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Effect of Paclobutrazol and 1-methylcyclopropene (1-MCP) Application on Rose (*Rosa hybrida* L.)

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ABSTRACT

Rose (*Rosa hybrida* L.) is an ornamental potted flower. Beside its beauty and varieties, its proportional shapes have also become customer's demand. This problem could be overcome by applying retardant substance in order to control the plants growth. The application of paclobutrazol and 1-Methylcyclopropene was proven to maintain the freshness of the plants (the previous experiment). The experiment was conducted in Rose Nursery Garden, Desa Cihideung, Lembang-West Java (Indonesia), in April-August 2014. The experiment was applying Randomized Group Design (RGD) consisted of seven treatments: (0 ppm+0 mL L^{-1}, 250, 500 ppm, 4, 6, 8 WAG, 0,5 mL L^{-1}). The results showed that the treatment of 500 ppm concentrations of paclobutrazol and 1-applied for 4 weeks after grafting showed the best result on the flower growth, crown display and quality.

Key words: 1-methylcyclopropene, freshness, paclobutrazol, rose

INTRODUCTION

Rose (*Rosa hybrid* L.) is a shrub, ornamental plant, often armed with sharp prickles and known as Ros or the Queen of Flower. One of the Rose variants with beautiful petals is Batik Rose. Beside its beauty, the various proportional shapes of the plants and the freshness longevity of the flower have become customer's demand. These problems could be overcome by applying retardant substance in order to slow down the plants growth. Paclobutrazol and 1-Methylcyclopropene application could maintain the freshness (previous experiment). Paclobutrazol treatment applications (1, 2, 3 ppm) at all level of treatment (mild, medium, strong) on begonian plants have produced the most-liked shapes and the color quality of flowers compared to the plants without the treatment (0 ppm) (Suradinata *et al*., 2013).

The beauty of potted flower is expected to be enjoyed longer. It also costs less because the plants can produce flowers repeatedly. However, the freshness doesn't usually last long and the flowers can shed easily. Thus, these problems need to be solved so the plants can stay fresh longer in order to improve the economic value. The descending quality and flower freshness were caused by several factors such as extreme temperature and a long dark period (Rapaka *et al*., 2008). Ethylene has been known as the main cause. Some types of ethylene inhibitors are widely used to improve flower freshness of both cut flowers and potted flowers. Those types are 2, 5-Norbornadine (2, 5-NBD), Diazocyclopentadine (DACP), STS and 1-Methylcyclopropene (Serek *et al*., 1995). Among those inhibitors, 1-Methylcyclopropene is the most commonly used because it has more benefit compared to the other types. It's also a non-toxic substance and more effective if used in low concentration.

Applying 1-Methylcyclopropene in low concentration: 0.25 μg mL^{-1}, has been able to maintain Chrysant cut flower 'Yellow Fiji'. It delayed the change of color, prevented flower from becoming withered and extended the flowers freshness longevity (Mubarok, 2012).

So, the present study was conducted to evaluate the effect of paclobutrazol and 1-Methylcyclopropene application on rose.

MATERIALS AND METHODS

The experiment was conducted in Rose Nursery Garden in Desa Cihideung, Lembang-West Java (Indonesia) in April-August 2014. The rose seeds at the age of 4, 6, 8 week after grafting; each has upper stem length±8, 15 and 15 cm; with the number of leaves±6, 8, 10 pieces and one primordial flower. The experiment design was using Randomized Group Design (RGD) with each treatments, controlled (0 ppm paclobutrazol and 0 mL L^{-1} 1-MCP), 0.5 mL L^{-1} 1-MCP (previous experiment) with paclobutrazol concentration (250, 500 ppm) at three levels of applications (at the age of 4, 6, 8 weeks after grafting). There were seven treatments with three repetitions, in which each treatment was using 2 plants at the age of 4, 6 and 8 WAG and the plants mediums consisted of chaff and manures (organic fertilizer) with a ratio 8:1 (v/v), 18 cm-diameter-size polybags. The seeds were planted in the mediums and poured with 600 mL of water based on the field capacity. After given labels, the polybags were placed in the experiment garden. The concentration of 250 and 500 ppm paclobutrazol were given once in the afternoon by being sprayed into the medium based on each concentration: 100 mL paclobutrazol/polybag (Suradinata *et al*., 2013).

Observation of plant growth and flower quality: The observed parameters during the experiments were, the growth of the plants height components, the stem diameter size, number of branches, the stalks length, number of leaves, the flowers diameter and its growth and the flowers freshness longevity. The experiment was conducted after the flower bloomed, at the age of 17, 19 and 21 Week After Planting (WAP) and when the effect of paclobutrazol had faded.

The 0.5 mL L^{-1} of 1-Methylcyclopropene was given when the bloom reached 10-25% (previous experiment). The 1-Methylcyclopropene application was conducted outside the experiment garden by placing the plants into mulches. The 1-Methylcyclopropene powder was placed in a plastic container in the middle of the mulches and was poured with some water (with the ratio 4:1 to the weight of 1-MCP). Mulches were then covered for 6 h, after that the plants were taken out of mulches and were put back into the experiment garden. Some observations were held to see the components of flower qualities such as: The stem length, diameter of bloomed flower, the flower diameter growth and on how long the bloomed flowers could stay until they died (when the end of the petals were dry). Differences are analyzed with treatment F, furthermore they were tested with Duncan Multiplied Distance Test.

RESULTS AND DISCUSSION

Plants height: Analysis of variance showed that the paclobutrazol and 1-MCP treatment had significantly affected the plants height compared to controlled (0 ppm paclobutrazol+0 mL L^{-1} 1-MCP). However, each treatment didn't show significant difference. At the age of 21 WAP treatment A, as controlled, the plant could reach 44, 42 cm high as with other treatment the plant could only reach 15.43-26.67 cm high.

The plants with paclobutrazol application were likely to have the average height growth lower than the controlled plants (Table 1). This was the effect that was caused by paclobutrazol which delayed the production of gibberellin. Runtunuwu *et al*. (2011), stated that plants height was the result of apical meristem cells division and extension stimulated by (growth regulator) gibberellin,

so that lack of gibberellin in plants may cause dwarf-plant growth. This is based on a research by Runtunuwu *et al.* (2011) that showed that paclobutrazol could affect the clove seeds to grow shorter as higher concentration of paclobutrazol was given. The same thing happened to an orchid plant which was given paclobutrazol. The paclobutrazol application delayed the growth of the orchid bud.

The inhibition of plants height growth at all treatments showed that paclobutrazol was anti-gibberellin substance that could inhibit the growth of roses. According to a study by Dick cited in Wattimena (1989) said that paclobutrazol consisted of synthetic organic compounds which could slow down the extension cell on sub-apical meristem and could also reduce the stem extension speed on responsive plants. Paclobutrazol inhibition on height and growth of rose seeds caused the plants components to grow shorter compared to ones that were with controlled treatment. Gibberellin activities, stimulating meristematic cell division and growth, were prevented by paclobutrazol the soil had absorbed. This caused reducing speed of cell division and extension so that the growth of plant height was retarded (Nasrullah *et al.*, 2012).

Stem diameter: Analysis of variance showed that paclobutrazol+1-Methylcyclopropene treatment affected significantly on the stem diameter (Table 2). The combined application of 500 ppm paclobutrazol+4 WAG+1-MCP (E) showed the smallest stem diameter 0.47 cm, at each insignificant treatment. In contrast, the controlled treatment (A) had the biggest diameter 0.63 cm. Gibberellin has a function as plant hormones to stimulate the stem cells elongation and enlargement. It is in a form of isoprenoid compounds, especially diterpene which is synthesized from acetate acetyl

Table 1: Average plants height (cm)

	Plant's height (cm)		
Treatments	17 WAP	19 WAP	21 WAP
A = Without paclobutrazol+1-MCP	38.92^{c}	42.58^{d}	44.42^{d}
B = 250 ppm paclobutrazol+4 WAG+0.5 mL L^{-1} 1-MCP	25.00^{b}	26.50^{f}	26.67^{c}
C = 250 ppm paclobutrazol+6 WAG+0.5 mL L^{-1} 1-MCP	21.18^{ab}	23.22^{bc}	23.45^{bc}
D = 250 ppm paclobutrazol+8 WAG+0.5 mL L^{-1} 1-MCP	21.10^{ab}	22.30^{bc}	22.67^{bc}
E = 500 ppm paclobutrazol+4 WAG+0.5 mL L^{-1} 1-MCP	15.35^{a}	15.43^{a}	15.43^{a}
F = 500 ppm paclobutrazol+6 WAG+0.5 mL L^{-1} 1-MCP	17.85^{ab}	18.72^{ab}	18.77^{ab}
G = 500 ppm paclobutrazol+8 WAG+0.5 mL L^{-1} 1-MCP	17.12^{ab}	17.53^{ab}	17.53^{ab}

Average values of the treatment is indicated by the same letter in the same column, show insignificant differences based on Duncan multiplied distance test on significant level 5%, WAP: Week after grafting

Table 2: Average diameter of the stems

	Stem's diameter (cm)		
Treatments	17 WAP	19 WAP	21 WAP
A = Without paclobutrazol+1-MCP	0.58^{b}	0.62	0.63
B = 250 ppm paclobutrazol+4 WAG+0.5 mL L^{-1} 1-MCP	0.52^{ab}	0.54	0.56
C = 250 ppm paclobutrazol+6 WAG+0.5 mL L^{-1} 1-MCP	0.50^{ab}	0.51	0.51
D = 250 ppm paclobutrazol+8 WAG+0.5 mL L^{-1} 1-MCP	0.48^{a}	0.52	0.54
E = 500 ppm paclobutrazol+4 WAG+0.5 mL L^{-1} 1-MCP	0.45^{a}	0.46	0.47
F = 500 ppm paclobutrazol+6 WAG+0.5 mL L^{-1} 1-MCP	0.47^{a}	0.49	0.49
G = 500 ppm paclobutrazol+8 WAG+0.5 mL L^{-1} 1-MCP	0.46^{a}	0.49	0.50

Average values of treatments indicated by the same letter in the same column show there are no significant differences according to Duncan multiplied distance test on level 5%, WAP: Week after planting

coenzyme-A through the path of mevalonic acid, forming pyrophosphate geranyl then is converted into kopalilpirofosfat and then kopalilpirofosfat is converted to kaurent. Kaurent is changed along the trajectory includes oxidation that occurs in the endoplasmic reticulum into kaurenol, kaurenal and kaurenat acid which then formed an aldehyde compound (GA12). Finally the aldehyde compounds formed gibberellin. Growth retardants substance such as paclobutrazol works by inhibiting gibberellin synthesis by inhibiting the conversion of geranil-geranil pyrophosphate into kopalilpirofosfat and hampering further process in the kaurent formation (Salisbury and Ross, 1992). The work mechanism of paclobutrazol, inhibiting biosynthesis gibberellin by slowing down the kaurene oxidation becoming kaurene acid, had caused gibberellin formation in sub-apical meristem were restrained and also slowed down cell division process in that area. In this case, paclobutrazol application showed the same result on the plants height growth inhibitor, that the inhibited gibberellin synthesis had restrained sub-apical cell elongation and division according a study by Krisnamoorthy, cited in Herlina *et al.* (1998).

Number of branches: Analysis of variance indicated that 250 ppm paclobutrazol+4, 6, 8 WAG at 17, 19, 21 WAP had shown insignificant difference as treatment A (controlled) (Table 3). However, combined treatment of 500 ppm+4, 6, 8 WAG+1-MCP had shown significant difference. Inhibited numbers of branches, produced in plants, were very closely related to the inhibited gibberellin activities by paclobutrazol. A higher concentration of gibberellin synthesis paclobutrazol would inhibit the kaurene oxidation to become kaurenat acid, thus it would slow down the process of cell division and elongation (Hasan *et al.*, 2012).

Number of leaves: Analysis of variance indicated that at the age of 17 WAP treatment showed insignificant different from treatment A (controlled) on the number of leaves (Table 4). This happened because paclobutrazol hadn't affected significantly on the leaves growth. At the age of 19 and 21 WAP all treatment seemed to give significant influence on number of leaves. Paclobutrazol application by pouring it had caused the absorption of paclobutrazol was through the roots. According to Wang *et al.* (1986), paclobutrazol absorbed through the roots would be translocated via xylem and transferred to the leaves and accumulated there. Gibberellin synthesis, inhibited by the accumulated paclobutrazol in the leaves, was suspected to cause the inhibited leaves growth. This caused the plant with paclobutrazol treatment had fewer leaves compared to the controlled treatment. The result of research conducted by Asgarian *et al.* (2013) showed that

Table 3: Average number of branches

	Number of branches (cm)		
Treatments	17 WAP	19 WAP	21 WAP
A = Without paclobutrazol+1-MCP	4^{b}	5^{c}	5^{c}
B = 250 ppm paclobutrazol+4 WAG+0.5 mL L^{-1} 1-MCP	3^{b}	4^{bc}	4^{bc}
C = 250 ppm paclobutrazol+6 WAG+0.5 mL L^{-1} 1-MCP	4^{b}	4^{bc}	4^{bc}
D = 250 ppm paclobutrazol+8 WAG+0.5 mL L^{-1} 1-MCP	3^{b}	3^{ab}	4^{bc}
E = 500 ppm paclobutrazol+4 WAG+0.5 mL L^{-1} 1-MCP	1^{a}	2^{a}	2^{a}
F = 500 ppm paclobutrazol+6 WAG+0.5 mL L^{-1} 1-MCP	1^{a}	2^{a}	2^{a}
G = 500 ppm paclobutrazol+8 WAG+0.5 mL L^{-1} 1-MCP	1^{a}	2^{a}	3^{ab}

Average values of treatments indicated by the same letter in the same column show there are no significant differences according to Duncan multiplied distance test on level 5%, WAP: Week after planting

Table 4: Average number of leaves

	Number of leaves (WAP)		
Treatments	17	19	21
A = Without paclobutrazol+1-MCP	39^{c}	47^{b}	51^{b}
B = 250 ppm paclobutrazol+4 WAG+0.5 mL L^{-1} 1-MCP	31^{b}	33^{a}	34^{a}
C = 250 ppm paclobutrazol+6 WAG+0.5 mL L^{-1} 1-MCP	28^{ab}	32^{a}	34^{a}
D = 250 ppm paclobutrazol+8 WAG+0.5 mL L^{-1} 1-MCP	26^{ab}	32^{a}	35^{a}
E = 500 ppm paclobutrazol+4 WAG+0.5 mL L^{-1} 1-MCP	22^{a}	25^{a}	26^{a}
F = 500 ppm paclobutrazol+6 WAG+0.5 mL L^{-1} 1-MCP	23^{a}	29^{a}	31^{a}
G = 500 ppm paclobutrazol+8 WAG+0.5 mL L^{-1} 1-MCP	21^{a}	25^{a}	27^{a}

Average values of treatments indicated by the same letter in the same column show there are no significant differences according to Multiplied distance test duncan on level 5%, WAP: Week after planting

paclobutrazol application on *Zinnia* affected significantly on controlled treatment, however paclobutrazol application did not show significant difference on each treatment with paclobutrazol.

Plants growth consisted of plant's height, stem diameter, number of branches and leaves with paclobutrazol treatment at 19 and 21 WAP, showed that the higher concentration of paclobutrazol given to the plants, the more decreasing those growth parameters were. A high concentration of paclobutrazol would reduce the whole development of plants. According to Chaney (2001) that when gibberellin formation was inhibited cell divisions were still continuing, however, those cells enlargement and elongation were retarded.

Flower quality

Stalk length: Treatment B, C, D were insignificantly different from controlled treatment (A), yet treatment E, F, G, showed significant difference compared to C (Table 5). Paclobutrazol concentration and different time application gave significant influence on the length of rose flower stalks which was seen in the different height of shoots with treatment A. From the result of analysis variance, it could be seen that 500 ppm paclobutrazol treatment showed significant difference compared to the other treatment of 250 ppm. According to Hasan *et al.* (2012), the higher provision paclobutrazol gibberellin synthesis is blocked, it will result in inhibition of kaurenat oxidation becoming kaurenat acid and thus it would slow the cells division and elongation.

Flower diameter: Analysis of variance showed that all treatments with the concentration of 1-MCP did not significantly affect the fluorescence (Table 5). Blooming flower diameter was suspectedly influenced by plant genetics. According to Moningka *et al.* (2012) paclobutrazol primarily influenced on vegetative growth suppression, yet on flowering (reproductive) it was a secondary effect (indirectly). Diameter size of roses was divided into three groups: Big diameter size (more than 9.5 cm), medium size (8.0-9.5 cm) and small size (less than 8.0 cm) (Darliah *et al.*, 1994). The average diameter size of bloomed flowers in this experiment was 8.18-8.41 cm. So, the flowers in this experiment were grouped into medium size flowers.

Flower diameter growth: Analysis variance indicated that giving 0.5 mL L^{-1} 1-MCP at 10-25% level of florescence were not significantly different at all stages of concentration and application time compared to the controlled treatment (A) (Table 5). During reproductive phase, flower buds will develop into anthesis (fully bloom). As a result, the higher level of florescence, the larger size of diameter. According to Lakitan (1996) flower bloomed due to the cells in the internal part of the

Fig. 1: Potted-rose displays with paclobutrazol treatment at different concentration level and grafting period+0.5 mL L^{-1}-1-MCP application, A: Without paclobutrazol and 1-MCP, B: With 250 ppm paclobutrazol+4 WAG+0.5 mL L^{-1} 1-MCP, C: With 250 ppm paclobutrazol+6 WAG+0.5 mL L^{-1} 1-MCP, D: With 250 ppm paclobutrazol+8 WAG+0.5 mL L^{-1} 1-MCP, E: With 500 ppm paclobutrazol+4 WAG+0.5 mL L^{-1} 1-MCP, F: With 500 ppm paclobutrazol+6 WAG+0.5 mL L^{-1} 1-MCP, G: With 500 ppm paclobutrazol+8 WAG+0.5 mL L^{-1} 1-MCP

Table 5: Effect of treatment on average stalk length, flower diameter, flower diameter growth and flower freshness longevity

Treatments	Stalk length (cm)	Flower diameter (cm)	Flower diameter growth (cm)	Flower freshness longevity (days)
A = Without paclobutrazol+1-MCP	7.40	8.10	0.63	10.67
B = 250 ppm paclobutrazol+4 WAG+0.5 mL L^{-1} 1-MCP	7.92	8.28	0.58	12.17
C = 250 ppm paclobutrazol+6 WAG+0.5 mL L^{-1} 1-MCP	6.20	8.29	1.35	12.33
D = 250 ppm paclobutrazol+8 WAG+0.5 mL L^{-1} 1-MCP	7.32	8.41	0.69	11.17
E = 500 ppm paclobutrazol+4 WAG+0.5 mL L^{-1} 1-MCP	5.22	8.35	0.69	11.33
F = 500 ppm paclobutrazol+6 WAG+0.5 mL L^{-1} 1-MCP	5.37	8.18	1.94	9.33
G = 500 ppm paclobutrazol+8 WAG+0.5 mL L^{-1} 1-MCP	5.55	8.21	0.59	10.00

Average values of treatments indicated by the same letter in the same column show there are no significant differences according to Multiplied distance test duncan on level 5%, WAG: Week after grafting

petals grew faster than ones in the external parts. The flower diameter growth is inversely proportional to the flower freshness longevity. The larger flower diameter growth, the shorter flower freshness will become, vice versa, the smaller flower diameter growth, the longer flower freshness will become.

Freshness longevity: Analysis of variance indicated that combined treatment with paclobutrazol at any concentration levels and different time applications and also 1-MCP application did not show significant differences (Table 5). The 1-Methylcyclopropene application was expected to reduce the flowers diameter growth, so the flowers could blossom longer. However, applying 1-Methylcyclopropene at high dose and the highest level of fluorescence did not significantly affect the flower freshness longevity. As stated by Blankenship and Dole (2002) that application of 1-Methylcyclopropene for prolonging the flower freshness longevity was influenced by many factors, some of them were the development and the maturity level of flowers. During the plants development stage, the application of 1-MCP needs to be considered as it will affect differently based on the plants maturity. According to Setyadjit *et al.* (2012), the level of

fluorescence was very determining, because if the flowers were fully bloomed, their senescence stage would happen faster so that 1-Methylcyclopropene application wouldn't be effective any longer.

The experiment result showed that treatment A (without paclobutrazol application) had mostly the highest value of all observed parameters (Fig. 1). This treatment hasn't fulfilled the criteria of potted flowers, because rose tree ass an ornamental potted flower, is generally preferred in medium size. In this experimental result, this criterion was fulfilled by all treatments with paclobutrazol because it could be seen from the growth inhibitor at the height increase while treatment A did not fulfill the criteria. Not only the tree size, potted roses has also been expected to have lush leaves, thick stem diameter, lots of branches and greener leaves.

Beside them, the flowering components have been supported to fulfill the criteria of potted flower. They are such as: The medium length of flower stalk; the medium size of flower diameter (8.0-9.5 cm) and the flower freshness longevity-more than 11 days. Based on the experiment result treatment E (500 ppm paclobutrazol+4 WAG+1-MCP) could fulfill the criteria of potted rose.

CONCLUSION

The concentration of 500 ppm paclobutrazol+4 WAG+0.5 mL L^{-1} 1-MCP application could fulfill the criteria of potted rose with more proportional plants shape and longer freshness of the flowers: 11, 33 days ass the flowers freshness with other treatment without paclobutrazol application could only last for 9, 39 days. The experiment was repeated by adding soil into the mediums. The chaff and manures medium were also used for cultivation.

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