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Defoliation of chrysanthemum (*Chrysanthemum morifolium* Ramat) cv. Reagan Sunny for improved flowering and cut flower quality

[Defoliasi tanaman kekwa (*Chrysanthemum morifolium* Ramat) kultivar Reagan Sunny untuk meningkatkan pembungaan dan kualiti bunga keratan]

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Key words: *Chrysanthemum morifolium*, defoliation, flowering, flower quality

Abstract

The effects of different levels of defoliation i.e. 0 (control), 20, 40, 60 and 80% at visible floral bud stage on growth, flowering and cut flower quality of chrysanthemum *(Chrysanthemum morifolium)* cv. Reagan Sunny were investigated. Plant height was only reduced by 5% at the highest level of defoliation, whereas the stem diameter was not affected. The time of floral bud break (showing colour), was delayed as level of defoliation increased. However, time of floral bud break within a plant was more synchronised.

The spray diameter was reduced and vase life was increased by defoliation up to 60%. Both contributed to better cut flower quality. Other quality parameters such as flower size and stem diameter were not markedly affected. Total fresh and dry weights were linearly decreased with level of defoliation. There was a change in dry matter distribution, in which more dry matter was partitioned to the structural parts i.e. the stems and flower stalks as level of defoliation increased. There was no change on dry matter partitioning to flowers by defoliation. Defoliation at 60% can be the compromised level for cv. Reagan Sunny grown under high temperature environment.

Introduction

It has been a common practice among the chrysanthemum growers to defoliate lower leaves of their plants. This is one of the techniques used to ascertain quality of cut flowers as reported for orchids by Clifford et al. (1995) and Lin-RueySong et al. (1998); and for hollies by Banko and Stefani (1999).

Lower leaves are removed due to their low photosynthetic efficiency. However these leaves still require energy for maintenance. Therefore, it is not required to retain too many leaves, since the photosynthate produced is much better be used by the plants for production of more economic importance such as floral organs.

Most growers believe that defoliation can increase the size of chrysanthemum flowers and reduce the incidence of fungal diseases. Defoliation is normally done manually which tends to increase production cost. This study was conducted to ascertain the claim that defoliation improves quality of cut chrysanthemum and to determine the optimum magnitude of defoliation.

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Materials and methods

The study was conducted at the Protected Crop Production Area, Horticulture Research Centre, MARDI, Serdang, Selangor. Rooted chrysanthemum cuttings cv. Reagan Sunny were planted on 1.0 m beds with planting distance of 12 cm x 15 cm. Immediately after establishment, a night interruption lighting using 100 W incandescent bulbs was provided up to five weeks. After five weeks, the lights were switched off for plants to initiate flower buds under natural photoperiod. Other cultural practices followed the standard procedures for chrysanthemum cut flower production (Mohd. Ridzuan et al. 2003).

Defoliation began after flower buds were visible (3 mm). The defoliation treatments were 0 (control), 20, 40, 60 and 80% *(Table 1).* Defoliation was done by removing the leaves from the base of the plant. The experiment was laid in randomised complete block design (RCBD) with four replications. Each plot has a size of 1.0 m x 1.2 m (66 plants).

Plant height and stem diameter

Plant height was measured from ground level to the tip of the highest shoot. Heights were recorded from five plants per plot and their average was taken as the actual reading. Stem diameter was measured at 40 cm from the ground level using a venire caliper. Two readings were taken perpendicular to each other and their average was determined.

Table 1. Percentages of defoliation and number of leaves retained under different defoliation treatments

Treatment (% defoliation)	Approximate number of leaves retained
0 (control)	All
20	30–32
40	22–24
60	14–16
80	7–8

Time to floral bud break

The number of days taken from the beginning of short day (SD) to floral bud break (bud showing colour) on buds1, 3, 6 and 10 for each sample plant were recorded. From the data obtained, the difference in times of floral bud breaking between buds 1 & 6 and buds 1 & 10 were determined. Recordings were done on ten randomly selected plants.

Growth analysis

At harvesting stage, three plants were selected from each plot for growth analysis. The stems were cut at the ground level. The length and diameter of the stems, length of peduncles and spray diameter were determined. The plants were then separated into major components: leaves, stems, peduncles and flowers. Dry weight of each component was determined after drying the sample at 80 °C in a force-draft oven for 48 h.

Vase life

Also at harvesting, flowers from three plants were selected from each plot for vase life study. The stems were cut to 45 cm from the end of inflorescence placed in solution containing *Sprite*, under room condition (temperature of 20 °C, day/night). The bases of stems were cut on alternate days to prevent blockage of the xylem. Vase life of the inflorescence was terminated when the first flower has wilted. The flower diameter was also measured on this inflorescence.

Results

Vegetative growth

Plant height was significantly reduced ($p < 0.01$) at all levels of defoliation *(Table 2).* Highest reduction was at 80% defoliation, with about 5 cm reduction in height as compared to the control plants. However, no significant differences were observed for defoliation levels of 20, 40 and 60%. Stem diameter was not significantly affected by defoliation.

Time to floral bud break

It was clearly shown that defoliation delayed bud breaking for all sampled buds *(Table 3).* The differences between defoliation treatments were more obvious on buds 1 and 3, which were highly significant (p <0.001) between control and defoliations and between defoliation levels. However, the differences between defoliation treatments were less on buds 6 and 10. For bud 10, significant difference was only observed between control and the defoliation levels, but not between them.

The differences in time to bud break between bud 1 & 6 and bud 1 & 10 within a plant *(Table 3)* clearly showed that defoliation significantly (p <0.001) reduced time differences of bud break between buds. The differences were 6 days and 10 days between buds 1 & 6 and 1 & 10 respectively for control plants but 3 days and 5 days for 80% defoliation. The results clearly indicated that defoliation improved synchronisation of buds breaking or time of flower development which is an important factor in determining the quality of cut chrysanthemum.

Flower quality

Spray diameter was reduced with defoliation levels, where significant differences were found at 40% of defoliation onwards *(Table 4).* Spray diameter with 80% defoliation was about 18% smaller as compared to control plants. The length of peduncles was not significantly influenced by all defoliation treatments. The effect of increased levels of defoliation on flower diameter was not clear. Defoliation at 20% and 80% gave the largest and smallest flower diameter respectively, and the differences between them were significant. The most significant effect of defoliation was found on the vase life. The vase life increased as the level of defoliation increased up to 60%, but at 80% defoliation,

Table 2. Effects of different defoliation levels on plant height and stem diameter

Treatment (% defoliation)	Plant height (cm)	Stem diameter (mm)
0 (control)	85.6a	5.25a
20	83.1b	5.19a
40	83.4b	5.05a
60	83.7b	5.31a
80	81.4c	5.12a

Mean values in each column with the same letter are not significantly different at p <0.05 according to DMRT

Table 3. Days to bud break of flower buds 1, 3, 6 and 10 under different defoliation treatments and differences in time of bud break between bud 1 & 6 and bud 1 & 10

Treatment (% defoliation)	Time to bud break (days)				Bud break time differences (days)	
	Bud 1	Bud 3	Bud 6	Bud 10	1 & 6	1 & 10
0 (control)	56.3d	60.2d	62.3c	66.1b	6.0a	9.8a
20	58.9c	62.2c	63.2c	69.0a	4.3b	10.1a
40	61.9b	62.5c	65.1b	69.1a	3.4c	7.2b
60	62.3b	64.2b	66.4ab	69.1a	4.1b	6.8b
80	64.0a	66.3a	67.4a	69.3a	3.4c	5.3c

Mean values in each column with the same letter are not significantly different at p <0.05 according to DMRT

Table 4. Effects of different defoliation levels on floral quality characteristics of *Chrysanthemun morifolium* cv. Reagan Sunny

Treatments (% defoliation)	Spray diameter (cm)	Peduncle length (cm)	Flower diameter (cm)	Vase life (days)
0 (control)	10.7a	15.5a	6.6ab	12.8b
20	9.9ab	13.3a	6.9a	13.0ab
40	9.8b	15.1a	6.6ab	13.5ab
60	9.7b	15.4a	6.4ab	15.0a
80	8.8b	13.6a	6.0b	11.2c

Mean values in each column with the same letter are not significantly different at $p < 0.05$ according to DMRT

Table 5. Dry weight of different plant components under different defoliation levels

Treatment (% defoliation)	Leaves (g)	Stems (g)	Peduncles (g)	Flowers (g)
0 (control)	3.97a (23.7)	6.38a (38.1)	2.51a (14.9)	3.30a (19.8)
20	2.33b (19.4)	5.33b (44.3)	2.11ab (17.5)	2.32b (19.7)
40	1.48c (13.4)	5.28b (47.9)	2.04b (18.5)	2.31b (20.5)
60	1.14c (10.8)	5.11b (48.6)	1.96b (18.6)	2.29b (21.5)
80	0.47d (6.2)	3.93c (52.5)	1.45c (19.4)	1.61b (21.9)

Mean values in each column with the same letter are not significantly different at $p < 0.05$ according to DMRT
Values in parenthesis are the percentages of dry weight of plant components relative to the total dry weight

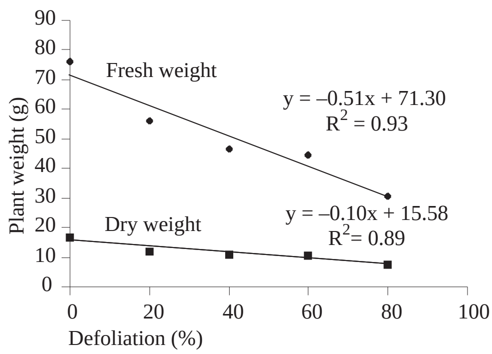

Figure 1. Relationship between total plant fresh weight and dry weight of chrysanthemum with percentage of defoliation

the vase life reduced sharply. The vase life increased more than two days (17%) at 60% defoliation as compared to control plants.

Fresh weight and dry matter distribution
Total plant fresh and dry weights were linearly decreased as level of defoliation increased, $y = -0.51x + 71.30$ ($R^2 = 0.93$) and $y = -0.10x + 15.58$ ($R^2 = 0.89$) respectively *(Figure 1)*. However, the reduction in fresh weight was more pronounced than the dry weight indicating that fresh weight was more sensitive to defoliation.

Dry weight of different plant components are shown in *Table 5*. The direct effect of defoliation was the reduction of leaves dry weight, and the reduction was almost proportional to the levels of defoliation. There were significant differences in leaves dry weight between all treatments, except between 40% and 60% defoliation. A similar trend was observed for stems and peduncles, where defoliation reduced the dry weight but at a lesser magnitude compared to the leaves dry weight. For flower dry weight, the differences were only significant between the control and defoliation treatment irrespective of their levels.

Dry matter distribution was strongly influenced by defoliation. The percentage of leaves dry weight declined as levels of defoliation increased. The structural components (stems and peduncles) increased with levels of defoliation but at the lesser extent. The percentage of flower dry matter was not affected by the different levels of defoliation.

Discussion

Plant height was reduced between 2 cm and 4 cm with different levels of defoliation, but the quantum can be considered as small i.e., only 5% reduction at 80% defoliation. The small reduction in plant height did not really affect cut flower quality since plant height can be adjusted easily by manipulating the duration of long day (vegetative phase). Stem diameter is an important quality parameter, but the result of this study showed that it was not affected by defoliation. In general, defoliation done during flowering (after buds have been formed) has little effect on growth, this contradicted to what have been reported for *Wrightia religiosa*, that defoliation strongly reduces stem diameter (Sharani 1991). Despite that, the overall plant weight was linearly decreased with defoliation. This phenomenon could be interpreted as negative effect of defoliation since the market required certain weight in order to meet certain set quality. On the other hand, defoliation can also be looked as the effective technique to reduce cut flower fresh weight if it is too heavy to meet certain desired weight.

Time of floral bud break or showing colour (Karlsson et al. 1989), is the stage where flowers begin to open. It was delayed with the levels of defoliation, indicating that even the lowest leaves are still functioning and contributing to the development of flower buds. There were some reports which mentioned that the rate of photosynthesis increases with defoliation (Tanaka and Fujita 1974; Hall and Ferre 1976; Wolk et al. 1983). It has also been reported that defoliation influences distribution of assimilate (Hodgkinson et al. 1972).

The results of this study showed that as the levels of defoliation increased, more dry matter was partitioned to the structural parts (stems and peduncles), but there was no influence on percentage of dry matter partition to the flowers. Defoliation reduces overall carbon assimilation and this is obvious in the present study on the total plant weight, that linearly decreased as defoliation increased. Low in carbon assimilation may delay flowering.

The positive effect of defoliation can obviously be seen on the flowering synchronisation, as indicated by the time differences between bud break in a plant. The differences between control and 80% defoliation were more than 3 days and 5 days for buds 1 & 6 and buds 1 & 10, respectively. Wolk et al. (1983) reported that defoliation done at late stages (four weeks before harvesting) increases percentage of fruit ripening in tomato (synchronised ripening). The mechanism on how defoliation improves synchronisation of flowering or fruiting is not fully understood. Synchronization in flowering is particularly important for spray chrysanthemum.

Cuttings are normally harvested when flower development is at H3 and H4 stage (Mohd. Ridzuan et al. 2003). If flowering is not synchronised, some flowers at harvesting already exceed the H4, whereas the others still not reaching H3 stage. From the observation made under high temperature condition such as in the lowland tropics, flowers harvested not reaching H3 are not able to develop into normal flowers.

Some other quality parameters were also improved by defoliation. Spray diameter, which is normally too large when grown under high temperature conditions, was reduced by defoliation. Since the length of peduncles was similar among treatments, the smaller spray diameter on the defoliated plants could merely be due to more erect peduncles. The compact nature of spray is essential for easier handling and packing and also improves the appearance quality.

The other important aspect of flower quality that can be improved by defoliation was the vase life. The longest vase life was under 60% defoliation (15 days), two days longer than the control, but at 80% defoliation the vase life was markedly reduced. Vase life is longer if the carbohydrate level especially the mobile sugar during harvesting is high (Nowak and Rudnicki 1990), sugar level at 60% defoliation might be the optimum.

Conclusion

Defoliation affects growth especially plant weight and delay flowering. However, flowering synchrony and other floral qualities such as spray diameter and vase life can be improved by defoliation. Defoliation at 60% is recommended for chrysanthemum cv. Reagan Sunny, grown under high temperature condition. Further study ought to be conducted on the other cultivars and growing conditions such as in the milder climatic regions.

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Abstrak

Kesan aras defoliasi yang berbeza iaitu 0 (kawalan), 20, 40, 60 dan 80% pada peringkat kudup bunga mula kelihatan terhadap pertumbuhan, pembungaan dan kualiti keratan bunga kekwa *(Chrysanthemum morifolium)* cv. Reagan Sunny telah dikaji. Tinggi pokok hanya berkurangan sebanyak 5% pada aras defoliasi tertinggi (80%), manakala saiz batang tidak terjejas. Masa untuk kudup bunga pecah (keluar warna), menjadi lambat dengan bertambahnya aras defoliasi. Walau bagaimanapun masa untuk kudup bunga pecah bagi sesuatu pokok pecah adalah lebih seragam.

Lebar jambangan berkurangan manakala jangka hayat jambangan pula meningkat dengan defoliasi sehingga aras 60%. Kedua-duanya menyumbang kepada peningkatan kualiti bunga keratan. Ciri-ciri kualiti yang lain seperti saiz bunga dan garis pusat batang tidak berubah dengan ketara. Jumlah berat basah dan kering berkurangan secara linear dengan pertambahan aras defoliasi. Pengagihan bahan kering (asimilat) juga berubah, dengan lebih banyak bahan kering diagihkan ke bahagian struktur tanaman iaitu batang dan tangkai bunga dengan pertambahan aras defoliasi. Pengagihan bahan kering pada bunga pula tidak berubah. Defoliasi pada aras 60% sesuai untuk kultivar Reagan Sunny yang ditanam dalam persekitaran suhu yang tinggi.

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