The effects of gibberellic acid (GA₃) on the harvesting time of spray type Chrysanthemum cut flowers in medium land

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Abstract. Shintiavira H, Sulistyahiyani E, Purwantoro A, Wulandari RA. 2020. The effects of gibberellic acid (GA₃) on the harvesting time of spray type Chrysanthemum cut flowers in medium land. Biodiversitas 21: 1723-1729. The high temperature of the medium land causes a delay in harvesting time and also decreases the diameter of Chrysanthemum cut flowers (Chrysanthemum morifolium R.). It is, however, possible to accelerate and increase the flower diameter through the use of the Gibberellic acid (GA₃). This research, therefore, aimed to obtain the best GA₃ concentration to accelerate harvesting time using three varieties of spray type Chrysanthemum cultivated on a medium land. The experimental design involved the use of a split-plot with three replications. The main plot varied the GA₃ concentration between 0, 200, 400, and 600 mgL⁻¹ while the subplot used the spray type Chrysanthemum varieties such us ‘Yastayuki’, ‘Arosuka Pelangi’, and ‘Socakawani’. It was applied on the 56, 63, and 70 days after planting (DAP). The data were analyzed using Analysis of Variance (ANOVA) and a further test was conducted using Duncan Multiple Range Test (DMRT) at α=0.05. The results showed GA₃ at 400 mgL⁻¹ was the best concentration to increase the harvesting time in all varieties. However, the harvesting time of spray type without secondary branching (‘Arosuka Pelangi’) was faster than spray type with secondary branching (‘Yastayuki’ and ‘Socakawani’). The harvesting time was earlier 13, 9, and 7 days for ‘Arosuka Pelangi’, ‘Yastayuki’ and ‘Socakawani’ compare with control, respectively. The average diameter of the blooming flowers was also wider with 54.9 mm compared to the control treatment which was 38.7 mm.

Keywords: Chrysanthemum, endogenous hormones, harvesting time, gibberellic acid, medium land

INTRODUCTION

Chrysanthemum cut flowers (Chrysanthemum morifolium R.) have been widely cultivated in different areas of the world including Indonesia where its cultivation ranges from the high to low lands (Sanjaya et al. 2018). However, the temperature and light intensity in medium lands had been reported negative effects on the development of Chrysanthemum. Shintiavira et al. (2019) reported that the C. morifolium ‘Yastayuki’, ‘Arosuka Pelangi’ and ‘Socakawani’ grown in medium land to have shown prolonged harvesting time and decreased flower size compared to those in high land. This reduces the quality of the flower which can, however, be mitigated through the use of GA₃.

According to Su et al. (2001), exogenous GA₃ improved the development of the Phalaenopsis hybrida inflorescence under temperature above 30°C. It has also been discovered that a higher endogenous GA₃ in flower development compared to the initiation period for C. morifolium ‘Jinba’ indicates that the acceleration of the cell division and elongation of florets by this auxin (Jiang et al. 2010a). The use of exogenous GA₃ in the improvement of flower quality had been reported by many researchers, for example, Mori et al. (2013) showed its 200 mgL⁻¹ concentration in flower bud 3.5 mm size accelerated the harvesting time and increased flower diameter compared to the control treatment of C. morifolium ‘Sansui’ in the subtropics area of Japan. Moreover, at 250-500 mgL⁻¹ concentrations, the diameter was found to have increased to 8.17-8.32 cm while the control was 6.56 cm in standard type Chrysanthemum cut flower cultivated in the medium land of Indonesia (Priambodo et al. 2014). However, there are no studies reported to have been conducted on the effect of different variations of GA₃ concentrations on spray type Chrysanthemum cut flower in medium land. Therefore, this research was conducted to obtain the best concentration of GA₃ required to improve the flower quality of Chrysanthemum varieties such as ‘Yastayuki’, ‘Arosuka Pelangi’, and ‘Socakawani’ cultivated in medium land Indonesia.
MATERIALS AND METHODS

Plant materials and growth conditions

The research was conducted at Samigaluh Village, Kulonprogo District, Special Region of Yogyakarta Province, Indonesia located on 07°40’ S and 110°12’ E at an altitude of 485 m above sea level (ASL) from July to November 2018. The spray type C. Morifolium cv ‘Yastayuki’, ‘Arosuka Pelangi’, and ‘Socakawani’ rooted cuttings with 3-4 full expand leaves were used as plant materials. The ‘Yastayuki’ and ‘Socakawani’ were spray type Chrysanthemum with secondary branching while ‘Arosuka Pelangi’ was whose without secondary branching. They were grown on a bench soil in the screen house with 10 cm spacing under long-day conditions for 4 weeks with supplemented lighting from 10.00 pm - 04.00 am. The soil medium was mixed with basic fertilizer consisted of 5 kgM⁻² goat organic manure, 200 kgHa⁻¹ Urea (Kujang, Indonesia), 300 kgHa⁻¹ SP-36 (Petrokimia, Indonesia) and 350 kgHa⁻¹ KCL (Kujang, Indonesia) as basic fertilizer. Additional fertilizer was 2 gL⁻¹ NPK 16:16:16 (Meroko Tetap Jaya, Indonesia), 1gL⁻¹ red KNO₃ (El Trovador, Chile), 2 gL⁻¹ Gandasil D (Kalatham, Indonesia) were given during 0-35 DAP. Then, 2 gL⁻¹ NPK, 1gL⁻¹ white KNO₃ (El Trovador, Santiago, Chile), 2 gL⁻¹ Gandasil B (Kalatham, Indonesia) were applied during 36 DAP until harvesting time. The fertilizer was mixed and applied in watering. Moreover, the microclimate such as air temperature, relative humidity, and light intensity were 29.1°C, 68.0%, and 18,290 lux, respectively. Thereafter, the GA₃ solution was applied on flowers bud at 57 DAP according to the treatment while the apical and bottom flower buds were removed at 64 DAP leaving only those located 20 cm to the top from the apical meristem. It is important to state that the plants were maintained according to the procedure of the operational standard of Chrysanthemum cultivation (Indonesian Directorate General of Horticulture 2012).

Research design

The experimental design involved the use of a split-plot with three replications. The main plot was GA₃ concentration varied between 0, 200, 400, and 600 mgL⁻¹ while the subplot was the Chrysanthemum varieties including ‘Yastayuki’, ‘Arosuka Pelangi’, and ‘Socakawani’.

Procedures

The GA₃ solution was made by dissolving pure GA₃ (AGROGIBB 40 SL, Indonesia) in aquadest based on the concentrations required for each treatment, 0, 200, 400, and 600 mgL⁻¹. The application of the solution started 56 DAP or at the flower bud diameter of ±3-5 mm. The volume sprayed on each flower bud per plant was ±0.9 ml and this was conducted every week till the 10th week. This means it was applied on the 56, 63, and 70 DAP.

Observations

Endogenous GA₃ and IAA in flower buds

All the flower buds were pinched at 71 DAP to determine the endogenous GA₃ by using Barendse’s (1987) method with minor modification. This involved the crushing of a total of 0.5 g samples of flower buds using liquid nitrogen after which 5 ml of 65% methanol (v/v) was added and centrifuged at 4000 rpm for 30 minutes at 4°C. The supernatant flowed using the C18 Sep-Pak cartridge and 5-5 µL of its content was injected into the HPLC equipped with a UV-Vis spectrophotometer (Shimadzu, Japan). It is, however, important to note that the wavelength of GA₃ was 200 nm and the wavelength of IAA was 218 nm. Furthermore, the endogenous hormones per flower bud were obtained by dividing the results of the endogenous hormones with the number of flower buds.

Growth parameters and quality traits of Chrysanthemum cut flowers

Growth parameters involved the diameter and number of flower buds as well as the length of pedicels measured every week. The variables of the quality traits of Chrysanthemum cut flowers included (i) the harvesting time which is defined as the state where more than 60% of the total half of the flower has opened at 45°, (ii) the length of the pedicel was measured by calculating the average length of the peduncle located 20 cm from the top of the plant, (iii) the total number of flowers was measured by calculating the total number of buds and blooming flowers located 20 cm from the top of the plant, (iv) the total number of blooming flowers was measured by calculating the total flowers opening at 45°, (v) the percentage of the blooming flowers was measured by dividing their total number by the total number of flowers in percent units, (vi) the diameter of the blooming flower was measured by calculating the length of the flower head from the left to the right petal, (vii) the length of the ray floret was measured by calculating the length of the detached ray floret from the base up to the top, (viii) the width of the ray floret was measured by calculating the width of those detached in the middle, (ix) The thickness of the ray floret was measured by calculating the thickness average of basal, middle and tip of 30 ray florets using a digital micrometer, and (x) The number of the ray floret per flower was measured by calculating the detached ray petal per flower.

Statistical analysis

The data were analyzed using ANOVA and if a significant difference was observed among the treatments, the DMRT method was applied at α= 0.05. Moreover, the correlation test was used to determine the relationship between variables. It is important to note that all the statistical analyses were conducted using SAS 9.12. (Abebe 2000).
RESULTS AND DISCUSSION

The effect of exogenous GA$_3$ concentration on endogenous GA$_3$ contents of flower bud

The results showed that there was no interaction between the concentration of exogenous GA$_3$ and varieties of endogenous GA$_3$ of flower bud at 71 DAP. However, there was interaction between the concentration of exogenous GA$_3$ and varieties of endogenous IAA of flower bud at 71 DAP (Table 1). An increase in endogenous GA$_3$ was followed by an increase in endogenous IAA in the ‘Yatsayuki’ and ‘Socakawani’. While, an increase in endogenous GA$_3$ was followed by a decreased in endogenous IAA in ‘Arosuka Pelangi’.

The effect of exogenous GA$_3$ level on the diameter of flower bud, length of the pedicel, and the number of flower buds

The 200-600 mgL$^{-1}$ GA$_3$ applied significantly increased the length of the pedicel after 70 DAP and this is associated with the excess solution applied at 63 DAP as shown in Figure 1. However, the first application of the solution at 56 DAP was discovered not to have any influence on the total number of flower buds at 63 DAP while the second caused the pinching of flower buds at 20 cm from the top. This, therefore, led to the reduction of the number of flower buds at 70 DAP. Moreover, the third application of GA$_3$ decreased the total number for both the bud and those blooming up to the harvesting time. Figure 2 shows the endogenous GA$_3$ accumulated on the bud from the 63 DAP has the ability to inhibit the growth of the axillary flower bud. Furthermore, the diameter of the bud required more GA$_3$ application compared to the control from 56 to 84 DAP while 200-600 mgL$^{-1}$ concentrations accelerated the opening of ray florets after 84 DAP and this was followed by the increase in the diameter of the blooming flowers. This, therefore, showed that an increment in the endogenous GA$_3$ at 71 DAP did not have any significant influence on the size of the flower bud diameter. However, those accumulated on the flower bud at 71 DAP accelerated the expansion of the ray floret after 84 DAP as shown in Figure 3.

Table 1. The average endogenous GA$_3$ and IAA of flower buds in varieties of exogenous GA$_3$ at 71 DAP

| Variables                  | Conc. exogenous of GA$_3$ (mgL$^{-1}$) | Yastayuki | Arosuka Pelangi | Socakawani | Average |
|----------------------------|---------------------------------------|-----------|-----------------|------------|---------|
| Endogenous GA$_3$ (ng)     | 0                                     | 15.18     | 16.12           | 43.33      | 24.88 b |
|                            | 200                                   | 255.10    | 393.46          | 360.31     | 336.29 a|
|                            | 400                                   | 492.50    | 353.85          | 355.56     | 400.63 a|
|                            | 600                                   | 289.34    | 377.15          | 343.70     | 336.73 a|
|                            | Average                               | 263.03 a  | 285.14 a        | 275.73 a   | (-)     |
| Endogenous IAA (ng)        | 0                                     | 343.56 de | 601.82 b        | 83.06 f    | 342.84  |
|                            | 200                                   | 487.20 bc | 441.28 cd       | 568.46 bc | 498.98  |
|                            | 400                                   | 583.71 bc | 449.42 cd       | 310.74 de | 447.96  |
|                            | 600                                   | 237.75 e  | 529.46 bc       | 753.27 a  | 506.83  |
|                            | Average                               | 413.06    | 505.51          | 428.88     | (+)     |

Note: CV = 29.74%. The means with the same letters are not significantly different based on DMRT, $\alpha=0.05$. However, (+) sign showed there was an interaction between the concentration of GA$_3$ and varieties while (-) sign means there was none.

Figure 1. The average length of pedicels after exogenous GA$_3$ applied in three varieties of Chrysanthemum. The means with the same letters are not significantly different based on DMRT, $\alpha=0.05$. 

Figure 2. The average endogenous GA$_3$ accumulated on the bud from the 63 DAP has the ability to inhibit the growth of the axillary flower bud.
Effect of exogenous GA$_3$ level on quality traits of Chrysanthemum cut flower

The harvesting time for all the varieties without GA$_3$ was 105 days but was significantly accelerated by the exogenous application of 200 mgL$^{-1}$ solutions to 98, 96, and 100 DAP in ‘Yastayuki’, ‘Arosuka Pelangi’, and ‘Socakawani’ respectively. Furthermore, there was a significant acceleration to 96, 92, and 98 DAP at 400 mgL$^{-1}$ and 600 mgL$^{-1}$. The effect of the GA$_3$ on the shortening of harvesting time supported the quality traits of Chrysanthemum as discovered with the increased length of pedicels and reduction in the total number of flowers at 400 mgL$^{-1}$. However, the percentage of the blooming flowers was not significantly different at all the GA$_3$ concentrations but was found to have increased its diameter and the value was observed to be 54.20 mm for all the varieties at 400 mgL$^{-1}$. Moreover, the opening of the ray floret has an influence on its length, width, thickness, and number. At 200-600 mgL$^{-1}$, the width and thickness were found to be decreasing while the length increased. However, the number of ray florets was dependent on the varieties with a significant difference found between the concentrations in ‘Socakawani’ while none was observed in ‘Yastayuki’ and ‘Arosuka Pelangi’. The application of GA$_3$ at 200, 400, and 600 mgL$^{-1}$ were increased the number of ray florets compared to the control for ‘Socakawani’.

Correlation analysis between endogenous hormones and the quality of Chrysanthemum cut flower

The exogenous GA$_3$ was found to be positively and significantly correlated to endogenous GA$_3$ with 0.64. Moreover, the endogenous GA also positively and significantly correlated to the length of pedicels with 0.62, the diameter of blooming flowers with 0.80, and the length of the ray floret with 0.51. However, a negatively significant correlation was discovered with shortening harvesting time at -0.72, the thickness of the ray floret at -0.52, the total number of flowers at -0.53, and total blooming flower at -0.59 as shown in Table 3.
Table 2. The average harvesting time, length of pedicels, total number of flower, number of blooming flowers, percentage of blooming flowers, the diameter of blooming flower as well as the length, width, thickness, and the number of ray florets

| Variables                          | Conc. exogenous of GA$_3$ (mgL$^{-1}$) | Yastayuki | Arosuka pelangi | Socakawani | Average |
|------------------------------------|----------------------------------------|-----------|-----------------|------------|---------|
| Harvesting time (days)              | 0                                      | 105.0 a   | 105.0 a         | 105.0 a    | 105.0   |
|                                    | 200                                    | 98.00 c   | 96.00 d         | 100.0 b    | 98.00   |
|                                    | 400                                    | 96.00 d   | 92.0 e          | 98.0 c     | 95.33   |
|                                    | 600                                    | 96.00 d   | 92.0 e          | 98.0 c     | 98.33   |
| CV=0.00 %                          | Average                                | 98.8      | 96.3            | 100.3      | +       |
| Length of pedicels (cm)             | 0                                      | 19.52     | 17.16           | 19.69      | 18.79 b |
|                                    | 200                                    | 25.47     | 20.98           | 27.83      | 24.75 a |
|                                    | 400                                    | 26.43     | 21.80           | 30.27      | 26.24 a |
|                                    | 600                                    | 27.56     | 23.25           | 29.47      | 26.76 a |
| CV=5.95 %                          | Average                                | 24.79 b   | 20.79 c         | 26.82 a    | -       |
| Total number of flowers             | 0                                      | 13.67 a   | 8.59 bc         | 8.72 bc    | 9.00 bc |
|                                    | 200                                    | 8.59 bc   | 7.58 c          | 8.43 bc    | 8.18    |
|                                    | 400                                    | 8.20 bc   | 7.91 bc         | 9.00 bc    | 8.26    |
|                                    | 600                                    | 8.72 bc   | 7.06 c          | 9.00 bc    | 8.26    |
| CV=13.24%                          | Average                                | 9.79      | 7.88            | 9.20       | +       |
| Number of blooming flowers          | 0                                      | 10.58     | 7.50            | 8.17       | 8.75 a  |
|                                    | 200                                    | 6.50      | 6.25            | 6.78       | 6.74 b  |
|                                    | 400                                    | 6.55      | 7.00            | 6.67       | 6.51 b  |
|                                    | 600                                    | 7.14      | 6.78            | 6.22       | 6.71 b  |
| CV=13.04%                          | Average                                | 7.96 a    | 6.88 a          | 6.95 a     | -       |
| Percentage of blooming flowers (%)  | 0                                      | 77.96     | 84.21           | 80.37      | 80.85 a |
|                                    | 200                                    | 76.49     | 82.44           | 74.50      | 77.81 a |
|                                    | 400                                    | 80.63     | 88.87           | 80.65      | 82.47 a |
|                                    | 600                                    | 82.25     | 96.00           | 69.37      | 82.54 a |
| CV=8.12%                           | Average                                | 79.34 b   | 87.88 a         | 75.82 b    | -       |
| The diameter of blooming flower (mm)| 0                                      | 41.70     | 35.80           | 38.67      | 38.72 c |
|                                    | 200                                    | 52.33     | 45.00           | 51.37      | 49.56 b |
|                                    | 400                                    | 61.63     | 47.77           | 55.43      | 54.94 a |
|                                    | 600                                    | 49.77     | 44.10           | 51.00      | 48.29 b |
| CV=5.09%                           | Average                                | 51.36 a   | 43.17 c         | 49.12 b    | -       |
| Length of the ray floret (mm)       | 0                                      | 2.433     | 2.176           | 1.953      | 2.187 b |
|                                    | 200                                    | 2.663     | 2.383           | 2.527      | 2.457 a |
|                                    | 400                                    | 2.913     | 2.230           | 2.437      | 2.527 a |
|                                    | 600                                    | 2.783     | 2.300           | 2.213      | 2.432 a |
| CV=7.15%                           | Average                                | 2.698 a   | 2.272 b         | 2.232 b    | -       |
| Width of the ray floret (mm)        | 0                                      | 0.867     | 1.267           | 0.796      | 0.977 a |
|                                    | 200                                    | 0.766     | 1.180           | 0.823      | 0.923 ab|
|                                    | 400                                    | 0.706     | 0.970           | 0.840      | 0.836 bc|
|                                    | 600                                    | 0.650     | 0.970           | 0.733      | 0.797 c |
| CV=10.71%                          | Average                                | 0.745 b   | 1.097 a         | 0.808 b    | -       |
| Thickness of ray floret (mm)        | 0                                      | 0.089     | 0.128           | 0.124      | 0.113 a |
|                                    | 200                                    | 0.103     | 0.098           | 0.107      | 0.100 ab|
|                                    | 400                                    | 0.065     | 0.078           | 0.068      | 0.071 c |
|                                    | 600                                    | 0.079     | 0.091           | 0.091      | 0.087 bc|
| CV=14.32                           | 0.008 b                                | 0.009 a   | 0.009 a         | -          |         |
| Number of ray floret per flower     | 0                                      | 57.00 ed  | 33.33 e         | 95.00 c    | 61.78   |
|                                    | 200                                    | 61.00 d   | 32.33 e         | 126.0 b    | 73.22   |
|                                    | 400                                    | 64.47 d   | 31.33 e         | 152.33 a   | 82.78   |
|                                    | 600                                    | 61.33 d   | 31.00 e         | 172.00 a   | 88.00   |
| CV=18.91%                          | 61.00                                  | 32.00     | 136.33          | +          |         |

Note: CV: coefficient of variations. The means with the same letters are not significantly different based on DMRT, α=0.05. However, (+) sign showed there was an interaction between the concentration of GA$_3$ and varieties while (-) sign means there was none.
Discussion

There was a positive correlation between endogenous GA$_3$ and the length of pedicels. Moreover, 200-600 mgL$^{-1}$ was applied at 56, 63, and 70 DAP on flower buds and the concentration was further increased at 71 DAP. However, the first response observed was the increment of the pedicels starting from 70 DAP due to the absorption of the solution in the flower buds leading to the elongation of its walls required to initiate the process of cell enlargement (Rayle and Cleland 1992). The effect of the GA$_3$ on the total number of flowers was also observed at 70 DAP. The total number of flowers, including the bud and blooms, decreased up to the harvesting time after the application of GA$_3$ at 400 mgL$^{-1}$.

The exogenous GA$_3$ increased endogenous GA$_3$ and IAA in ‘Yastayuki’ flower bud. Jiang et al. (2010b) indicated that endogenous GA$_3$ and IAA played a role in the formation of axillary buds. According to Huh et al. (2011), increasing IAA in shoot apex has the ability to decrease branching in Chrysanthemum. However, a high concentration of this solution in the apex flower bud could inhibit its lateral growth (Chen et al. 2013; Dierck et al. 2018). Moreover, at 400 mgL$^{-1}$, the flower diameter was affected such that the reduction in the number of flowers was observed to be inversely proportional to the diameter of the blooming flower due to the assimilation competition between the flower buds (Kozlowska et al. 2011). The size of the flower diameter was larger when the number of total flower buds was reduced (Carvalho et al. 2006). The results showed the harvesting time for all the varieties with 0 mgL$^{-1}$ GA$_3$ concentration was 105 days while the exogenous application of GA$_3$ at 400 mgL$^{-1}$ significantly accelerated it up to 96 DAP for ‘Yastayuki’. However, the exogenous GA$_3$ increased endogenous GA$_3$ and IAA in ‘Socakawani’ flower bud but it did not decrease the number of flower buds. It might be, transportation of endogenous IAA to axillary has occurred after 71 DAP. This condition caused the harvesting time was longer than ‘Yastayuki’ (98 DAP). Meanwhile, the exogenous GA$_3$ increased endogenous GA$_3$ and decreased endogenous IAA in ‘Arosuka Pelangi’ flower bud. It showed that there was transportation of endogenous IAA to axillary bud. Therefore, there was no significantly decreased the number of flower bud. Moreover, the harvesting time of ‘Arosuka Pelangi’ was fastest (92 DAP) than ‘Yastayuki’ and ‘Socakawani’.

This, therefore, proved the positive correlation between endogenous GA$_3$ and the diameter of blooming flowers at harvesting time. The average flower bud size at 84 DAP was 8 mm and it has been reported by Qi et al. (2016) that after this period, flower development moves to the pigmentation phase or S3-S4 and this means the harvesting time would be accelerated. According to Jiang et al. (2010b), cell of flower buds undergoes a differentiation process that requires more cytokinin compared to gibberellins that assist the expansion of Chrysanthemum ray florets. Therefore, the rate of blooming and increment in flower diameter was due to the speed of expansion and opening of the rolling ray florets (Martin and Gerats 1993) which further increased the number of ray florets depending on the varieties. Furthermore, the GA$_3$ treatment did not influence the increase in the number of ray florets per flower in ‘Yastayuki’ and ‘Arosuka Pelangi’ but affected ‘Socakawani’. Another factor affecting the flower diameter was the length of ray florets. In line with Zhang et al. (2012) and Li et al. (2015), the application of exogenous GA$_3$ increased the length of the ray floret by driving the cell elongation of Gerbera hybrida. However, an increase in the length was followed by a reduction in the width and thickness and this is in agreement with the positive correlation established between endogenous GA$_3$ and length and the negative relationship it has with the width and thickness of the ray florets.

From this study, 400 mgL$^{-1}$ GA$_3$ was discovered to have the best concentration required to accelerate the harvesting time in all varieties with different mechanisms.

Table 3. Correlation between endogenous GA$_3$ and the quality of Chrysanthemum cut flower

| Variable                 | 1    | 2    | 3    | 4    | 5    | 6    | 7    | 8    | 9    | 10   | 11   | 12   | 13   | 14   | 15   |
|-------------------------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
| Exogenous GA$_3$        | 1    | 1.00 |      |      |      |      |      |      |      |      |      |      |      |      |      |
| Endogenous GA$_3$       | 2    | 0.64* | 1.00 |      |      |      |      |      |      |      |      |      |      |      |      |
| Harvesting time         | 3    | -0.80* | -0.72* | 1.00 |      |      |      |      |      |      |      |      |      |      |      |
| Length of pedicels      | 4    | 0.65* | 0.62* | -0.40 | 1.00 |      |      |      |      |      |      |      |      |      |      |
| Total number of flowers | 5    | -0.48 | -0.53* | 0.63* | -0.12 | 1.00 |      |      |      |      |      |      |      |      |      |
| Number of blooming flower | 6    | -0.48 | -0.59* | 0.54* | -0.37 | 0.85* | 1.00 |      |      |      |      |      |      |      |      |
| Percentage of blooming flower | 7    | 0.12 | 0.02 | -0.32 | -0.39 | -0.46 | 0.08 | 1.00 |      |      |      |      |      |      |      |
| Diameter of blooming flower | 8    | 0.53* | 0.80* | -0.49 | 0.76* | -0.29 | -0.43 | -0.17 | 1.00 |      |      |      |      |      |      |
| Number of flower bud    | 9    | -0.25 | -0.20 | 0.45 | 0.25 | 0.73* | 0.26 | -0.93* | 0.02 | 1.00 |      |      |      |      |      |
| Diameter of flower bud  | 10   | -0.43 | -0.33 | 0.35 | -0.28 | 0.17 | 0.08 | -0.22 | -0.24 | 0.21 | 1.00 |      |      |      |      |
| Vase life               | 11   | 0.32 | 0.24 | 0.06 | 0.77* | 0.04 | -0.23 | -0.48 | 0.48 | 0.37 | -0.06 | 1.00 |      |      |      |
| Length of ray floret    | 12   | 0.30 | 0.51* | -0.30 | 0.39 | -0.08 | -0.15 | -0.08 | 0.61* | 0.05 | -0.02 | -0.03 | 1.00 |      |      |
| Width of ray floret     | 13   | -0.36 | -0.27 | 0.10 | -0.59* | -0.16 | 0.01 | 0.33 | -0.57* | -0.30 | 0.41 | -0.49 | -0.25 | 1.00 |      |
| Thickness of ray floret | 14   | -0.54* | -0.52* | 0.54 | -0.49 | 0.05 | 0.04 | -0.02 | -0.58* | 0.04 | 0.31 | -0.17 | -0.45 | 0.37 | 1.00 |
| Number of ray floret    | 15   | 0.20 | 0.10 | 0.19 | 0.64* | 0.09 | -0.19 | -0.51* | 0.36 | 0.40 | 0.03 | 0.95* | -0.15 | -0.44 | -0.05 | 1.00 |

Note: * Significant at 5% based on Pearson Correlation Test
The harvesting time of spray type without secondary branching ('Arosuka Pelangi') was faster than spray type with secondary branching ('Yastayuki' dan 'Socakawani').

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