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Effect of Accel on the Postharvest Vase Life of Easter Lily

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Abstract: Laboratory trials were carried out to investigate the effect of Accel on the postharvest vase life of Easter lily cut flowers. Flowering stems of Easter lily cultivar 'St. Joseph' were purchased from a commercial farm in Gaborone, Botswana. Accel at 25, 50, or 75 mg L^{-1} significantly delayed postharvest catastrophic leaf yellowing of Easter lily, flower senescence and abscission, improved flower water uptake, increased flower vase life and retarded leaf chlorophyll and nitrogen degradation. The results indicated that Accel can be used as a commercial cut flower preservative solution for Easter lily and other cut flowers with postharvest leaf yellowing as a problem.

Key words: Easter lily, accel, delayed leaf yellowing, delayed flower senescence, chlorophyll, nitrogen

INTRODUCTION

Easter lily is an important cut flower in Southern Africa, Kenya, Israel, United States of America, Europe and Japan. The lily family is large and contains many commercially important floriculture crops including *Allium*, *Brodiaea*, *Convallaria*, *Eremurus*, *Hyacinthus*, *Lachenlia*, *Muscari*, *Ornithogalum* and *Tulipa*[1].

Chlorosis and death of lower leaves is a common problem in the production of Easter lily[2]. Leaf yellowing in lily occurs as a gradual disorder during production in the greenhouse or as a sudden, catastrophic event following cold storage of budded lilies. During production, leaves yellow and die, beginning at the base of the stem and gradually moving upwards over time. Leaf yellowing reduces the aesthetic quality of Easter lilies. Two applications of Accel (10:1 benzyladenine: gibberellins GA_{4+7}) at 50 ppm prevented lower leaf yellowing[2]. The first application was done at 10 to 14 days prior to visible bud and the second 10 to 14 days after visible bud[2]. Application of Promalin (1:1 benzyladenine: gibberellins GA_{4+7}) at 100 ppm on the lower leaves 60 days after emergence prevented leaf yellowing[3]. However, application of A-Rest (ancymidol) aggravated lower leaf chlorosis and death of Easter lily. The gradual yellowing of basal leaves of Easter lily has also been attributed to nitrogen deficiency which can be prevented by top dressing a dry slow-release nitrogen fertilizer[4].

The problem of leaf yellowing in Easter lily continues in postharvest storage, handling, shipping and marketing. This yellowing is disastrous and is termed as catastrophic 'yellowing'. This disorder strikes quickly, causing a normal looking plant to turn almost entirely yellow within a few days after cold storage. Cultural factors such as growth regulators, low phosphorus, poor root rot control, high temperature during forcing, shipping delays and cold storage, have been attributed to be the major causes[4]. It has been suggested that the problem may be due to plant stress resulting from low nitrogen or phosphorus, and interactions with growth regulator drenches[5].

A-Rest, Bonzi and Sumagic have been linked to gradual leaf yellowing of Easter lilies when applied as drenches[6]. It has been suggested that plant growth regulators may cause leaf senescence by reducing sugar and nutrient export to developing buds which are the major carbohydrate sink during the last 6 weeks of development[6,7]. It has been reported that spraying Easter lily plants with 25 ppm of Promalin significantly reduced postproduction leaf yellowing[8]. It has also been reported that application of benzyladenine (BA) at 500 ppm to the flower buds of Easter lily increased the postharvest life of the flowers[9]. Leaf yellowing of excised Easter lily leaves was delayed by BA or gibberellic acid[10]. The problem of leaf yellowing in some cut flowers can be eliminated by use of a pretreatment agent containing phytohormones such as auxins, gibberellins and cytokinins[11]. Cytokinins and gibberellins have been reported to delay leaf senescence and improve the keeping quality of many cut flowers[12-14]. Gibberellic acid (GA_3) has been reported to delay leaf yellowing and flower shedding in *Alstroemeria* but BA was less effective[15]. Accel at 25 or 50 mg L^{-1}

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significantly delayed leaf chlorosis of *Alstroemeria* cut flowers[12]. Cytokinin sprays have been reported to have little effect on stored Easter lilies, but too low a concentration may have been used[16]. The response of plants and/or plant organs to plant growth regulators (PGRs) depends on several factors such as type of PGR, concentration of PGR, application time, plant species, plant organ or part to which the PGR is applied, stage of development of the plant and/or organ, growth environment, temperature, relative humidity, etc. The objective of this study was to evaluate the effect of Accel on the postharvest vase life of Easter lily (*Lilium longiflorum* Thunb. Cv. St. Joseph lily).

MATERIALS AND METHODS

Experimental site: Two laboratory trials were carried out to investigate the effect of Accel on the postharvest vase life of Easter lily cut flowers. Flowering stems of Easter lily cultivar ‘St. Joseph’ were purchased when buds were puffy white and one flower was open on 8th April 2004 and 13th April 2004 at a commercial farm in Gaborone, Botswana. Shoots between 50 and 80 cm were purchased in the morning, packed and received the same day in the plant physiology laboratory at the Department of Crop Science and Production, Botswana College of Agriculture.

Procedure and experimental design: The flowers were immediately unpacked and the lower 2 cm were cut off under water to avoid air embolism. The cut stems were then placed in a 10 L plastic buckets containing a solution of 10% sucrose at 38-43°C for two hours, in order to rehydrate the flowers. Ten stems were used for each treatment. The stems of the flowers were placed in plastic vases containing Accel at 0, 25, 50, or 75 mg L^{-1}. Accel is a liquid concentrate containing 20 g a.i L^{-1} benzyladenine (BA) and 2 g a.i L^{-1} GA_{4+7} (Abbott Laboratories, North Chicago, Illinois, USA). The vases containing Accel at various concentrations were arranged in a Completely Randomized Design with 4 replicates. The control flowers were held in distilled water. The vases also contained 10% sucrose and 0.23% sodium hypochlorite. Experiments were carried out in a laboratory at an ambient temperature of 24±2°C and 40-45% RH and continuous lighting with cool-white Sylvania Fluorescent lamps (65W, 240V) at an intensity of 4160 J S^{-1}.

Dependent variables determined: The vase life of Easter lily cut flowers was determined by counting the number of days to 50% leaf yellowing (chlorosis) and number of cut stems showing leaf yellowing after 3, 7 , 14, 21 and 28 days, number of flowers abscised and vase life of the flowers (number of days to 50% petal colour fading).

Leaf chlorophyll content was determined after 28 days from five leaves per replicate. Two discs (17 mm diameter) per leaf were cut using a cork borer. The ten discs per replicate were extracted in 4 mL 0.1 N HCl in methanol at 25°C in a dark room for 24 h. Absorbance of the extracts were measured using Spectro UV-VIS RS spectrophotometer. The total leaf chlorophyll content was measured as absorbance at 653 nm[17,18]. The following equation was used to calculate the relative total leaf chlorophyll content[18]. Chlorophyll (mg cm^{-2}) = 24.88X A_{653}, where A is absorbance at 653 nm and 24.88 is the molar extinction coefficient.

Dry weight of leaves was determined after 28 days. Ten leaves were sampled from 5 cut flowers per replicate. Ten grams of fresh leaves were weighed using Mettler PM 400 digital balance. The leaf samples were put in brown paper bags and oven dried at 66°C to constant weight (72 h) using Term-O-Mat incubator, then reweighed for dry weight. Water content of leaves was determined by subtracting dry weights from their corresponding fresh weights. The dry weights and water content are reported in grams. Total leaf nitrogen content (mg g^{-1} dry weight) was analyzed from 1.25 g dry weight using Microkjeldahl method according to the Association of official Analytical Chemists[19].

Data analysis: Analysis of variance was performed on the data collected using the general linear models (Proc GLM) procedure of the statistical analysis system program package. Proc Univariate procedure was carried out on residuals to support the assumptions of normality made by the researchers. Where a significant F-test was observed, treatment means were separated using the Least Significant Difference at P=0.05. Due to the similarity of the data in the two trials, the data was pooled during analysis.

RESULTS

Accel significantly delayed the postharvest onset of leaf yellowing in Easter lilies (Table 1). Easter lily flowers held in distilled water started to yellow after 3 days, while the flowers held in Accel at 25 or 50 mg L^{-1} showed symptoms of yellowing after 14 days (Table 1). Accel at 25, 50, or 75 mg L^{-1} significantly reduced the number of cut flower stems with leaf yellowing (Table 1). There were no significant differences among Accel concentrations in their ability to reduce the onset of catastrophic leaf yellowing in Easter lilies after 14 days (Table 1). Holding Easter lilies in 25, 50, or 75 mg L^{-1} Accel significantly increased the number of days to 50% leaf yellowing (Table 1). The delay in leaf yellowing increased with

Table 1: Effect of Accel on leaf chlorosis, nitrogen and chlorophyll content of Easter lily

Accel	No. of flower stems yellowing			No. of days to	Leaf chlorophyll	Leaf nitrogen
mg L^{-1}	3 days	7 days	14 days	50% leaf yellowing	mg cm^{-2}	mg L^{-1}
0	6.00a	8.33a	8.67a	18.50c	4.83b	13.52b
25	0.00b	0.00b	1.33b	25.33b	5.58a	18.12a
50	0.00b	0.00b	1.00b	37.00a	5.77a	19.81a
75	0.00b	0.00b	0.00b	26.33b	5.65a	18.33a
Significance	****	****	****	****	**	**
LSD	2.00	2.88	2.56	3.68	0.73	4.59

****, ** Significant at P=0.0001 and 0.01, respectively; means followed by the same letter within the column are not significantly different

Table 2: Effect of Accel on flower opening, leaf dry matter and water content of Easter lily

Accel	No. of open flowers		No. of flowers not open		Leaf water	Leaf dry
mg L^{-1}	7 days	14 days	7 days	14 days	content (g)	matter(g)
0	7.67b	8.67b	2.33a	1.00a	5.72c	4.28a
25	17.00a	15.89a	2.00a	0.00a	6.73b	3.27b
50	18.33a	17.33a	1.00a	0.33a	7.51a	2.50c
75	15.67a	16.00a	2.33a	0.67a	6.74b	3.26b
Significance	**	**	NS	NS	****	****
LSD	7.79	7.20	2.68	2.28	0.41	0.41

, **, NS Significant at P=0.01, 0.0001 or nonsignificant, respectively; means followed by the same letter within column are not significantly different

Table 3: Effect of Accel on flower senescence of Easter lily

Accel	No. of flowers abscised		No. of days to
mg L^{-1}	7 days	14 days	50% flower fading
0	5.67a	10.00a	14.33c
25	0.67b	1.33b	19.00b
50	0.33b	1.33b	20.67a
75	0.33b	0.33c	19.33ab
Significance	****	****	****
LSD	1.66	1.00	1.49

**** Significant at P=0.0001; means followed by the same letter(s) within the column are not significantly different

increase in Accel concentration. Easter lily flowers held in 50 mg L^{-1} Accel increased the number of days to 50% leaf yellowing by 19.5 days compared to the control (Table 1). There was no significant difference between flowers held in either 25 or 75 mg L^{-1} Accel in their ability to increase the number of days to 50% leaf yellowing (Table 1). Easter lily flowers held in 50 mg L^{-1} Accel stayed greener for 11.7 and 10.7 days longer than flowers held in 25 and 75 mg L^{-1} Accel, respectively (Table 1).

Accel significantly reduced leaf chlorophyll degradation and nitrogen breakdown during senescence of Easter lilies compared to the control (Table 1). The flowers held in Accel had significantly higher leaf chlorophyll and nitrogen content 28 days after the start of the experiment than flowers held in distilled water (Table 1). There were no significant differences among Accel concentrations in their ability to retain leaf chlorophyll and nitrogen content.

Accel significantly increased the number of flowers open and reduced the number of flowers abscising after 7 and 14 days, respectively, compared to the control flowers (Table 2 and 3). However, Accel had no effect on the opening of the flowers. Accel concentration at 25, 50, and 75 mg L^{-1} significantly kept more Easter lily flowers open and reduced flower abscission in a similar fashion. Accel further increased the vase life of Easter lily cut flowers compared to the control by increasing the number of days to 50% petal colour fading. Accel at 50 mg L^{-1} significantly increased the number of days to 50% petal colour fading than 25 mg L^{-1} Accel, but was not significantly different from 75 mg L^{-1} (Table 3). The petals of Easter lily flowers held in 50 mg L^{-1} Accel lived longer by 6.3 days than the petals of control flowers (Table 3). There were also significant differences in organ senescence. The leaves of Easter lily flowers had a longer vase life than petals (flowers) (Table 2 and 3). The leaves of Easter lily flowers held in 50 mg L^{-1} Accel had a vase life of 16 more days than petals.

Accel significantly increased the Easter lily leaf water content, but decreased the leaf dry matter compared to the control (Table 2). Easter lily flowers held in 50 mg L^{-1} Accel significantly increased and decreased the leaf water and dry matter content, respectively, compared to flowers held in 25 or 75 mg L^{-1} (Table 2). However, there were no significant differences between 25 or 75 mg L^{-1} Accel in their ability to increase and decrease leaf water and dry matter content, respectively (Table 2).

DISCUSSION

Accel contains the phytohormones benzyladenine and gibberellins (GA_{4+7}) in a ratio of 10:1, respectively. Accel at 25, 50 or 75 mg L^{-1} significantly delayed postharvest leaf yellowing of Easter lilies by delaying leaf chlorophyll and nitrogen degradation. Cytokinins have been shown to delay leaf senescence by arresting

chlorophyll and protein degradation rather than enhancing the rate of protein synthesis[20,21]. Cytokinins have also been reported to promote chloroplast development and chlorophyll synthesis[22]. Cytokinin and gibberellin pulses of *Alstroemeria* cut flowers effectively reduced leaf yellowing[12,14,23]. Spraying 100 mg L^{-1} BA in combination with 100 mg L^{-1} GA_{4+7} (Fascination) to Easter lily plants when flower buds are 8 cm long, but no more than 14 days prior to cold storage or shipping was effective to prevent postharvest leaf yellowing[24]. Fascination did not reverse leaf yellowing but prevented healthy leaves from senescing[24].

Accel prolonged the flower vase life of Easter lily and maintained the flowers open because of increased flower water uptake and increased mobilization of carbohydrates to flower buds which are stronger sinks at this stage of development as evidenced by the decrease in leaf dry matter with increase in Accel concentration. Gibberellins have been reported to increase fresh weight but not dry weights[14,22]. The decrease in leaf dry matter content in Easter lily is a GA_{4+7} effect because gibberellins have been shown to increase hydrolysis of starch, fructans and sucrose (constituents of dry matter) into glucose and fructose[12,14,22], which are utilized by the flowers for metabolism and keeping the flowers open. One of the most important factors determining cut flower longevity is the ability of the flower to maintain turgidity[12,25]. In Easter lily cut flowers, a high level of turgidity is necessary to keep the flowers open. Accel treated Easter lily cut flowers in the present study had higher leaf water content than flowers held in distilled water. The increase in leaf water content is a GA_{4+7} effect, because gibberellins increase water uptake in cut flowers by making the cell's water potential more negative[14,22]. As a result of the decrease in water potential, water enters more rapidly, causing cell expansion and diluting the sugars in the tissues[22]. Results with external applications of cytokinins which delay flower senescence of various flowers support the possibility of diminishing internal concentrations of phytohormones (cytokinins and gibberellins) may be associated with senescence processes in cut flowers[26,27].

Cytokinins have been reported to be better inhibitors of flower abscission in roses[28]. In the present study Accel at 25, 50 or 75 mg L^{-1} delayed flower abscission and reduced petal colour fading. Accel delayed flower senescence in Easter lily probably BA and GA_{4+7} acted synergistically to inhibit ethylene biosynthesis and action. Most cut flowers produce high levels of ethylene at flowering time. Ethylene causes in-rolling of petals, colour fading, wilting and abscission of many flowers[29]. In conclusion, Accel delayed leaf yellowing, flower senescence, improved flower water uptake and retarded chlorophyll and nitrogen degradation, therefore increasing the vase life of Easter lily cut flowers.

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