) + citric acid (0.1 g/l)	28.2	35.6	41.5	46.8	56.5	61.5	65.8	68.3	69.8	70.2	71.0	71.5	72.5	[illegible]
Deionized water	12.3	32.7	70.3	81.9	85.8	100.0								

[a]8-hydroxyquinoline citrate
[b]8-hydroxyquinoline sulfate

Table 3. Effect of commercial and chemical floral preservatives on the rate of flower stem leaf darkening

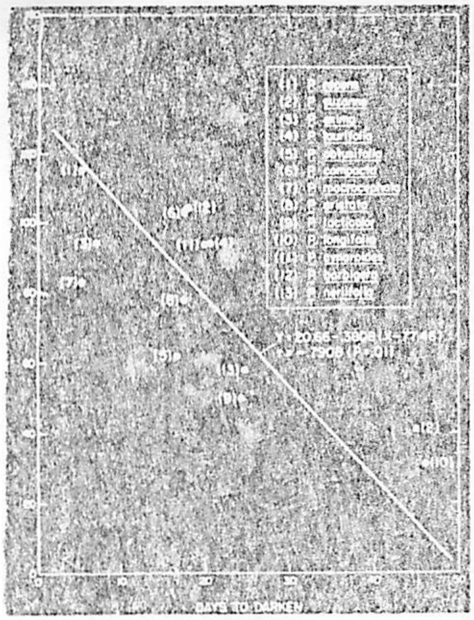

Figure 1. Relationship between the Mn content of flower stem leaves and their rate of darkening in species of ornamental protea

Freshly cut terminal shoots with buds just beginning to open were obtained from the Maui research center and stored in a commercial shipping package in the laboratory for two days to simulate shipping and handling time for air-shipped flowers from Hawaii to the US mainland. At the end of the second day, the stem butts were freshly cut to retain 15 leaves on each before being placed in the vase solutions in the laboratory. Each treatment was composed of a single stem with 15 leaves which were numbered chronologically from the butt to the tip of the stem. The vase solutions of the various commercial floral preservatives (Everbloom, Floralife, Roselife, Petalife and Oasis) and chemical preservatives (sucrose, 8-hydroxyquinoline citrate, 8-hydroxyquinoline sulfate, silver nitrate and citric acid) were made with deionized water and placed in glass jars. The required volume of the vase solutions was replinished as needed with deionized water without the addition of preservatives. The rate of leaf darkening was observed daily. The diameter of the bud opening was also measured daily until the bud began to close, when measurements were terminated.

RESULTS. The rate of flower stem leaf darkening of the 16 species varied widely from approximately five days for Protea repens and P. macrocephala to 46 days for P. longifolia (Table 1). When the leaf darkening rate was correlated with the leaf chemical composition of 13 species (chemical composition of Leucospermum cordifolium, L. tottem, and Leucadendron discolor was not determined due to insufficient leaf samples), the correlation (r) varied widely with the chemical constituents (Table 2). Only three constituents were significantly correlated with the rate of flower stem leaf darkening: Mn and Zn had highly significant negative correlations (P = .01) and N had a significant negative correlation (P = .05). The relationships between these chemical constituents and the rate of flower stem leaf darkening of the different species are depicted in Figures 1, 2, and 3 with a linear regression equation line drawn for each relationship. The number of days required for the leaves to darken decreased with increasing concentrations of Mn, Zn and N—the higher the concentrations, the more rapidly the leaves darkened.

The effect of floral preservatives on the rate of flower stem leaf darkening is shown in one of the experiments conducted for a period of 28 days (Table 3). All treatments were superior to the control (deionized water only). Whereas in deionized water, all leaves were completely darkened in 10 days; in Roselife, they were darkened in 20 days and in the other preservatives, they were not completely darkened

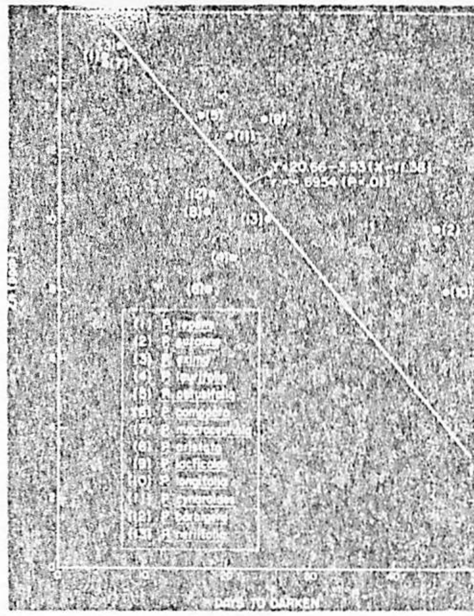

Figure 2. Relationship between the Zn content of flower stem leaves and their rate of darkening in species of ornamental protea

even after 28 days. Among those remaining in the test for 28 days, Petalife, Oasis and sucrose + 8-HQC were most effective for reducing the rate of leaf darkening; the others were less effective. Among the preservatives used in these investigations, Everbloom, sucrose and citric acid were also found effective for delaying senescence of flowers and leaves of Protea exima elsewhere (2).

The rate of flower closing was compared with the rate of leaf darkening as affected by the various floral preservatives (Table 4). All preservatives

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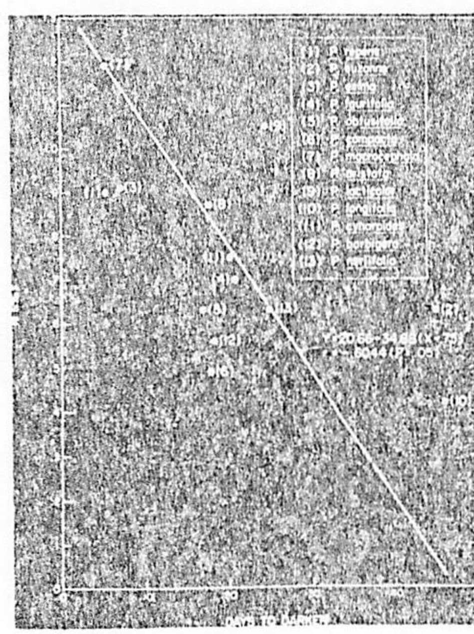
Figure 3. Relationship between the N content of flower stem leaves and their rate of darkening in species of ornamental protea



[illegible]	Days to begin flower closing	Ranked order of flower closing rate (1 = earliest)	Ranked order of leaf darkening rate (1 = earliest)
[illegible]	10	6	5
[illegible]	9	5	6
[illegible]	7	[illegible]	2
[illegible]	11	[illegible]	8
[illegible]	13	9	7
[illegible] + 8-HQC[a] 0.2 g l[-1]	10	8	9
[illegible] + 8-HQS[b] 0.2 g l[-1]	8	4	4
[illegible] + $AgNO_3$ .05 g l[-1]	6	[illegible]	3
[illegible] acid 0.1 g l[-1]			
[illegible] water	5	1	1

[a] [illegible] citrate
[b] [illegible] sulfate

Table 4. Effect of commercial and chemical floral preservatives on the rate of [illegible] and ranked order of flower closing and leaf darkening rates

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filled with less fragile Christmas novelties. Miscellaneous figurines, stars, Santas, reindeer, angels, minature fireplaces, stockings, tiny bells and others. There are 128 of these bins—the average capacity is seven cubic feet, and all have matching tapered shoulders. They can be quickly folded flat at season's end, and so present no significant storage problems.

TO AVOID STORAGE PROBLEMS, the Beals, like many retailers, hold a half price sale after Christmas on all seasonal decoratives and closely related gift items. Year-round staple lines, such as indoor-outdoor gardening supplies, bird seed, feeders, power equipment, etc., are not included. Unlike most of the competition, however, the Beals keep their sale going through the first week of January. Over the years, volume handled during this activity has averaged from 12 to 15 percent of the total beginning Christmas inventory. Moving out that much merchandise leaves only 8 to 9 percent of the original stock, valued at approximately $10,000, to be repacked for storage in the company warehouse.

"Although our annual clearance sale is seldom better than a break-even proposition in itself, it is really a lifesaver in terms of holding down storage costs," says Bob Beal. "When considering escalating insurance premiums, carryover expense can now be 17 to 20 percent of the potential retail value of merchandise." That's why the Beals no longer consider storing slow-moving decoratives more than once. If they don't move during their second exposure, they're donated to charitable organizations: Repacking and reinsuring would virtually eliminate any residual value. Furthermore, the goodwill aspects of this gesture may represent potential profits.

Proteas

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prolonged the life of the flower, i.e., they reduced the rate of flower closing. When the preservatives were ranked according to their efficiency to delay closing of flower and to delay browning of leaf (Table 4), there was a highly significant positive correlation of .9824 (P .01) between the two rankings. Thus the effect of any preservative on flower closing and leaf darkening was the same preservatives that delayed senescence of flowers also delayed leaf browning to the same degree.

CONCLUSIONS The rate of darkening of leaves on flower stems of ornamental protea varied widely among different species and was negatively correlated with the Mn, Zn and N content of the leaves. Leaves of species with higher levels of these elements darkened earlier than those with lower levels. The rate of flower closing in flower stems in preservative solutions was positively correlated with the rate of leaf browning: Floral preservatives that delayed flower closing were also equally effective for delaying leaf browning. All preservatives used in these investigations were effective for delaying senescence of flowers and leaves, and among these, Petalife, Oasis and sucrose + 8-HQC were most effective. In breeding programs to improve flower quality, chemical composition of leaves should be considered to alleviate the problem of leaf browning in ornamental proteas.

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EDITOR'S NOTE: Ernest K. Akamine, Theodore Goo and Robert Suehisa are horticulture professor and associate researchers, respectively, in the botany department at the University of Hawaii in Honolulu. This research paper is Journal Series No. 2353 of the Hawaii agricultural experiment station. To simplify information, trade names of products have been used. No endorsement of named products is intended, nor is criticism implied of similar products not mentioned. Mention of a chemical does not imply guarantee of effectiveness or safety, nor that the chemicals or uses discussed have been registered by appropriate state and federal agencies.

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