LOW PRESSURE AND REFRIGERATED STORAGE OF ROOTED AND UNROOTED ORNAMENTAL CUTTINGS[1]

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Abstract. Rooted and unrooted cuttings of geranium (*Pelargonium* × *hortorum*, Bailey 'Irene'), poinsettia (*Euphorbia pulcherrima*, Wild. 'Annette Hegg Dark Red'), tallhedge buckthorn (*Rhamnus frangula* L. 'Columnaris'), Regel's privet (*Ligustrum obtusifolium* Sieb. & Zucc. var. *regelianum* (Koehne) Rehd.), and compact European cranberry bush viburnum (*Viburnum opulus* L. 'Compactum'), were stored up to 9 weeks using low pressure (LP) and refrigerated (RF) storage systems. Low pressure storage extended the storage life of rooted geranium and poinsettia cuttings 2 weeks beyond that achieved with RF storage. Unrooted geranium and poinsettia cuttings had 2 week and 4 day longer storage periods with LP than RF storage, respectively. Unrooted compact European cranberrybush viburnum, Regel's privet, and tallhedge buckthorn cuttings stored 6 weeks using LP storage were superior to RF storage. Regardless of treatment, quality of all plant materials stored decreased with each progressive removal date.

INTRODUCTION

Extended refrigerated (RF) storage of rooted and unrooted cuttings is often limited by loss of pigmentation (4,17), defoliation (5,22), pathogen invasion (13,16,23,25), high rates of transpiration (14,17,23), excessive respiration (17,20), and the condition of the plant material at the time of placement into storage (4,13,20,24). Refrigerated storage is useful in extending the storage life of cuttings (10,25) by retarding both respiration and the growth of pathogens (15,17). Experiments utilizing LP storage have shown that this system can extend the storage life of cuttings beyond periods achieved with RF storage (2,3).

Low pressure (LP) storage reduces the partial pressure of gases that compose the storage atmosphere (oxygen, CO_2, etc.) which retards respiration to a greater degree than RF storage (2,6,11). Also, gases that normally accumulate in the commodity diffuse at a faster rate since the atmosphere is less dense (11). Gases that normally accumulate in the storage chamber are exchanged with uncontaminated incoming humidified air (2,6,11). An additional benefit of the LP storage system when compared

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to RF storage systems is a retardation of pathogen growth (26).

Refrigerated storage of cuttings is limited to rooted material (10,14,18,19,22,23,24,25) and to a lesser extent to the storage of unrooted cuttings (1,13,16,19,21). Low temperatures (0 and 4.4°C) and the use of fungicides prolonged the storage of rooted cuttings for periods up to 180 days (10). Storage periods for unrooted cuttings have generally been shorter than for rooted cuttings (1). Unrooted softwood azalea (21) and rhododendron (13) cuttings have been successfully stored for 70 days. In general, the more succulent the material the shorter the storage period (16).

Using LP storage, carnations, chrysanthemums and some foliage plant cuttings can be stored successfully for periods at least twice as long when compared to RF storage systems (2,3).

If rooted and unrooted cuttings could be stored for extended periods, it would free production area and subsequently increase productive capacity since a greater number of cuttings could be stored in anticipation of peak sales. In addition, cutting material in the proper condition for propagation could be stored and removed when labor and space were available. The producer with an overabundance of stock could benefit by storing cuttings, thereby preventing liners from becoming overgrown. Thus, studies were initiated to investigate the use of LP and RF storage systems in extending the storage life of rooted and unrooted cuttings. Partial results of this work have been reported previously (8,9).

MATERIALS AND METHODS

Uniform cuttings of 'Irene' geranium, Regel's privet, 'Annette Hegg Dark Red' poinsettia, tallhedge buckthorn and compact European cranberrybush viburnum were obtained from commercial sources and placed in storage the same day. Prior to storage, unrooted cuttings were immersed or sprayed to run-off with Bravo 6F (tetrachloroisophtolonitrile), 1.3 ml/liter, allowed to dry, wrapped and loosely tied with 1.9^2 cm. plastic netting.

Cuttings were placed vertically in 40 liter stainless steel milkcans. Treatments consisted of LP (35mm. Hg) and RF storage (atmospheric pressure) with storage periods of unrooted geranium, poinsettia and woody ornamental cuttings, being no longer than 6, 3, and 9 weeks, respectively. Each treatment had a control group which was directly rooted, or with rooted cuttings, placed into a greenhouse after receiving the initial 4.4°C. treatment for 3 hours.

The storage system utilized in these experiments was similar to LP systems outlined previously (6,8,9). Woody ornamental

cuttings were maintained at 2°C while poinsettia and geranium cuttings were stored at 5°C.

Upon removal from storage, the foliage of all unrooted and rooted cuttings was visually evaluated (Figure 1). In addition, supplemental foliage evaluations were obtained on days 1 and 7 following removal from storage, using the same rating scale.

Following removal from either the LP or RF storage system, unrooted cuttings were placed in a 1:1:1 peat-perlite-sand medium (by volume) after recutting the basal end. Tallhedge buckthorn cuttings received a basal dip of 0.1% IBA powder hormone application prior to being placed in rooting medium. Poinsettia, geranium and woody ornamental cuttings remained in the propagation bed for 21, 26, and 42 days, respectively. A 6 min/6 sec mist cycle was employed in all experiments. Temperature of the propagation medium was maintained at 25° ± 2°C. After rooting, cuttings were evaluated using a visual rating scale where 1.0 indicated a dead cutting and 6.0 indicated a heavily rooted cutting.

At removal rooted cuttings were placed under mist for 1 day then transferred to a 20°C greenhouse for 13 additional days prior to recording the final foliage evaluation. Intermediate evaluations on days 1 and 7 following removal from storage were also obtained with rooted cuttings.

Unrooted cuttings used as controls were evaluated after 26 days in the propagation house using the previously outlined visual evaluation scales for foliage and rooting characteristics. Rooted cuttings used for controls were placed under mist for 1 day and then were placed in a 20°C greenhouse for 13 days before final foliage characteristics were evaluated.

Unless otherwise stated, all experiments consists of 4 replications with 5 observations per replicate for each storage treatment. Data were analyzed using Tukey's omega procedure (hsd) at the 1% level (23).

RESULTS

Woody Ornamentals. Cuttings from 3, 6 and 9 week LP storage had survival percentages of 50% or greater while only the 3 and 6 week RF storage showed similar trends. A significant treatment × week interaction was apparent when unrooted cuttings were removed from storage (Figure 1). Cuttings from LP storage showed a decline in quality with each progressive removal period while cuttings from RF storage deteriorated at a faster rate. The quality of Regel's privet and tallhedge buckthorn cuttings from the 3 and 6 week LP or RF storage treatments were not significantly different, while compact

European cranberrybush viburnum cuttings were similar only at the 3 week treatment. After 9 weeks of storage all treatments in LP storage were superior to RF storage.

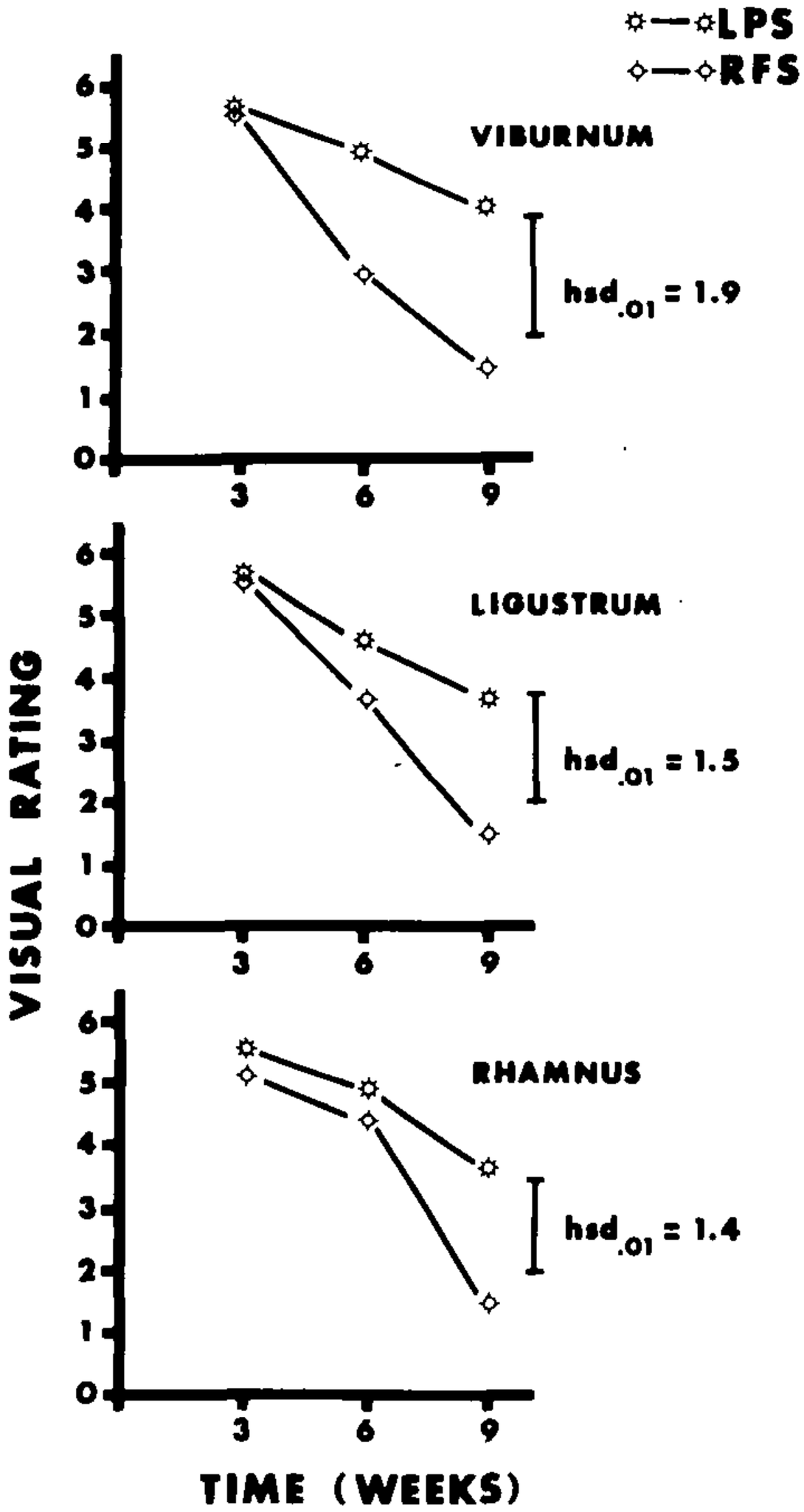


Figure 1. Visual evaluation of the foliage of unrooted *Viburnum*, *Ligustrum* and *Rhamnus* cuttings at removal after 3, 6, or 9 weeks LP or RF storage. (1- cutting dead, 2- leaves completedly deteriorated (defined as the loss of tugor, yellowing, defoliation or the appearance of neucrotic leaf tissue) 3- more than ½ the leaves deteriorated, 4- less than ½ the leaves deteriorated, 5- 1 or 2 leaves deteriorated, 6- leaves in good condition no loss of tugor).

Cuttings evaluated after 42 days in the propagation bed exhibited nearly identical foliage and root evaluations, but only foliage evaluations will be presented. Cuttings stored for 3 and 6 weeks in the chambers were comparable to control cuttings (Figure 2). Compact European cranberrybush viburnum cuttings from the 3 week RF storage treatment were comparable in quality to similar material from LP, however, as the storage period

increased, the differences in quality between the RF and LP systems became greater. All woody cuttings from the 9 week treatment regardless of the storage facility were not comparable to controls (Figure 2).

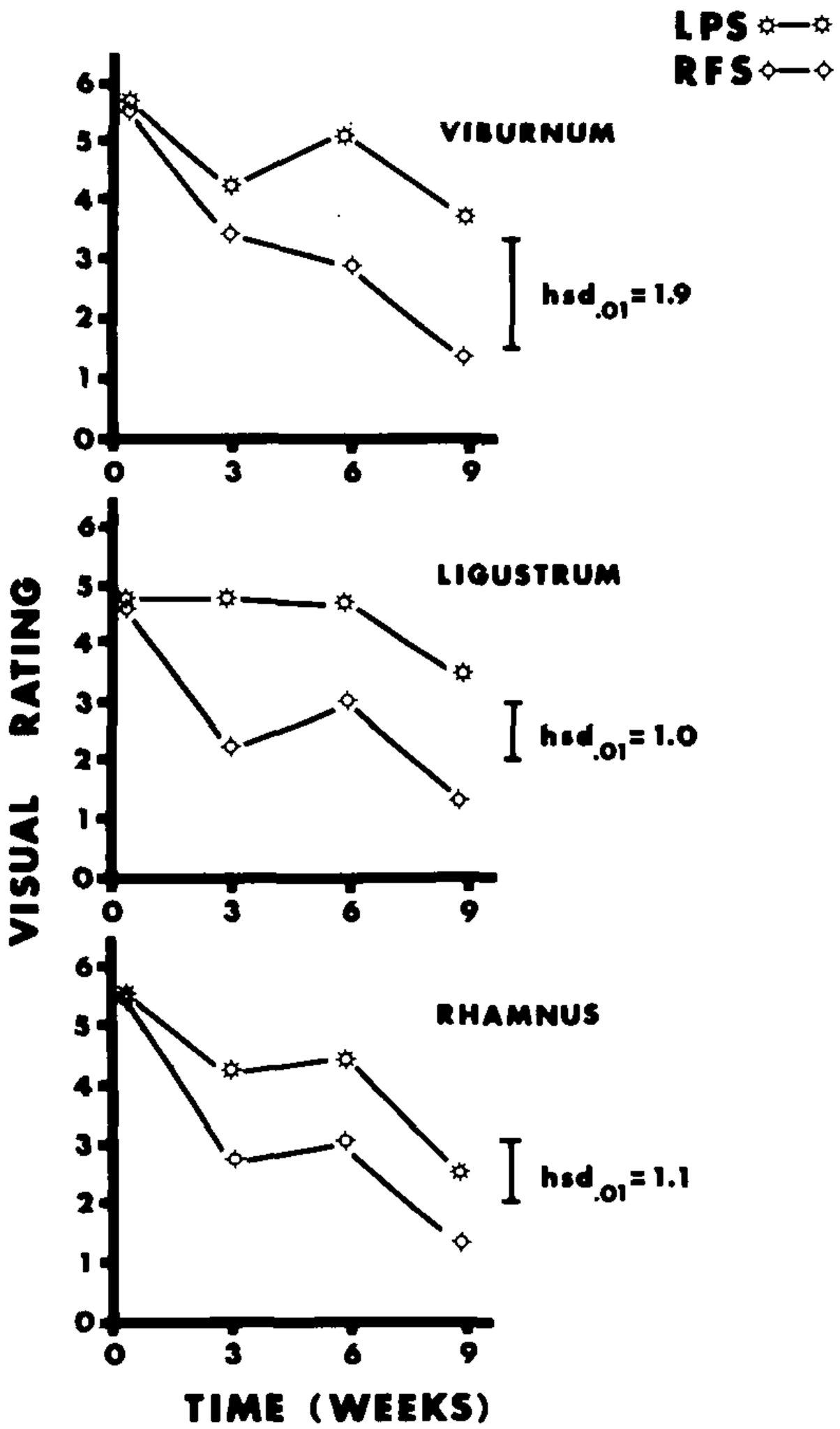


Figure 2. Visual evaluation of the foliage (See Figure 1) of unrooted *Viburnum*, *Ligustrum* and *Rhamnus* cuttings after 6 weeks in the propagation bed following 3, 6, or 9 weeks LP or RF storage.

Poinsettias. Unrooted poinsettia cuttings showed a significant treatment × week interaction regardless of the parameter measured. Only the 1 week LP storage cuttings were of acceptable quality at removal, 1 day and 7 days after removal (Figure 3). Unrooted cuttings from the 1 week RF storage treatment were of acceptable condition only at removal, but did not compare in quality with similar cuttings from LP. Cuttings from 3 week RF storage were totally deteriorated and were not placed in the mist bed for rooting. Though poinsettia cuttings stored

for 3 weeks in the LP chambers were of acceptable condition at removal, the tissue collapsed and was unacceptable 1 day after removal from storage.

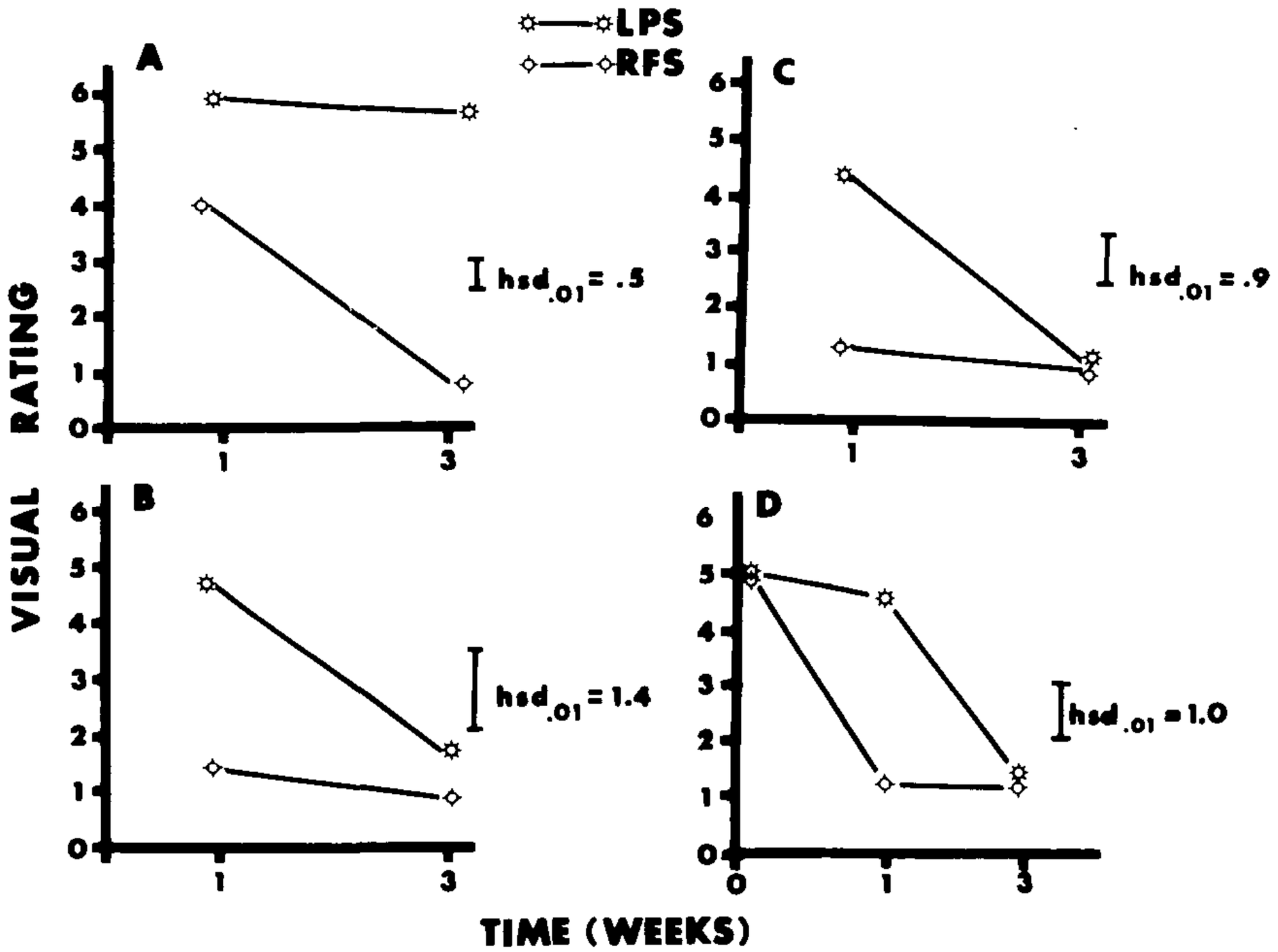


Figure 3. Visual evaluation of the foliage of unrooted poinsettia cuttings (See Figure 1) following 1 and 3 weeks LP or RF storage (A- at removal from storage, B- after 1 day in the propagation bed, C- after 7 days in the propagation bed, D- after 21 days in the propagation bed).

Unrooted poinsettia cuttings were placed in rooting media and evaluated after 21 days in the propagation bed. Again, root and shoot evaluations were similar and only data from shoots will be presented (Figure 3D). Cuttings from the 1 week LP treatment were comparable to control cuttings while all other cuttings from the RF storage treatment were completely deteriorated.

Rooted poinsettia cuttings exhibited a different trend than unrooted cuttings when they were removed from storage. At removal from storage, all treatments were in excellent condition and only those cuttings from the 3 week RF storage treatment showed gradual decline in quality upon evaluation 7 days after removal (Figure 4). Cuttings when evaluated 14 days after removal from storage, were all comparable to control cuttings except the 3 week RF storage treatment (Figure 4).

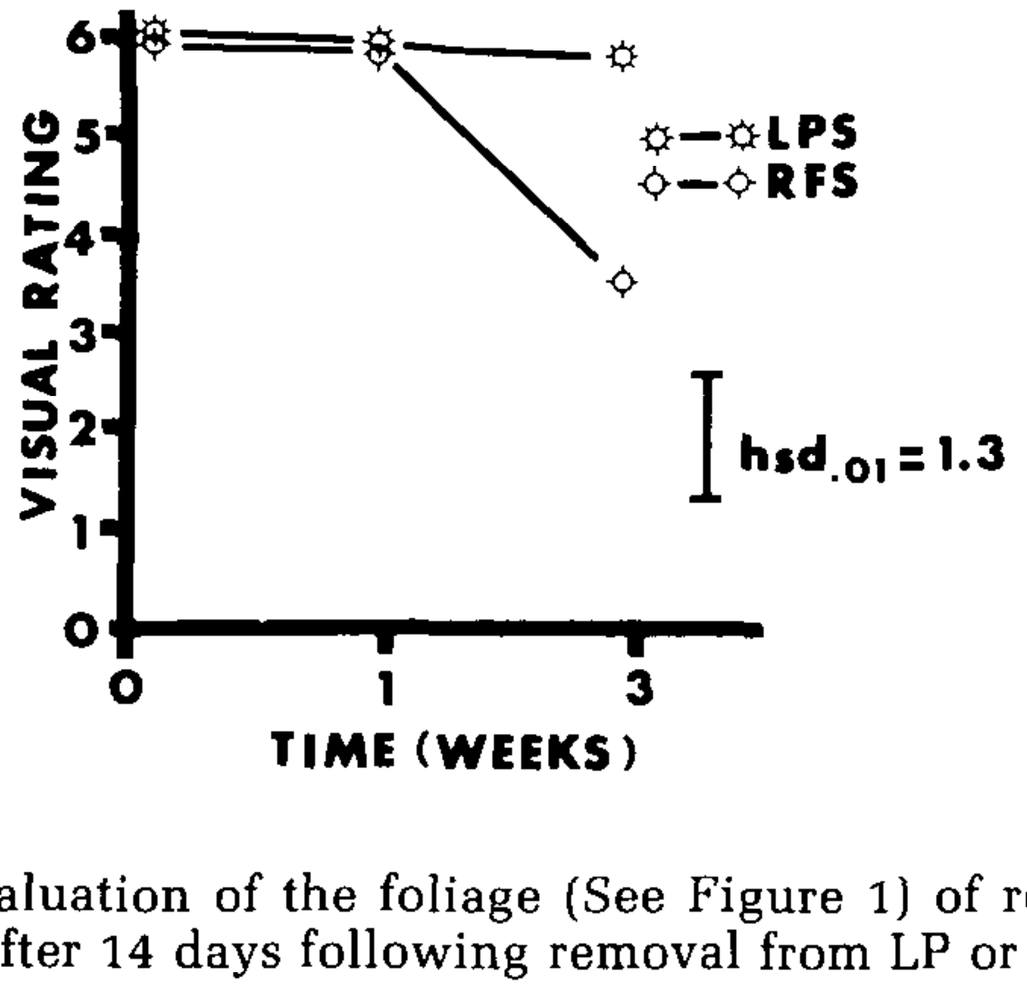
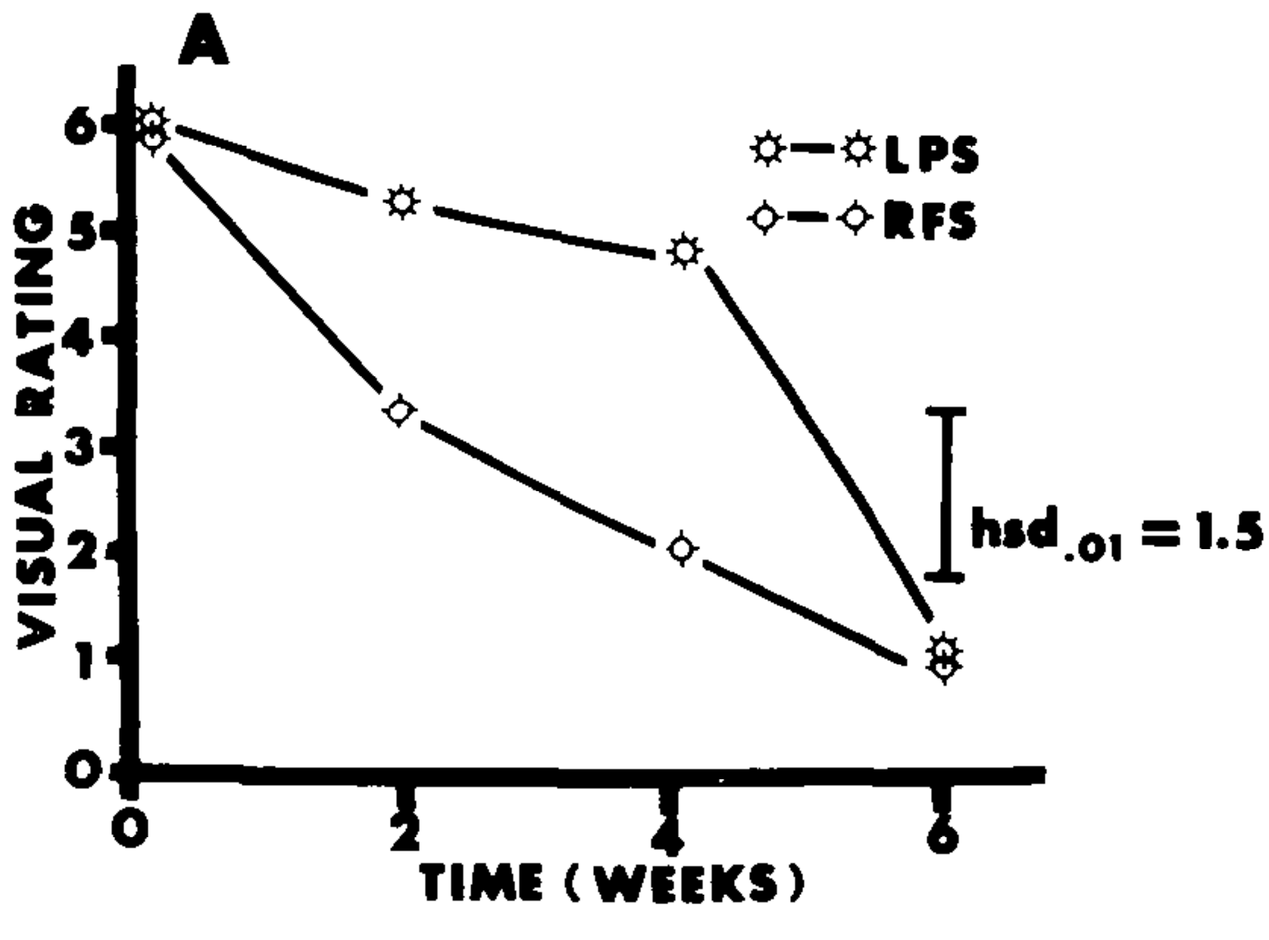


Figure 4. Visual evaluation of the foliage (See Figure 1) of rooted poinsettia cuttings after 14 days following removal from LP or RF storage.



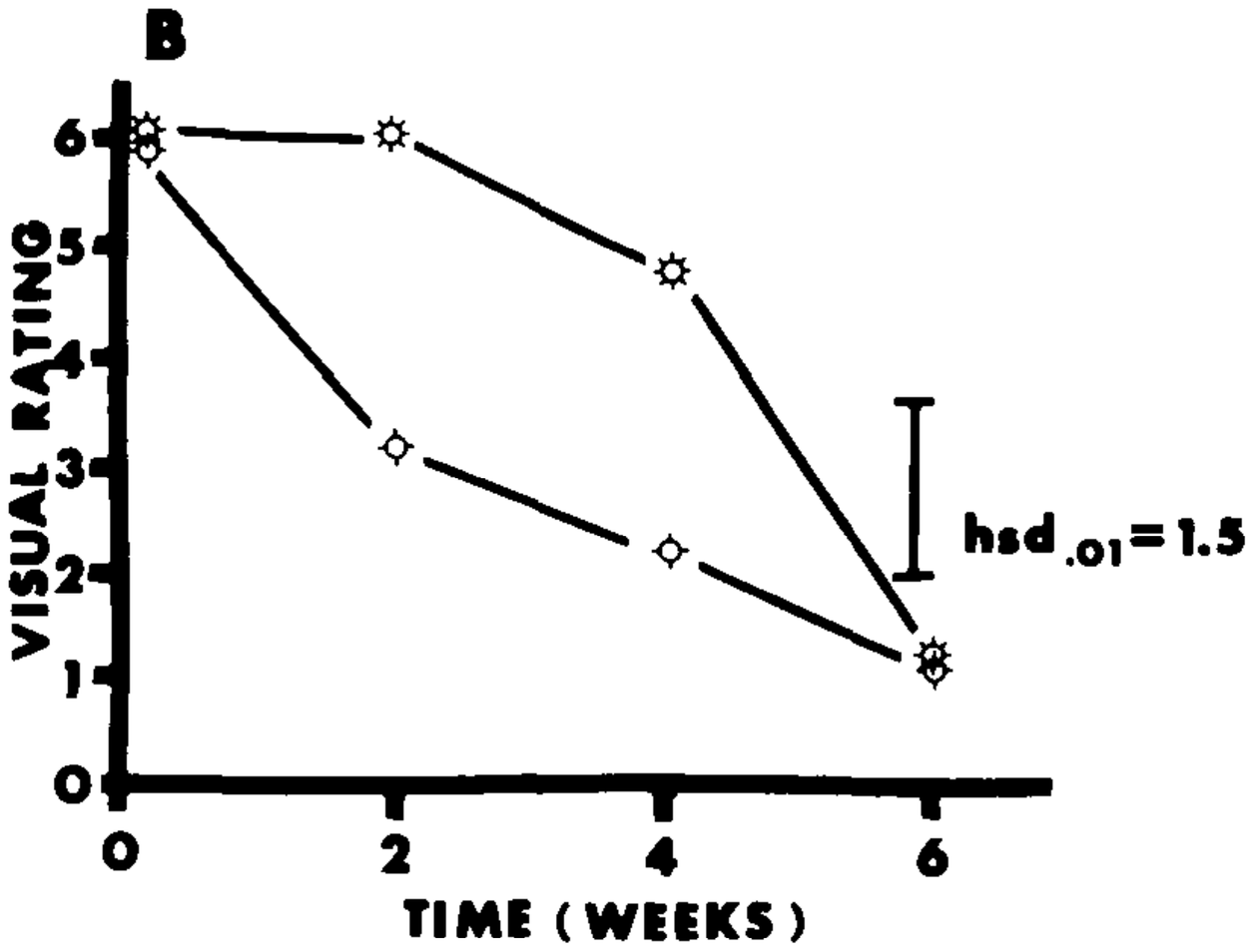


Figure 5. Visual evaluation of unrooted geranium cuttings after 26 days in the propagation bed following 2, 4, and 6 week LP or RF storage (A- foliage evaluation, see Figure 1, B- root evaluation, see text).

Figure 6. A comparison of unrooted geranium cuttings after 4-week LP or RF storage following 26 days in the propagation bed. (In the picture, CCS should be interpreted as RFS).

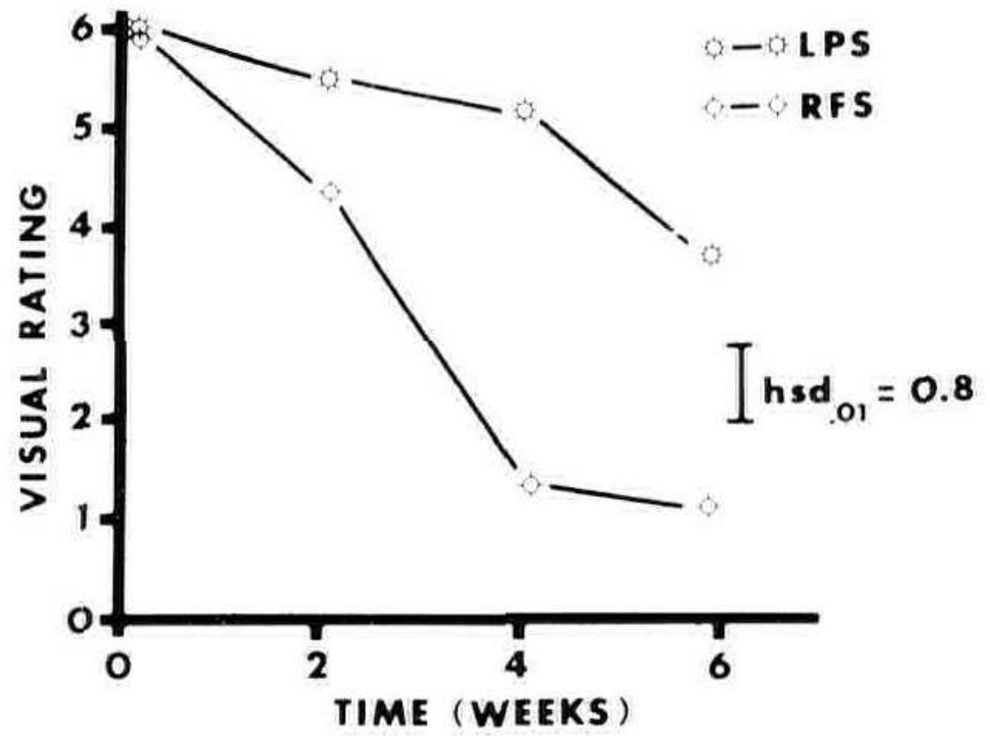


Figure 7. Visual evaluation of the foliage (See Figure 1) of rooted geranium cuttings after 14 days following removal from 2, 4, or 6 week LP or RF storage.

Geraniums. Upon removal from storage, unrooted geranium cuttings exhibited a significant treatment × week interaction. As the length of the storage period increased, the quality of the cuttings decreased (Figure 5), but reduction in plant quality occurred gradually with each progressive removal date from LP while similar cuttings from RF storage showed a more rapid decline in quality. In general, cuttings stored in LP for 2 or 4

weeks were of acceptable quality at removal while only the 2 week RF storage treatment were acceptable at removal.

When cuttings were evaluated after 26 days in the propagation bed, root and shoot evaluations were similar and thus only shoot evaluations will be presented (Figure 5). Cuttings from the 2 week LP or RF storage treatments were of acceptable quality, but only the cuttings from the 2 week LP treatment were comparable to control cuttings. As the storage period increased, only those cuttings from the 4 week LP treatments were of acceptable quality. Differences between the storage systems were evident after the 4 week treatment (Figure 6) with good foliage and root development on cuttings stored under LP.

Rooted geranium cuttings exhibited nearly identical patterns to those of unrooted geranium cuttings at removal from storage and when final evaluations were taken, rooted cuttings were in better condition than unrooted cuttings from the LP storage systems (Figure 7). Also, rooted cuttings from the 6 week LP storage were not completely deteriorated whereas unrooted cuttings from the LP treatment were.

DISCUSSION

Generally, storage of both rooted and unrooted materials in the LP system was superior to the storage of similar material in the RF system. The deterioration of stored unrooted cuttings as characterized by foliar chlorosis and/or necrosis, yellowing or loss of chlorophyll was found to be the limiting factor in our studies, as well as in other studies (4,17). Depletion of carbohydrates with high rates of respiration enhance foliar yellowing (20) and could be the limiting factor in our storage experiment. One of the principles of LP storage that extends the storage life of various crops is the ease in which the system reduces the partial pressures of the gases in the storage chamber (2,6). Since oxygen is one of the substrates for respiration, a low O_2 tension would lower the respiratory rate. Thus, if the respiration of a commodity is reduced, then carbohydrate levels would not decrease as rapidly and a better quality crop may result at removal from storage. This could be the factor which sustained LP stored cuttings for longer periods than those in RF storage in good condition.

Low temperatures will slow respiration (2,17) but our results indicated that lower temperatures alone were inadequate. In many experiments this was evidenced by the treatment × week interactions (Figure 5). Essentially these interactions indicated that if short term storage (2 weeks) were desired, either LP or RF storage would be adequate. However, if a longer stor-

age period were desired, then the LP storage system was clearly advantageous.

Ethylene causes leaf abscission, and/or yellowing of plant material that has been stored for extended periods (5,22). Another principle of LP storage that extends the storage life of crops is the rapid removal of ethylene and CO_2 from within the commodity and the storage atmosphere (2,6). Defoliation of Regel's privet and tallhedge buckthorn cuttings was observed when they were removed from RF and not from LP storage. Ethylene levels were not monitored, but Regel's privet and tallhedge buckthorn cuttings may be susceptible to ethylene damage.

Leaves are known to produce auxins and rooting cofactors as well as being a site of carbohydrate synthesis which interact to enhance rooting. Cuttings stored in the LP system consistently exhibited better root development when compared to RF storage (Figure 6), which can be correlated to greater leaf number at removal from storage.

Diseases play a role in limiting the storage of cuttings (16,22). Low pressure storage limits the growth of pathogens (25); however, low temperatures and the use of fungicides also reduce pathogen growth (16,22). With rooted and unrooted geranium and poinsettia cuttings, diseases were noted only on the material stored in the RF storage system, while material stored in the LP storage system appeared disease-free. Diseased tissue was not observed on the geranium cuttings until the plant material had been in storage for 4 weeks or more.

When poinsettia cuttings were stored, differences were noted in the length of successful storage achieved using rooted and unrooted cuttings (Figure 3 and 4). Storage of unrooted poinsettia cuttings was successful with LP for 1 week and for 3 days with RF storage (7), while rooted material could be successfully stored for 1 week with RF storage and for 3 weeks with the LP storage system. Possibly because poinsettia plants have thin, delicate leaves, they lose excess amounts of water after storage and unless roots are present this lost water cannot be fully replenished before dessication occurs.

The results presented here do not differ from previous LP work with cuttings (2,3). Storage times with LP were doubled when comparing LP to RF storage, thus indicating the possibilities of using a LP storage system for extending the storage of cuttings. However, controlled atmosphere storage using the same partial pressure achieved at LP were not used as controls in our first experiments. Since the writing of this manuscript, further research has been conducted using controlled atmospheric (CA) storage. It appears from our first experiments that

CA storage (1% O_2, 99% N_2) can extend the storage of unrooted geranium cutting for periods similar to LP storage. Controlled atmospheric storage with 5% and 10% O_2 extended the storage period when compared to RF storage, but did not equal storage periods achieved with 1% O_2 or LP (Unpublished data).

Mention must be made concerning some inconsistencies in our results with geranium cuttings. In some instances, the day following removal from storage, regardless of treatment, cuttings appeared wilted. The older leaves soon abscised while the newer leaves recovered. Cuttings from LP and CA chambers recovered sooner than cuttings in RF storage.

The factors involved with this problem are unknown at present, but it is highly probable that the condition of the material at time of entry into storage had a major influence on its condition at the completion of the storage period. Since cuttings for a great many of our experiments came from greenhouses where plants were being forced, high nutrient levels leading to excessive succulence may have been one of the factors. Research in this area will give us a better understanding of the factors involved in the proper storage of rooted and unrooted cuttings.

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Friday Morning, December 1, 1978

NEW PLANT FORUM

Alfred Fordham served as moderator.

MODERATOR FORDHAM: Our first speaker on this portion of the program will be Tom McCloud who has four plants which he would like to discuss.

TOM McCLOUD: The four plants I would like to tell you