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# Growth, flowering and cut flower quality of spray chrysanthemum (*Chrysanthemum morifolium* Ramat) cv. V720 at different planting densities

[Pertumbuhan, pembungaan dan kualiti keratan bunga kekwa jenis spray (*Chrysanthemum morifolium* Ramat) kultivar V720 pada kepadatan yang berbeza]

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Key words: chrysanthemum, density, growth, flowering, quality

**Abstract**

Growth, flowering and flower quality of spray chrysanthemum (*Chrysanthemum morifolium* Ramat) cv. V720 planted at densities of 44, 56, 70, 83 and 104 plants/$m^2$ were evaluated. Stem diameter, leaf number, total leaf area, and overall plant fresh weight were reduced by 16, 7, 36 and 25%, respectively, but the leaf area index was increased by 50% at the highest planting density (104 plants/$m^2$) as compared to the lowest density (44 plants/$m^2$). Time taken to showing colour and harvesting, which was calculated from the beginning of short day, was delayed by high planting density. Measurement on the spray diameter showed a clear reduction at 83 plants/$m^2$, and this improved the spray form. The length of flower stalks and vase life were not affected. There was marked reduction in the number of flower stalks as well as flower number at high densities (83 and 104 plants/$m^2$). Generally, the cultivar (V720) used in this study can be planted at high density (83 plants/$m^2$) under lowland condition and able to produce the premium grade flowers.

## Introduction

Chrysanthemum (*Chrysanthemum morifolium* Ramat) is one of the most important cut flowers in Malaysia. Most of cut chrysanthemum are produced in the highlands such as Cameron Highlands, Pahang and Kundasang, Sabah. Total area under chrysanthemum in Cameron Highlands was estimated at 247 ha, or about 80% of the total area planted with temperate cut flowers (Noor Auni et al. 1990), and the same acreage is maintained until today. Attempts have been made to produce cut chrysanthemum in the lowlands. Early results showed that there are cultivars that have potential for cultivation in such areas (Ros Anita 2001). However, cultivation in the lowlands requires some modification of cultural practices to ensure the production is economical and the quality is acceptable by the market.

Planting density and spacing are among the important factors that directly affect yield, spray quality and production cost of cut chrysanthemum. Various studies have been reported on density and spacing. Generally, yield per plant decreases as planting density increases (Jhon and Paul

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1995; Janick and Durkin 1996). The time of flowering is also delayed as density increases (Hoeven et al. 1976). However, yield measured by the number of flower stalks and flowers/$m^2$ increases with increasing planting density for cv. Alba (Barman and Pal 1999). Earlier, Ferrato et al. (1996) reported that optimum density for cv. Alba is 50 plants/$m^2$ as compared to 20 and 40 plants/$m^2$.

Planting density and spacing were also reported to affect flower quality. Jhon and Paul (1995) tested three spacings i.e. 20 cm x 30 cm, 30 cm x 30 cm and 30 cm x 40 cm on pinched chrysanthemum, and they found that close spacing reduces branching. However, Kai et al. (1995) found that wide spacing (low density) produces plants with too big spray. Wide spacing also causes short flower stalks (Holcomb and Masterlerz 1997).

Most of the studies reported were on pinched chrysanthemum, in which the optimum density is normally lower as compared to the single-stem chrysanthemum. According to Kofranek (1980), optimum spacing depends on cultivars, seasons and other cultural practices. For example, the optimum spacing for pinched chrysanthemum is 15 cm x 18 cm in summer and 18 cm x 20 cm or 18 cm x 22 cm in winter. For single-stem chrysanthemum, the optimum is 10 cm x 15 cm in summer and fall, and 13 cm x 15 cm in winter. In Malaysia most chrysanthemum are single-stem spray and the recommended spacing is 12.5 cm x 12.5 cm (64 plants/$m^2$) for highland cultivation (Mohd. Ridzuan et al. 2003). The spacing requirement and the optimum density for lowland cultivation may differ from the highlands. Thus, this study was conducted to evaluate the performance of spray chrysanthemum planted at different densities and to determine the optimum planting density under lowland conditions.

## Materials and methods

The study was conducted at the Protected Crop Production Area, MARDI, Serdang, Selangor. Rooted chrysanthemum cuttings cv. V720 from Van Der Kamp (M) Sdn. Bhd., Tapah, Perak were planted on 1.0 m beds at five different planting densities. The densities (plants/$m^2$) and spacings (cm) were 44, 56, 70, 83 and 104; and 15 x 15, 15 x 12, 12 x 12, 15 x 8 and 12 x 8 respectively. The experiment was laid in randomized complete block design (RCBD) with four replications, and each plot had a size of 1.0 m x 1.8 m.

Immediately after establishment, a night interruption lighting was provided from 10.00 pm to 2.00 am with 100 W incandescent bulbs (one bulb for 10 $m^2$ area). Interruption lighting was switched off five weeks after establishment for the plants to initiate flower buds under natural photoperiod. Other cultural practices followed the standard procedures for chrysanthemum cut flower production as suggested by Mohd. Ridzuan et al. (2003).

### *Time of flowering*

The number of days to floral bud break (bud showing colour) from the beginning of short day (SD) was determined on bud 2 (bud 1 was disbuded). Recording was done on ten randomly selected plants from each plot. On the same sample plants, time of harvesting was also determined following the harvesting stage as recommended by Mohd. Ridzuan et al. (2003).

### *Growth analysis*

At harvesting stage, four plants were selected from each plot and the stems were cut at ground level. The overall height of plants, diameter of stems, number and length of flower stalks, spray diameter, number of leaves, number of opened flowers and buds were determined. Plants were then separated into major components: leaves, stems, flower stalks and flowers. The total leaf area (TLA) was measured using leaf area meter (LI-COR 2000). Dry weight of each

Table1. Plant height, number of leaves, stem diameter and total leaf area of chrysanthemum cv. V720 under different planting densities

| Planting density (plants/$m^2$) | Plant height (cm) | Number of leaves | Stem diameter (mm) | Total leaf area ($cm^2$) |
|---|---|---|---|---|
| 44 | 88.6a | 34.9ab | 6.29a | 1145a |
| 56 | 89.5a | 36.2a | 6.32a | 995b |
| 70 | 90.4a | 34.8ab | 6.29a | 1018b |
| 83 | 90.8a | 34.6ab | 5.57b | 825c |
| 104 | 90.9a | 32.5b | 5.28b | 730c |

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

component was determined after drying the sample at 80 °C in a force-draft oven for 48 h.

***Vase life***

At harvesting stage also, four plants were selected from each plot for vase life study. The stems were cut at 45 cm from the top of the spray and all the cut stems were placed in a solution containing *Sprite* under room conditions (temperature 20 °C, day/night). The bases of stems were cut on alternate days to prevent from xylem blockage. Vase life of the inflorescence was considered to end when the first flower had wilted.

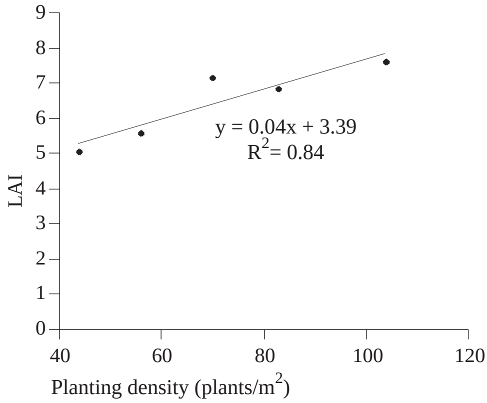


*Figure 1. Relationship between LAI and planting density of chrysanthemum cv. V720*

***Data analysis***

Statistical analysis was performed using SAS (SAS Inst. 2000) and treatment means were compared using Duncan multiple range test (DMRT).

**Results**

***Vegetative growth measurements***

Vegetative growth measurements (per plant basis) of chrysanthemum cv. V720 under different planting densities are summarized in *Table 1*. Plant height was not significantly ($p$ <0.05) affected by planting densities. There was a significant difference between the leaf number at 56 and 104 plants/$m^2$, but the differences among the other densities were not significant. The stem diameter significantly reduced at two highest densities, but there were no differences among the three lower densities. There was a reduction of about 16% in stem diameter at 104 plants/$m^2$ as compared to the lowest density (44 plants/$m^2$). The TLA per plant was the most significantly affected by planting density. There was a 36% reduction in TLA from the lowest to the highest density.

The relationship between LAI and planting density is shown in *Figure 1*. The LAI increased linearly as planting density increased and the relationship is represented by the equation y = 0.04x + 3.39 ($R^2$ = 0.84).

***Time of showing colour and harvesting***

Time of showing colour and harvesting are shown in *Table 2*. Time of showing colour was significantly ($p$ <0.01) delayed as density increased, with the difference between the lowest and the highest density of 3.7 days. A similar trend was observed for time of harvesting, but the difference

Table 2. Time of showing colour and harvesting of chrysanthemum cv. V720 under different planting densities

| Planting density (plants/$m^2$) | Time of showing colour (days) | Time of harvesting (days) |
|---|---|---|
| 44 | 57.8c | 75.1b |
| 56 | 59.2bc | 75.3b |
| 70 | 59.9bc | 76.4ab |
| 83 | 60.3ab | 76.5ab |
| 104 | 61.5a | 77.8a |

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

between the lowest and the highest density was only 2.7 days.

### *Spray and flower characteristics*

As planting density increased, the spray diameter decreased, and the lowest diameter was found at 83 plants/$m^2$ *(Table 3)*. There was significant ($p$ <0.05) difference in diameter between the lowest and the two highest densities. The number of flower stalks did not differ significantly between the three lowest densities, but there was significant reduction ($p$ <0.001) at the two highest densities. Measurements on the length of flower stalks did not show any significant difference between the planting densities.

The flower characteristics were also influenced by planting density. Both the number of opened flowers and flower buds were significantly ($p$ <0.001) lower at two highest densities as compared to the three lowest densities. However, the differences in the number of opened flowers and flower buds between the three lowest densities were not significant. Planting density did not affect the vase life significantly although there was a slight declining trend in vase life as density increased.

### *Total plant weight and dry weight of different components*

The relationships between total plant fresh and dry weights with planting densities are shown in *Figure 2*. The relationship between fresh weight and densities was linear with the equation of y = –0.44x + 109.88 ($R^2$ = 0.72). This negative linear relationship indicated that the weight decreased with the increased in the planting densities. For the dry weight, the trend was slightly different with only about 59% of the variations that can be explained by the model. The equation

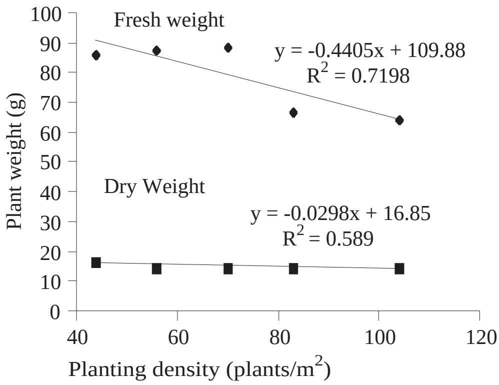


*Figure 2. Relationships between plant fresh weight and dry weight with different planting densities*

Table 3. Spray and flower characteristics of chrysanthemum cv. V720 under different planting densities

| Planting density (plants/$m^2$) | Spray diameter (cm) | Number of flower stalks | Length of flower stalks (cm) | Number of opened flowers | Number of flower buds | Vase life (days) |
|---|---|---|---|---|---|---|
| 44 | 16.4a | 16.7a | 8.3a | 21.1a | 14.1a | 8.8a |
| 56 | 15.8ab | 17.9a | 9.5a | 19.3a | 13.9a | 8.5a |
| 70 | 16.0ab | 15.9a | 9.6a | 19.9a | 10.9a | 8.6a |
| 83 | 13.9b | 13.4b | 9.5a | 12.9b | 5.6b | 7.0a |
| 104 | 15.0b | 13.5b | 9.8a | 12.6b | 5.3b | 7.1a |

Mean values in each column with the same letter are not significantly different at $p$ <0.05 according to DMRT for dry weight was y = –0.03x + 16.85 ($R^2$ = 0.59).

The dry weights of different components are summarized in *Table 4*. Leaf dry weight was significantly ($p$ <0.01) reduced as planting density increased, about 20% if the lowest density (44 plants/$m^2$) was compared with the highest density (104 plants/$m^2$). A similar trend was observed for flower stalk dry weight, where significant reduction occurred at densities of 56 to 104 plants/$m^2$. The reduction at highest density was 36% as compared to the lowest density (44 plants/$m^2$). There was no significant influence of planting density on stem and flower dry weights.

The highest percentage of dry matter was partitioned to the stems, followed by leaves, flowers and flower stalks. The percentage of dry matter to the stem was slightly increased with density, but the trend was reversed for the flower stalk. The effects of planting density on percentages of dry matter to the leaves and flowers were not clear.

**Discussion**

The increase in planting density from 44 to 104 plants/$m^2$ did not cause a significant increase in plant height. Unlike what had been reported for tomato, the plant height increases with density increase, but as planting density becomes too high, plant height is suppressed (Papadopoulus and Omrod 1988; De Koning and De Ruiter 1991). There were reductions in the stem diameter and leaf number of chrysanthemum, but only at higher planting densities. The reductions in stem diameter and leaf number were 16% and 7%, respectively at highest density as compared to the lowest density. TLA was reduced remarkably when planting density was increased, about 36% at the highest density. It has been reported that removal of chrysanthemum leaves (defoliation) affects growth and flowering (Sakinah 2000). The low TLA observed in this study may contribute to the reduce growth and flowering at high densities.

The overall plant weight in *Figure 2* showed that plant fresh weight was linearly reduced as density increased. The overall plant fresh weight at highest density (104 plants/$m^2$) was below 70 g, less than the weight required by the market. Generally, the vegetative measurements and the plant growth were reduced at high planting density. The reduction on the important parameters, such as the stem diameter and fresh weight to a value below that required by the market may not permit the planting to be done at too high density such as at 104 plants/$m^2$.

High planting densities affected both the time of showing colour and harvesting. Similar results were also reported by Hoeven et al. (1976) for different

Table 4. Dry weights of different components of chrysanthemum cv. V720 under different planting densities

| Planting density (plants/$m^2$) | Components of dry weight (g) | | | |
|---|---|---|---|---|
| | Leaves | Stems | Flower stalks | Flowers |
| 44 | 4.62a (28.3) | 5.60a (34.3) | 3.15a (19.3) | 2.95a (18.1) |
| 56 | 4.40ab (30.4) | 5.16a (35.6) | 2.74b (15.1) | 2.74a (18.9) |
| 70 | 3.89bc (26.9) | 5.50a (38.2) | 2.54b (17.6) | 2.48a (17.2) |
| 83 | 4.05bc (28.2) | 5.48a (38.2) | 2.00b (13.9) | 2.83a (19.7) |
| 104 | 3.72c (26.5) | 5.38a (38.3) | 2.15b (15.3) | 2.81a (19.9) |

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

Numbers in parenthesis are the percentages of dry weight of plant components over total dry weight chrysanthemum cultivar. As planting density increased, the LAI *(Figure 1)* was increased from 5.03 at 44 plants/$m^2$ to 7.59 at 104 plants/$m^2$. The availability of photosynthetic light in the canopy was low and this may cause delay in flowering (Larson and Persson 1999). Changes in LAI under high density, also changed the light composition particularly the amount of red relative to far-red light (R:FR) (Smith 1981). Low R:FR has been reported to cause delay in flowering (Kadman-Zahavi and Ephart 1974; Wright and Sandrang 1993).

Planting density also influenced spray characteristics. Spray diameter was reduced at high densities, about 15% at 83 plants/$m^2$ as compared to the lowest density. A similar result has been reported by Kai et al. (1995). However, the length of flower stalks was not affected by density. Holcomb and Masterlerz (1979) reported that spacing of 12” x 5” (24 cm x 12.5 cm) produces plants with short flower stalks, but in this study there was no such effect observed, even at the lowest density. Good appearance cut chrysanthemum should have a compact spray form. Planting at high density (83 plants/$m^2$) may have benefited in that respect especially for chrysanthemum grown under tropical conditions, where spray is normally too large. Compact spray also makes handling and packaging easier.

The other quality parameters such as the number of flower stalks and flowers were also influenced by density. Zahara and Timm (1973) and Rodriguez and Lambeth (1975) reported that flower number is reduced as planting density increases. It was evident in this study that the number of flower stalks, flowers and buds were markedly reduced at high densities (83 and 104 plants/$m^2$). Intense competition for growth resources exists under high plant population, hence reduces assimilate production, causing low flower production (Cockshull et al. 1992). It has been reported that planting density affected assimilates distribution that may affect flowering. Evidence in this study showed that the proportion of assimilate partitioning to flower was not affected by density, but the proportion of assimilate into other components such as stems and flower stalks varied among densities. Usually five or six flowers are sufficient for a good spray form. Moreover, the excessive flower stalks are usually removed during packing operation. Based on the study conducted, although there was a marked reduction in flower number at high planting densities, spray chrysanthemums produced are still recognized as premium grade, provided the other quality aspects meet the market requirement.

## Conclusion

Increasing planting density from 44 to 104 plants/$m^2$ did not affect plant height, but decreased stem diameter, leaf number, total leaf area and overall plant weight by 16, 7, 36 and 25%, respectively and increased the leaf area index. The reduction in vegetative parameters related to quality particularly the overall plant fresh weight was substantial at the highest planting density. The time of showing colour and harvesting were also delayed by 3.7 and 2.7 days at highest density respectively. High planting density (83 plants/$m^2$) improved spray form (reduced diameter), but the length of flower stalks and the vase life were not affected. Although there was a marked reduction in number of flower stalks and flowers at high planting densities, the values were still within the acceptable range for production of premium grade of spray chrysanthemum. The results of this study reveal that chrysanthemum cv. V720 can be planted up to a density of 83 plants/$m^2$ under lowland conditions, but the economic aspect of cultivation at such density requires further evaluation.

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**Abstrak**

Pertumbuhan, pembungaan dan kualiti bunga kekwa (*Chrysanthemum morifolium* Ramat) jenis spray, kultivar V720 yang ditanam pada kepadatan 44, 56, 70, 83 dan 104 pokok/$m^2$ telah dinilai. Garis pusat batang, bilangan daun, jumlah luas daun, dan berat basah pokok masing-masing berkurangan sebanyak 16, 7, 36 dan 25%, manakala indeks luas daun meningkat 50% pada kepadatan tertinggi (104 pokok/$m^2$) berbanding dengan pada kepadatan terendah (44 pokok $m^2$). Bilangan hari untuk keluar warna dan bunga dituai, bermula dari permulaan siang pendek bertambah dengan peningkatan kepadatan. Ukuran garis pusat jambangan berkurangan dengan ketara pada kepadatan 83 pokok/$m^2$ dan ini membaiki bentuk jambangan. Walau bagaimanapun panjang tangkai bunga dan jangka hayat jambangan tidak berubah dengan kepadatan. Terdapat pengurangan yang amat ketara dalam bilangan tangkai bunga dan bunga pada kepadatan tinggi (83 dan 104 pokok/$m^2$). Pada keseluruhannya kultivar V720 yang digunakan dalam kajian ini boleh ditanam sehingga kepadatan 83 pokok/$m^2$ di kawasan tanah rendah dan mampu menghasilkan bunga gred premium.

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