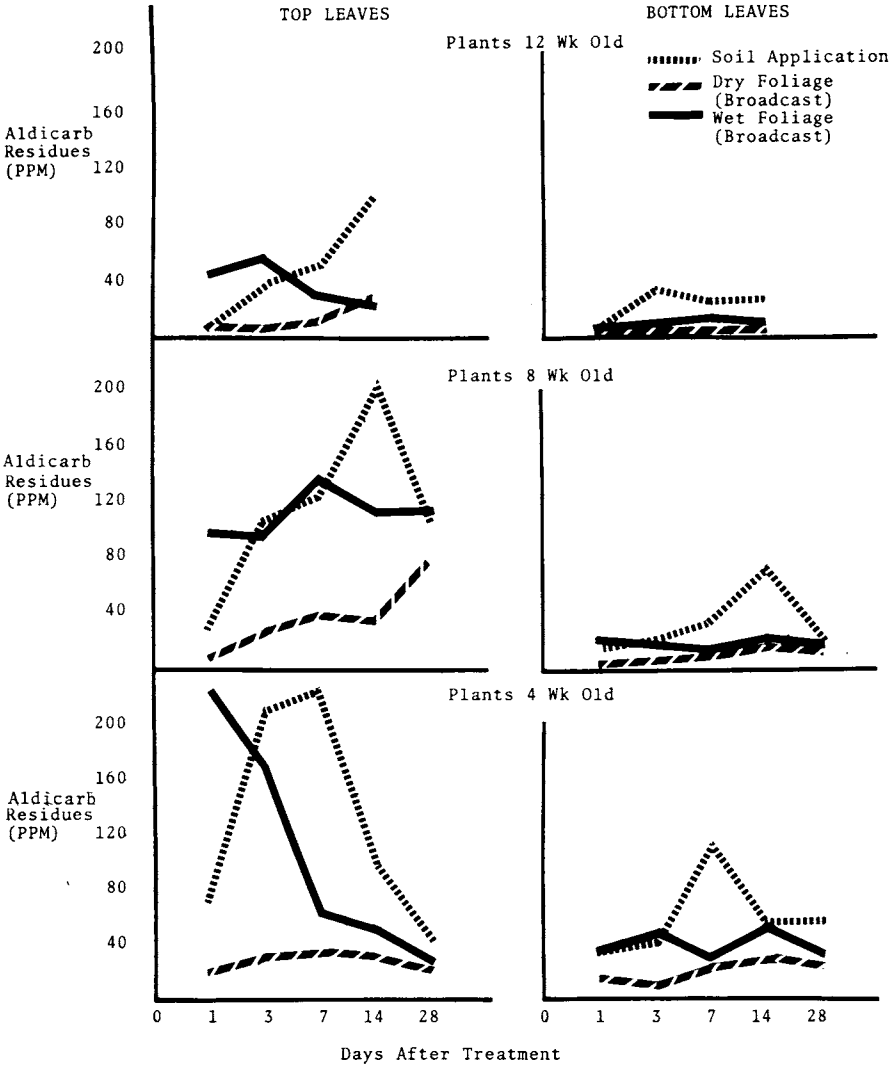

Fig. 1. Residues of aldicarb and its toxic metabolites in chrysanthemum leaves from plants 4, 8, and 12 weeks old when treated using different application methods.

Samples for residue analysis were taken 1, 3, 7, 14, and 28 days after treatment (except from plants in flower on July 18). At each sampling date, 10 plants were selected from each maturity and application method group. Upper leaves, lower leaves, buds and flowers (if present) were removed and frozen at −15°C until analyzed. Aldicarb granules adhering to foliage were shaken off before placing leaves in sample bags. Flowers present on oldest plants receiving the foliar broadcast treatments were not sampled for residue analysis, because granules could not be easily removed. The analytical procedure was the same as described by Lindquist et al. (2).

When foliage residues were plotted (Fig. 1), we concluded the following: 1) Plants 12 weeks old when treated had lower aldicarb residues with all application methods (except for soil broadcast applications to 4-week old plants 14 days posttreatment); 2) Upper leaves had highest residues with all application methods and plant age groups; 3) Broadcast applications to dry foliage resulted in lowest residues; 4) Residues in top leaves from broadcast applications to wet foliage were initially higher than from soil broadcast applications in plants of all ages, but residues from soil applications eventually reached or exceeded those levels. These results were generally corroborated by those from the buds and flowers of the plants treated at 8 weeks (Table 1).

Table 1. Aldicarb residues in buds and flowers of chrysanthemums after different methods of application.

Days after treatment[z]	Residues (ppm) resulting from indicated application method		
	Soil[y]	Dry foliage[x] (broadcast)	Wet foliage[x] (broadcast)
1	3.5	3	25
3	22.5	7	47.5
7	37.5	8.5	47.5
14	35.5	6	25
28	4	1.8	2.2

[z]Plants approximately 8 weeks old when treated.
[y]Treated at 0.1 gm aldicarb/10 cm diam pot.
[x]28 gm aldicarb/2.25 m^2.

These data show that relatively rapid dissipation of aldicarb residues resulting from broadcast applications to wet foliage, especially on the youngest plants, may allow more rapid reinfestation by a migrant insect or mite population and may require more frequent applications than if granules were applied on the soil. Also, residues resulting from applications to mature plants may not reach levels toxic enough to control insect and mite pests of chrysanthemum.

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Bud Opening of Chrysanthemums after Long Term Storage[1]

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Abstract. **Buds of standard chrysanthemums (*Chrysanthemum morifolium* Ramat cvs. Albatross and Fred Shoesmith) from 5 to 12 cm in diameter were cut with 60 cm stems and stored at low temperatures (−0.5 to 1.5°C) for up to 5 weeks. Flower buds were opened in sucrose solutions containing 25 ppm silver nitrate and 75 ppm citric acid. Small size buds developed flat heads when stored over 2 weeks; the disc florets failed to develop fully. Leaves which are normally free of necrosis when opened in sugar solutions developed desiccation injury after long storage. The flat shape of the inflorescence can be prevented by storing large buds (10-12 cm); however, botrytis becomes a major problem on the exposed ray florets.**

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Standard chrysanthemums can be opened in sugar solutions from the bud stage with no loss of quality (3, 4, 5). The value of bud opening has been reported as: saving space during shipment (1); harvesting the crop at one time and opening the immature flowers in sugar solutions (2); opening cut buds under controlled conditions to obtain better quality during periods of low light in the greenhouse (3); and conserving space in the storage of flowers (5). The authors have found that chrysanthemum buds stored longer than two weeks resulted in the reduction of flower quality. The inflorescence may become flattened developing small tufts of florets protruding in the center (Fig. 1). Sometimes the inflorescence is round but florets on the periphery may become distorted giving a ragged appearance. Many experiments were conducted to find ways to reduce the poor quality resulting from storing buds more than two weeks.

The general handling of the cut stems prior to storage were as follows: flower buds of various stages (Fig. 2, 3) were harvested with 60 cm stems, leaves on the lower third of the stems were removed, and stems with buds were placed into polyethylene bags made water vapor tight with tape. This was done as soon as possible to avoid foliage wilting. The bags with the stems were placed upright in air tight drums which were insulated to prevent temperature fluctuations during the cycling of the refrigerator. The temperatures inside the drums were maintained between −0.5 to 1.5°C.

'Albatross' flowers were grown in our Davis greenhouse in containers and were harvested in the appropriate bud stage as needed. After storage, buds were opened in sugar solutions also containing 25 ppm $AgNO_3$ (Ag) and 75 ppm citric acid (CA). The sugar concn varied with the experiment. Room conditions for bud opening were: 21°C, 35-55% relative humidity, and 1080 lux from fluorescent lamps for 24 hr at bud height.

In a preliminary experiment using 'Albatross' or 'Fred Shoesmith', some cut stems with buds were pretreated for 4 hr prior to cold storage with sugar solutions containing either 200 ppm 8-hydroxyquinoline citrate or the Ag plus CA mentioned above. Stems so treated developed excessive botrytis rot in the buds and the leaves were severely injured during storage. Reducing the water content of the leaves by 5 or 10% by slowly wilting them prior to a 2 week storage resulted in delayed bud opening and reduced inflorescence size.

Subsequent experiments were limited to storing buds for given periods and later opening them in various sucrose concentrations. In all cases stems were recut before placing them in the bud opening solution. Bud sizes used were: stage 2 = 5 cm, stage 3 = 9 cm and stage 4 = 12 cm diam, (Fig. 2, 3).

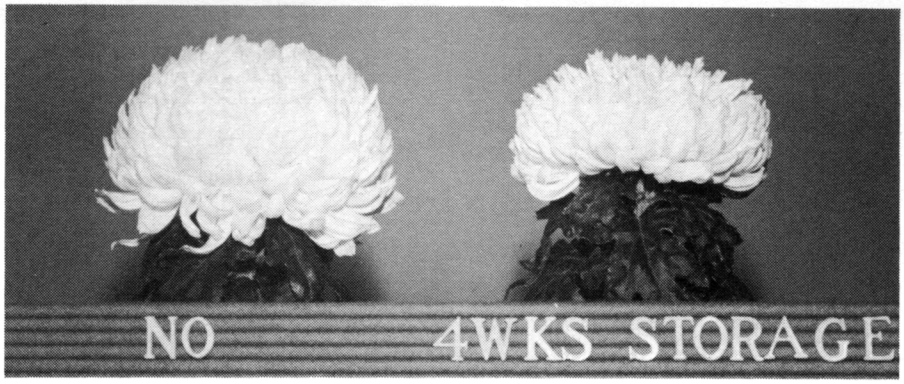

Fig. 1. Side view of fully open 'Albatross' flowers opened from Stage 3 bud with (right) and without storage (left). Note the flatness and the shagginess of the central florets on the inflorescence which developed from a stored bud (right). The unstored bud developed into a normal globular shaped flower.

Fig. 2. Three developmental stages of 'Albatross' buds used for opening. The lower facing buds were taped to the stem to illustrate a top view of the typical stages.

Stage 2 sizes were stored up to 4 weeks and stage 3 buds were stored up to 5 weeks (Table 1). When buds of either stage were not stored (controls) and opened in solution immediately after harvest, they developed into perfect flowers and had the greatest longevity. Buds were removed from the opening solutions upon reaching maximum size and placed in deionized water for subsequent longevity observations. With longer periods of storage, distortion of inflorescences and florets was greater and longevity was reduced over the controls, however, these differences were most pronounced for the small bud sizes (Table 1). Stage 2 buds stored 3 or 4 weeks developed very poor quality inflorescences because of floret distortion. On the other hand, stage 3 stored 3 weeks developed into very good quality flowers. Inflorescence shape ratings were made by viewing the entire inflorescence from the side. If the inflorescence was globular, the numerical rating was 0 and as it became flatter the numerical rating increased to a maximum of 3. If the central florets were small, the inflorescence had a flat appearance (Fig. 1). When dissecting mature inflorescences with "flat tops," it was found that the central florets had failed to develop completely. Some of those central florets were discolored brown after long storage periods. This occurred more readily with stage 2 than with stage 3 buds. These central florets of stage 2 buds were at such an

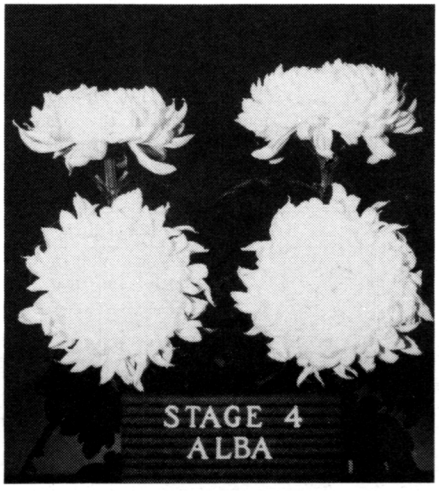

Fig. 3. Four samples of stage 4 buds used for 3 weeks cold storage. The average diam is 12 cm; buds weigh about 24 g.

immature stage that they were either injured either by the prolonged cold or by desiccation during storage. If these central florets failed to develop properly as shown on the right in Fig. 4, the center appears open from the top and flat from the side. The left flower of Fig. 4 has normal size central florets which curve inwardly.

Floret shape ratings were made on the lower peripheral florets (most mature) of the inflorescences. If they were twisted and distorted compared to their normal incurved ones, they were numerically rated according to the degree of distortion. Table 1 shows a significant floret distortion with increasing storage time. Two or more weeks storage of stage 2 resulted in a ragged irregular appearance rather than a normal uniform, incurved inflorescence shape; however, storing stage 3 up to 3 weeks did not impair floret or inflorescence shape (Table 1).

In a study later in the year 3 weeks storage of stage 3 buds resulted in distorted inflorescences; the opening of stage 4 buds essentially exhibited the same quality as unstored stage 3 flowers (Table 2). The final fresh wt of nonstored vs. stored buds did not differ significantly. When stage 4 was stored the central florets were almost fully developed at the time they were placed in storage and their subsequent development was not affected by the cold storage as were the central florets of stage 3 buds.

There is some advantage of storing stage 4 over fully developed flowers since their fresh wt as buds are only about one half that of mature blooms (24 vs. 51 g., respectively).

An attempt was made to find if sucrose concn higher than 3% could be used to enhance opening after storage. Flower quality followed the same patterns as in Table 1 for the various storage periods of stage 3 buds. However, foliar damage is caused by increasing length of storage or sugar concn used for subsequent opening (Table 3). Leaf injury as judged by the degree of marginal necrosis was rated on each leaf and averaged (3). Leaf damage was slight with freshly opened buds or those stored one week but injury approached the moderate rating after 2 weeks storage. Although sugar concn higher than 3% are not required for successful bud opening of 'Albatross' (3, 4), it is interesting to note that the leaf necrosis was manifest by higher sucrose concn than 3% for any storage period.

We conclude that the long term storage of 'Albatross' buds may have limited use if one adheres strictly to the high quality standards of achieving incurved globular flowers having a moderate longevity of 2 weeks. If flat inflorescences are tolerated, one can store buds up to 3 weeks (stage 3) without serious leaf or floret injury. Stage 4 buds are more difficult to pack in storage containers than smaller buds because of the many open peripheral florets (Fig. 4); however, there is a slight advantage over storing fully open blooms. To obtain high quality blooms comparable to fresh flowers, storage is not recommended beyond 3 weeks with stage 4 buds and no longer than 2 weeks with stage 3 buds. Stage 2 buds should not be stored because they are too immature. Bud opening with sucrose concn higher than 3% when used in combination with long term bud storage is not recommended because of resulting leaf damage.

Table 1. The influence of low temp bud storage on the longevity, inflorescence flower size and shape of 'Albatross' chrysanthemum. Buds were harvested in July and stored dry at −0.5 to 1.5°C. Buds were removed after the storage period and opened in a 2.5% sugar solution containing 25 ppm Ag No_3 and 75 ppm citric acid.

	Inflorescence measurements				
Weeks stored	Longevity (days)	Diam (cm)	Fresh wt (g)	Shape[z]	Floret shape[z]
		Stage 2			
0	17.0	14.8	49.2	0	0
2	13.5	13.8	42.4	0.5	1.8
3	12.3	14.1	43.1	0.5	3.0
4	9.0	13.5	36.6	2.5	2.5
LSD 5%	3.8	1.0	10.1	1.3	1.2
		Stage 3			
0	18.3	15.1	48.2	0	0
2	14.8	13.9	44.1	0.5	1.0
3	14.0	13.9	51.8	0.3	0.5
4	10.0	13.5	47.7	0.8	2.3
5	6.0	13.4	47.3	1.3	2.3
LSD 5%	2.4	1.1	N.S.	N.S.	1.2

[z]Ratings: 0 = excellent, 1 = good, 2 = fair, 3 = poor.

Table 2. The influence of low temp bud storage and stage of development on 'Albatross' inflorescence size and shape. Buds were harvested in early Oct. and stored at −0.5 to 1.5°C. After removal from storage the buds were opened in 3% sucrose solution. Stage 4 buds were 12 cm and the fresh wt was 24 g; stage 3 buds were 9 cm in diam.

		Inflorescence measurements			
Weeks stored	Bud stage	Diam (cm)	Fresh wt (g)	Shape[z]	Floret shape[z]
0	3	14.4	54.1	0	0
3	4	13.2	50.8	0	0
3	3	13.6	50.5	2.2	1.7
LSD 5%		N.S.	N.S.	1.0	1.4

[z]Ratings: 0 = excellent, 1 = good, 2 = fair, 3 = poor.

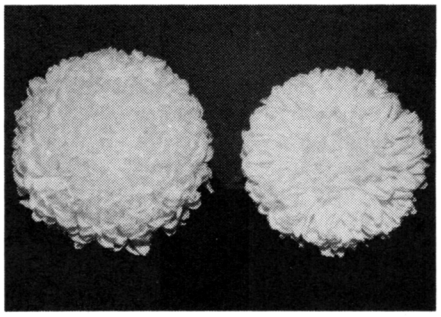

Fig. 4. Top view of fully developed 'Albatross' inflorescences. The normal incurved florets resulting from unstored buds (left); the open center and distorted florets resulting from 3 weeks storage of stage 3 buds (right).

Table 3. The influence of low temp bud storage and sugar concn in the opening solutions on the degree of marginal leaf necrosis. 'Albatross' buds, stage 3, were harvested in August.

	Leaf injury rating[z]		
	Sucrose concn in opening solution		
Weeks stored	3%	4%	5%
0	0	4	4
1	0	1	4
2	9	14	14
3	13	21	28
4	21	21	28
LSD 5% = 2.8			

[z]Ratings: 0 = none, 10 = slight, 20 = moderate, 30 = severe.

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