EFFECT OF FLORAL BUD REDUCTION ON INDIVIDUAL FLOWER LONGEVITY IN ASIATIC HYBRID LILIES

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Abstract

Floral bud abortion was found to be an undesirable source of non-genetic variation in breeding trials directed on the improvement of individual flower longevity in Asiatic hybrid lilies. It increased the longevity of the remaining flowers of the inflorescence. A similar response was found after elimination of developing terminal flower buds by hand, which significantly increased the longevity of the remaining flowers in inflorescences of eight of the eleven Asiatic hybrid lilies studied. The response to bud reduction was independent of the original flower longevity, so ranking of the cultivars based on longevity values will change due to bud abortion and selection results will be disturbed. Preharvest and postharvest influences of bud removal on flower longevity were distinguished by comparing longevities of undetached and detached flowers within four cultivars. Our data suggest that the increase in flower longevity of the remaining flowers after bud removal was mainly attributed to a decrease in sink strength within the harvested inflorescence. In two of the four cultivars tested the increase in flower longevity was partly caused during cultivation and was accompanied by an increase in methanol soluble sugar content in the flower petals at harvest. Bud opening and flower longevity were not significantly influenced by defoliation after harvest, indicating that within lily inflorescences translocation of metabolites mainly takes place between developing flower buds. Flower longevity and carbohydrate content in open flowers at harvest did not correspond between the two cultivars studied probably due to differences in developmental stage of the other flower buds of the inflorescence and, therefore, sink strength.

1. Introduction

In preliminary breeding studies on individual flower longevity in cut lily inflorescences bud abortion was found to introduce undesirable non-genetic variation within genotypes because it increased the longevity of the remaining flowers of the inflorescence. Development of the flowers is acropetal, whereas abortion generally occurs in basipetal order. Removal of small flower buds by hand reportedly influenced partitioning of dry matter among organs in lily (Wang and Breen, 1986ab) and other bulbous species (De Hertogh et al., 1983; Kalin, 1954); whereas bud abortion increased corm weight in Gladiolus (Shillo and Halevy, 1976). Therefore, flower bud abortion might influence flower longevity by its effect on dry matter partitioning.

Asiatic hybrid lilies have two major carbon sinks namely the bulb and the inflorescence. Influence of bud removal on bulb size has been object of many studies (e.g. Wang and Breen 1986ab) but, to our knowledge, information about the influence of bud removal on flower longevity is lacking. Lily flower buds have a high sink strength and assimilate consumption shows a peak near anthesis (Wang and Breen, 1984; Wang and Breen, 1986b). Because the inflorescence of Asiatic hybrid lilies contains several flowers at different stages of development longevity might be affected by sink alteration upon flower bud reduction during cultivation.

The objectives of this study were to investigate the influence of bud removal on flower longevity of various cultivars, and to examine interactions related to individual flower longevity within lily plants.

2. Material and methods

Bulbs of Asiatic lily hybrids (Lilium L.) were obtained from commercial growers in The Netherlands and from the CPRO-DLO lily collection. The choice of the cultivars was based on differences in individual flower longevity. The bulbs were stored in soil at approximately -2°C air temperature until used. Bulb circumferences varied between 12 and 16 cm. Standard conditions were used during the preharvest, harvest, and postharvest stages (Van der Meulen-Muisers et al., 1992). Lily flowers were cultivated in a growth chamber (17°C, 60% relative humidity [RH], 24 W/m^2 using high pressure metal halide lamps [HPI-T 400W, Philips] for 16 h/day). Lily inflorescences were harvested at anthesis of the most mature floral bud. Bud length at harvest was measured. Cut inflorescences were placed in tap water without additives in a climate room (17°C, 60% RH, 3 W/m^2 using fluorescent lamps [TL-D84 36W, Philips] for 12 h/day). Each flower was observed individually and daily at fixed hours. Flower longevity was measured as the time between bud anthesis and wilting of the individual flower.

To determine the effect of floral bud removal on flower longevity eleven Asiatic hybrid lilies ('Bright Beauty' [BB], 'Crete' [CR], 'Dreamland' [DR], 'Enchantment' [EN], 'Fuego' [FU], 'Jolanda' [JO], 'Ladykiller' [LA], 'Monte Negro' [MN], 'Orange Mountain' [OM], 'Red Night' [RN] and 'Sirocco' [SI]) were used. Inflorescences with an equal number of floral buds were selected per cultivar before elongation (most mature bud per inflorescence < 30 mm) and the least developed floral buds were removed. Three classes of plants were composed by removing about one third or two third of the original number of buds per inflorescence, while intact inflorescences were used as a control. Individual flower longevity was calculated per stem. Data of 5 inflorescences per treatment combination were used for statistical analyses.

To study interactions within lily plants related to flower longevity four Asiatic hybrid lilies were tested. Inflorescences with 7 (FU) or 8 (MN, RN, SI) buds were selected. Three classes of plants were composed by bud removal as mentioned above (FU: 1, 4, 7 buds; MN, RN, SI: 2, 5, 8 buds). Interactions within the lily stem before and after harvest were studied by comparing longevities of detached and undetached flowers and by determining the influence of defoliation after harvest on flower longevity. Flowers of all three classes of bud numbers were detached immediately after harvest and were individually placed on tap water, undetached flowers were used as a control. Stems of intact inflorescences were defoliated immediately after harvest to determine the influence of the leaves on flower longevity. Per treatment combination individual flower longevity data of the open flowers at harvest of 5 inflorescences were used for statistical analyses.

Petals of flowers of RN and SI obtained from stems containing 2, 5 or 8 buds were used for carbohydrate analyses. Sugars were extracted from lyophilized petal tissue (30 mg dry weight) of open flowers at harvest using hot 80% methanol for 20 min (2x). Chloroform was used to remove the pigments from the extract. The extracted carbohydrates were separated and quantified by high performance liquid chromatography (HPLC) using a Sugarpak tm I column (Waters), with water as a solvent and a refractive index detector. Enzymatic determination of starch was carried out by glucose determination after amyloglucosidase digestion of the extract in pH 4.6 citrate buffer for 15 min at 55-60°C. Enzymes were supplied by Boehringer Mannheim. Samples of three different flowers were examined per treatment combination.

Completely randomized designs were used. Treatment means were compared using the Students t-test.

3. Results

For eight of the eleven cultivars tested flower longevity significantly ($\underline{P}<0.05$) increased with an increase in the percentage buds removed per stem (Fig.1). Only in 'Bright Beauty', 'Crete' and 'Dreamland' no significant differences between treatment means were found although a similar tendency was visible. For seven cultivars the increase in flower longevity was significant upon removal of about one third of the original number of buds. In 'Ladykiller' and 'Monte Negro' a second significant ($\underline{P}<0.05$) increase in flower longevity was found upon removal of about two third of the buds. Longevity of flowers of 'Orange Mountain' only increased significantly after removal of about two third of the original number of buds.

Bud length at harvest hardly varied between treatments (e.g. 'Sirocco', Fig.2). Only in 'Bright Beauty' and 'Orange Mountain' and to a lesser extent in 'Crete' and 'Dreamland' bud growth increased during cultivation with an increase in number of buds removed. In 'Orange Mountain' the largest effect of bud removal on bud growth was found upon removal of about one third of the original number of buds (Fig.2).

In control plants (7, 8 buds) of 'Fuego', 'Monte Negro', 'Red Night' and 'Sirocco' longevity increased in detached flowers compared to undetached flowers (Fig.3). The extent of this increase depended on the cultivar and varied from 0.5 days in 'Sirocco' to 1.8 days in 'Fuego'. As mentioned before flower longevity of those four cultivars increased in undetached flowers with the number of buds removed per stem. This increase varied from 0.5 days within 'Monte Negro' to 2.1 days within 'Red Night' (Fig.3). In detached flowers longevity only increased with bud removal within 'Red Night' and 'Sirocco', 1.3 and 0.8 days, respectively (Fig.3).

In the initial time period after harvest the increase in number of open flowers in intact inflorescences of 'Fuego', 'Monte Negro' and 'Sirocco' fell behind compared to the number of open flowers in inflorescences of 'Red Night' indicating differences in developmental stage of the buds between cultivars at harvest (Fig.4).

Elimination of developing terminal flower buds during cultivation significantly ($P<0.05$) increased the proportion of methanol soluble sugars (sucrose, glucose and fructose) in petal tissue of open flowers at harvest in both 'Red Night' and 'Sirocco' (Fig.5). The ratio of the three sugars stayed unchanged both within and between cultivars. Petal sugar content was the highest in 'Sirocco' independently of the number of buds per stem. After opening of the flowers starch content was less than one percent of the petal dry weight in both cultivars (data not shown).

Defoliation after harvest did not significantly influence individual flower longevity of undetached flowers compared to flowers of control plants (Fig.6). The largest effect of defoliation on flower longevity (0.3 days) was found in both 'Fuego' and 'Red Night', a decrease and an increase, respectively. No influence of defoliation on the percentage flowering buds was found. Just like in inflorescences without defoliation all buds developed into flowers (data not shown).

4. Discussion

Elimination of developing terminal flower buds by hand generally increased the longevity of the remaining flowers in inflorescences of Asiatic hybrid lilies (Fig.1) as found before in preliminary studies for inflorescences showing bud abortion. Most cultivars tested already showed a significant increase after removal of a relatively small number of buds (up to 4) comparable with the number we usually found in case of abortion. The response to bud reduction appeared to be independent of the original flower longevity, so ranking of the cultivars based on longevity values will change due to bud abortion. Inflorescences showing bud abortion will, therefore, disturb selection results on individual flower longevity because they will cause an overestimation of this longevity, especially if selection takes place at individual plant level as in the case of seedlings. Therefore, lily inflorescences with floral bud abortion should be excluded from breeding trials directed on the improvement of individual flower longevity.

Because developing lily flower buds have a high sink strength (Wang and Breen, 1984; Wang and Breen, 1986b) competition for assimilates between the bulb and inflorescence can be expected during cultivation (Wang and Roberts, 1983; Wang and Breen, 1986ab). Although sink strength of the inflorescence was reduced by removal of part of the buds most cultivars showed an increase in flower longevity of the remaining buds (Fig.1) while in some cultivars also bud length increased (Fig.2). Therefore, reduction of sink strength within the inflorescence by bud removal appears not to be fully in favour of the bulb in this stage of development. The remaining sinks in the inflorescence are compensating this reduction. The period from bud removal to harvest at anthesis of the most mature floral bud, took about three weeks under standardized conditions in the lily cultivars tested. During these three weeks of cultivation in some of the cultivars growth of the remaining buds improved, possibly indicating a change in carbon partitioning within the inflorescence. In 'Orange Mountain' no significant increase in flower longevity was found upon removal of one third of the buds (Fig.1), whereas the effect of this treatment on bud length was relatively large (Fig.2).

Although in most cultivars flower longevity increased after bud reduction longevity could have been influenced both during cultivation and after harvest. Preharvest and postharvest influences of bud removal on flower longevity were distinguished by comparing longevities of undetached and detached flowers upon harvest of the inflorescence. In all four cultivars tested longevity values increased in detached flowers obtained from intact inflorescences compared to undetached flowers. In 'Fuego' and 'Monte Negro' no significant differences were found between treatments comparing longevities of flowers which were detached from the inflorescence upon harvest (Fig.3). So, these data suggest that in 'Fuego' and 'Monte Negro' the increase in longevity of undetached flowers upon bud removal is totally attributed to factors after harvest. In 'Red Night' and 'Sirocco' longevities of flowers which were detached from the inflorescence upon harvest differed between treatments (Fig.3), these differences must have been caused during cultivation. In all four cultivars tested differences between longevity values of detached and undetached flowers after harvest of the inflorescence increased with an increasing number of buds still present. Therefore, the beneficial influence of bud removal during cultivation on flower longevity is mainly due to a decrease in sink strength within the lily inflorescence after harvest, but can be preceded by a beneficial effect during cultivation probably due to a change in carbon partitioning depending on the cultivar.

Data on petal sugar status in 'Red Night' and 'Sirocco' indicated that reduction of potential sinks during cultivation can be beneficial for the translocation of carbohydrates to the remaining buds prior to harvest. In flower petals of 'Red Night' and 'Sirocco' both sugar content and flower longevity increased with an increase in the number of buds removed (Fig.5). Petal starch is supposed to play a role in opening of flowers of bulbous crops because it is often exhausted at the early stage of the unfolding process (Ferreira et al., 1986; Yamane et al., 1991). This could explain the low starch content we found in lily petals at anthesis.

Assimilate consumption of lily flower buds peaks near anthesis (Wang and Breen, 1984; Wang and Breen, 1986b). Therefore, after harvest large sink activities can be expected within lily inflorescences which contain several flower buds at different stages of development. However, the available amount of carbohydrates is limited. Leaves did not seem to contribute much to the metabolite supply necessary to maintain flower longevity after harvest (Fig.6). These results suggest that translocation of carbohydrates within cut lily inflorescences mainly takes place between developing flower buds.

Although there seems to be a positive correlation between petal sugar content (Fig.5) and flower longevity (Fig.3) within cultivars, both parameters do not correspond between cultivars. This could be due to differences in sink strength within inflorescences which can be expected between inflorescences of 'Red Night' and 'Sirocco' because of the differences in opening pattern of the flowers (Fig.4). The number of open flowers in 'Red Night' sharply peaked within 4 days after harvest whereas flower opening in 'Sirocco' maintained at a constant low level from 4 up to 11 days after harvest. These results indicate that part of the flower buds within inflorescences of 'Red Night' are further in their development at harvest compared to flower buds within inflorescences of 'Sirocco'. Therefore, in 'Sirocco' a larger part of the carbohydrates available in open flowers might be necessary for the development of the less matured buds than in case of 'Red Night'.

Further research into carbohydrate status of buds and flowers is necessary for a better understanding of the relationship between carbohydrates and flower longevity of lily genotypes. The possible use of carbohydrates as markers for indirect selection for flower longevity is under investigation.

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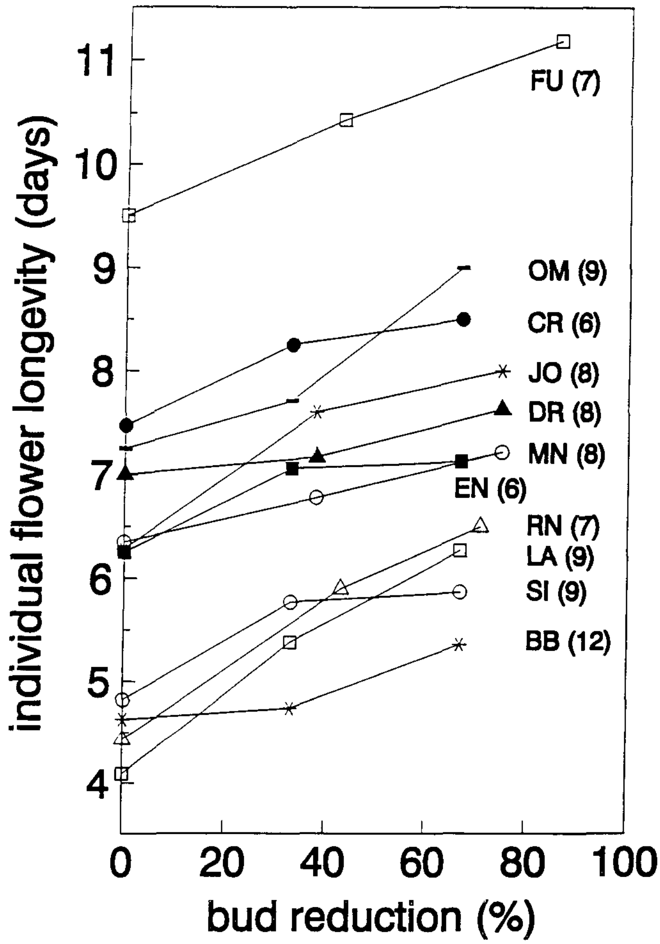

Figure 1 - The effect of bud reduction during cultivation on flower longevity within eleven Asiatic hybrid lilies; original number of floral buds per inflorescence is given between parentheses; for explanation of the abbreviations see material and methods.

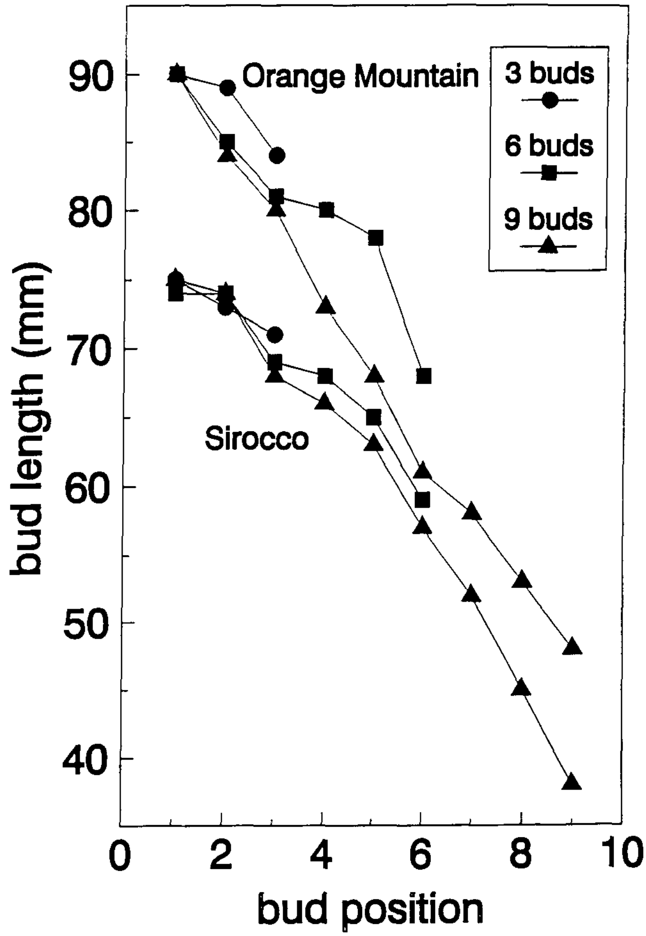

Figure 2 - The effect of bud reduction during cultivation on bud length at harvest within 'Orange Mountain' and 'Sirocco'.

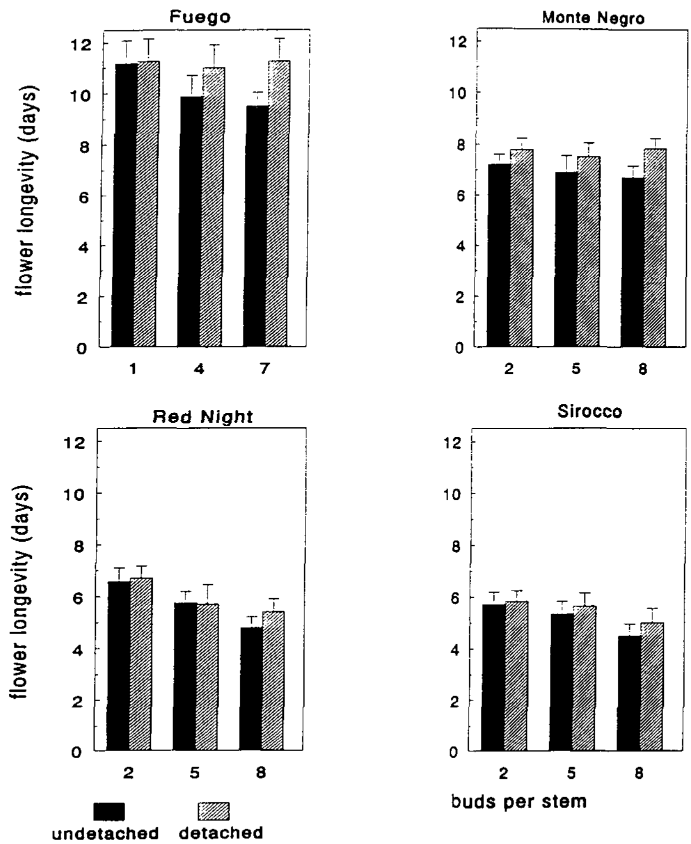

Figure 3 - The effect of bud reduction during cultivation on flower longevity of detached and undetached open flowers at harvest within four Asiatic hybrid lilies (control plants: 7, 8 buds); bars represent se values.

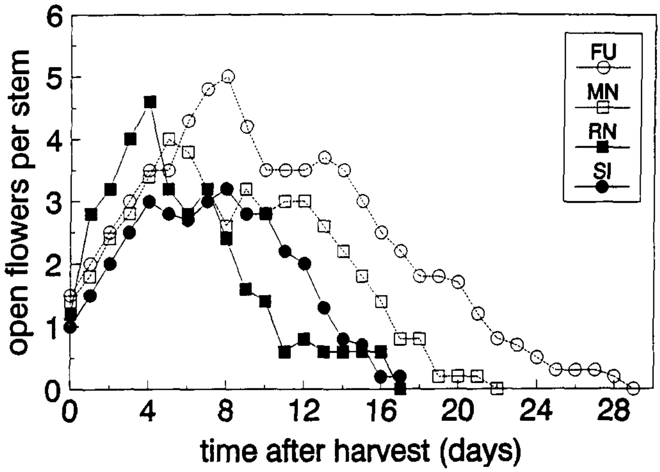

Figure 4 - The mean number of open flowers per stem at days after harvest of intact inflorescences of four Asiatic hybrid lilies; for explanation of the abbreviations see material and methods.

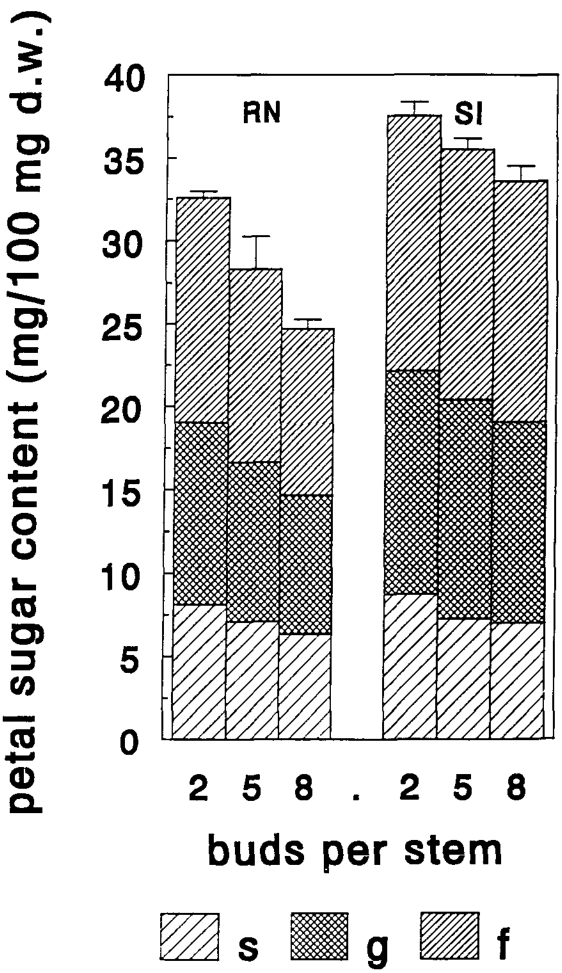

Figure 5 - The effect of bud reduction during cultivation on methanol soluble sucrose (s), glucose (g) and fructose (f) in petals of open flowers at harvest of four Asiatic hybrid lilies; bars represent se values.

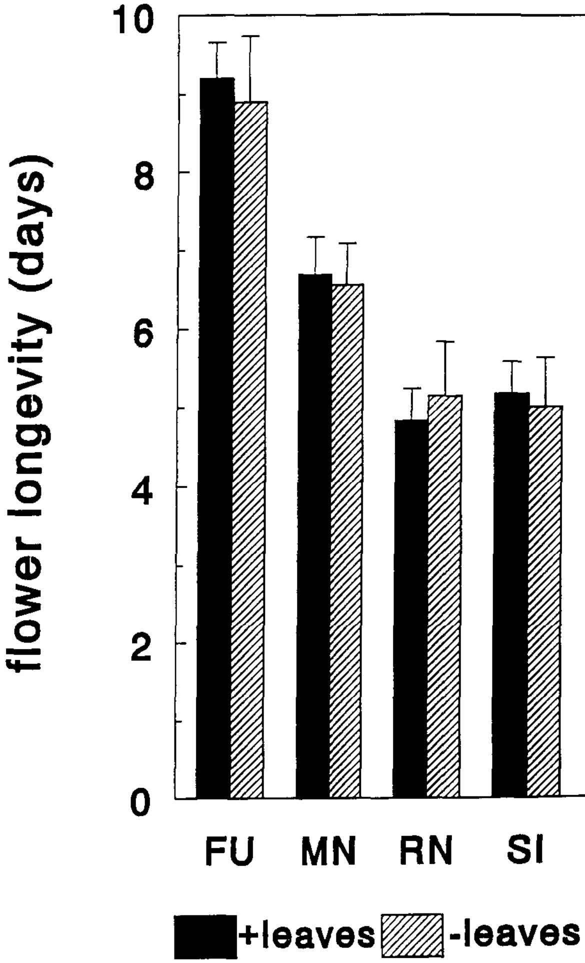

Figure 6 - The effect of defoliation of intact inflorescences after harvest on flower longevity of open flowers at harvest within four Asiatic hybrid lilies; bars represent se values.