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Research Article
Influence of Salicylic Acid on Some Physiological Responses of *Chrysanthemum* "Mai Vang"

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Abstract

Background and Objective: Salicylic Acid (SA) is a plant hormone that plays a key role in regulating many physiological processes in plants, including seed germination, plant growth, photosynthetic efficiency, crop yield, flowering and senescence. This study aimed to investigate the physiological responses of *Chrysanthemum* variety "Mai Vang" to different concentrations of SA (0, 0.5, 1.0, 1.5 and 2.0 mM). **Materials and Methods:** The *Chrysanthemum* were treated by various concentrations of SA (0.5, 1.0, 1.5 and 2.0 mM), water treatment (SA_0) was considered as control. The experiment conducted in a complete randomized design with a total of five treatments, each plot consisted of 15 plants. Duncan's multiple range test was being used for statistical analysis at the 5% level of significance ($p = 0.05$). **Results:** The SA treatments affected the content of photosynthetic pigments, proline and malondialdehyde (MDA) in leaves as well as anthocyanin in florets. Generally, SA treatments at a concentration of 0.5 and 1.0 increased the content of chlorophylls and carotenoids while decreasing the content of MDA compared to water treatments. In contrast, $SA_{1.5}$ and $SA_{2.0}$ treatments decreased the content of these pigments while enhancing the accumulation of MDA compared to control. All SA treatments displayed higher content of proline in leaves than control. Also, plants treated by SA at 0.5 and 1.0 mM exhibited higher maximum quantum yield of photosystem II (Fv/Fm) value than untreated and 1.5 and 2.0 mM of SA treated ones. **Conclusion:** The present study provides further insight into the effectiveness of SA on the physiological characteristics of *Chrysanthemum* "Mai Vang". Especially, SA at 1.0 mM had the maximum positive effect on the content of photosynthetic pigments, proline, anthocyanin and Fv/Fm index. Moreover, $SA_{1.0}$ treatments exhibited a significant decrease in MDA content compared to control.

Key words: *Chrysanthemum* "Mai Vang", salicylic acid, physiological response, photosynthetic pigment, proline, anthocyanin, malondialdehyde, maximum quantum yield of photosystem II

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Chrysanthemum (*Chrysanthemum morifolium* Ramat.) is an herbaceous perennial in the Asteraceae family. This species is one of the most economically important and favored floricultural crops traded both in pots and as cut flowers, achieved the second rank in the cut-flower trade after roses[1]. It is reported that *Chrysanthemum* is a source of various natural compounds like flavonoids[2,3] phenols[4], volatiles[3,5]. Further, the pharmacological benefits of *Chrysanthemum* flowers such as anti-inflammatory, antipyretic, sedative, anti-arthritic and anti-hypertensive effects were also reported[6]. *Chrysanthemum* is widely produced in the world, especially in China, Japan, Netherland, Korea and Vietnam[7].

The plant growth regulators affect many physiological processes in plants. Salicylic acid (SA) is considered one of the most important plants growth regulators. It plays crucial roles in both physiological aspects and plants defense responses such as seed germination, plant growth, photosynthetic efficiency, crop yield, flowering and senescence[8,9]. Many works proved that SA affected prolonging the vase life of some cut flowers such as roses (*Rosa hybrida* L.)[10,11], carnation (*Dianthus caryophyllus*)[12], Lilium (*Lilium pumilum*)[13] and *Chrysanthemum*[14]. In detail, SA decreased the content of MDA while increasing the antioxidant activities in roses[10]. Similarly, SA treatments inhibited the increase of MDA in parsley (*Petroselinum crispum* L.)[15]. Therefore, it is reported that SA was inefficient in extending the longevity of carnation through decreasing lipid peroxidation[12].

Due to the unknown knowledge of SA's roles on the physiological responses of *Chrysanthemum* "Mai Vang" recently, studies of this effect will provide scientific and practical benefits for farmers in horticultural production. The present study aimed to explore the influence of SA on some physiological responses of *Chrysanthemum* "Mai Vang" focused at the flowering stage.

MATERIALS AND METHODS

Study area: This study was conducted at the greenhouse at the Faculty of Natural Sciences, Hung Vuong University, from October, 2018 to March, 2019 period.

Materials: *Chrysanthemum* "Mai Vang" seedlings micropropagation originated were acclimatized the potted. SA was soluble in distilled water and was easily dissolved at lower concentrations. Four levels of SA namely, 0.5, 1.0, 1.5 and 2.0 mM of concentrations and water were used in this experiment.

Research procedure: Acclimatized *Chrysanthemum* "Mai Vang" seedlings at a 4 week-old stage with a height of 10±1 cm were transferred into a plastic pot (size of 15×18 cm in diameter×height) containing 2000 g soil and compost. Four months after transferring, most plants which had the average height 50±5 cm and main flower (at terminal flower bud on the apex of the main stem) at stage 4 according to Preece and Wilcox[16] were treated by foliar spraying 50 mL SA solution at different concentrations 0.5 ($SA_{0.5}$), 1.0 ($SA_{1.0}$), 1.5 ($SA_{1.5}$) and 2.0 ($SA_{2.0}$) mM. Distilled water (SA_0) treatment was considered as control. The experiment was a complete randomized design with a total of five treatments. Each plot consisted of 15 plants.

The Fv/Fm was measured by OS30p+(Opti-Sciences, Inc., USA). The measurements involved the third leaf of each plant. Mature leaves and/or flowers randomly sampled every 5 days after SA application, D_0, D_5, D_{10} and D_{15}, respectively from each experimental plot were used to analyze the physio-biochemical characteristics.

Chlorophyll and carotenoids were extracted from 1 g of fresh leaf by 80% acetone before absorbance measurements at 663, 647 and 470 nm using UV-VIS GENESYS 10 uv (Thermo Electron Corporation, USA). Content of chlorophyll a, total chlorophyll (a+b) and carotenoids (μg g^{-1} FW) was calculated according to Lichtenthaler[17]. Proline was extracted from 0.1 g of fresh leaves by 3% sulfosalicylic acid then estimated according based on reaction with ninhydrin as described by La *et al.*[18]. MDA was extracted from 0.2 g of fresh leaves then determined in terms of Thiobarbituric Acid Reactive Substances (TBARS) concentration[19]. The absorbance of the centrifuged supernatant of mixture reaction was measured at 532 nm for MDA using UV-VIS GENESYS 10 uv (Thermo Electron Corporation, USA). The TBARS concentration was calculated using its absorption coefficient of 155 mM^{-1} cm^{-1} for MDA as described by Alamer and Fayez[15]. Anthocyanins were extracted from 0.2 g of petals by ethanol concentrated HCl (pH = 1) as previously described study[20] before absorbance measurements at 530 and 657 nm using UV-VIS GENESYS 10 uv (Thermo Electron Corporation, USA). The corrected value of absorbance was calculated (A530-0.25 x A657) to eliminate the absorbance of chlorophyll and degradation products[21].

Statistical analysis: Statistical analysis of all data was performed by using the ANOVA and means separated by Duncan's multiple range test at the 5% level of significance ($p = 0.05$).

RESULTS AND DISCUSSION

Influence of salicylic acid on photosynthetic pigment contents in leaves: In this study, contents of photosynthetic pigments, including chlorophyll a, total chlorophyll (chlorophyll a+b) and carotenoids, following SA treatments were determined and presented in Table 1-3.

The chlorophyll a content continued to decline over time from D_0-D_{15} in SA_0 treatment. Similarly, a decreased trend of chlorophyll a content from D_0-D_{15} was observed in $SA_{2.0}$ treatment, too. In contrast, the content of this pigment increased from D_0-D_{15} in $SA_{1.0}$ treatment. In the rest two SA treatments, $SA_{0.5}$ and $SA_{1.5}$, respectively, the chlorophyll a content firstly increased (from D_0-D_5) then decreased from D_5 ($SA_{1.5}$ treatment) or D_{10} ($SA_{0.5}$ treatment) to D_{15} (Table 1). The highest value of chlorophyll a content was remarked in $SA_{1.0}$ treatment at all time points. The contents of chlorophyll a in $SA_{0.5}$ and $SA_{1.0}$ (1583 and 1649 μg g^{-1} FW at D_5, 1584 and 1714 μg g^{-1} FW at D_{10} and 1512 and 1754 μg g^{-1} FW at D_{15}, respectively) were significantly higher than that in the SA_0 (1535 μg g^{-1} FW at D_5, 1452 μg g^{-1} FW at D_{10} and 1348 μg g^{-1} FW at D_{15}, respectively). However, the effect of $SA_{1.5}$ and $SA_{2.0}$ treatments on chlorophyll a content was fluctuated. At D_5, in compared to SA_0 treatment, the relative increases by 105.2 and 104.6% of chlorophyll a content were observed in $SA_{1.5}$ and $SA_{2.0}$ treatments, respectively. In contrast, at D_{15}, the content of chlorophyll a in $SA_{1.5}$ (1133 μg g^{-1} FW) and $SA_{2.0}$ (983 μg g^{-1} FW) was significantly lower than that in SA_0 treatment (1348 μg g^{-1} FW), with a decrease of 15.9 and 27.1%, respectively.

Generally, SA treatments led to a similar change in total chlorophyll compared to chlorophyll a content (Table 2). The highest value of total chlorophyll content was observed in $SA_{1.0}$ treatment at each day after treating. The content of total chlorophyll in SA_0 treatment exhibited relatively lower levels than that in $SA_{1.0}$ treatments but higher levels than that in $SA_{0.5}$, $SA_{1.5}$ and $SA_{2.0}$ treatments. In detail, in comparison to in SA_0 treatment (2014 μg g^{-1} FW), the total chlorophyll content in $SA_{0.5}$ (2271 μg g^{-1} FW), $SA_{1.0}$ (2605 μg g^{-1} FW), $SA_{1.5}$ (1706 μg g^{-1} FW) and $SA_{2.0}$ (1520 μg g^{-1} FW) reached relative values of 111.3, 129.4, 84.7 and 75.5% at D_{15}, respectively.

Content of carotenoids in leaves of *Chrysanthemum* "Mai Vang" exhibited variations in different treatments during experiment time points (Table 3). In SA_0 treatment, the content of carotenoids remained stable from D_0-D_5 then declined from D_5-D_{15}. Similarly, this variation pattern was observed in $SA_{1.0}$ treatment. However, no significant change in carotenoids content was detected during all experiment time points in $SA_{0.5}$ treatment. The carotenoids content was unchanged (in $SA_{2.0}$ treatment) or slightly increased (in $SA_{1.5}$ treatment) from D_0-D_5 then rapidly declined from D_{10}-D_{15} in two remained SA treatments. The content of carotenoids in $SA_{1.0}$ treatment was higher than that in other treatments at D_5, D_{10} and D_{15}. The $SA_{0.5}$ and $SA_{1.0}$ treatments enhanced the accumulation of carotenoids compared to SA_0 treatment. In contrast, $SA_{1.5}$ and $SA_{2.0}$ treatment decreased carotenoid content at the end of the experiment. At D_{15}, in comparison to in SA_0 treatment (178 μg g^{-1} FW), the carotenoids content in $SA_{0.5}$ (223 μg g^{-1} FW), $SA_{1.0}$ (252 μg g^{-1} FW), $SA_{1.5}$

Table 1: Influence of salicylic acid on chlorophyll a content in *Chrysanthemum* "Mai Vang" leaves (μg g^{-1} FW)

Treatments	D_0	D_5	SA_0 treatment (%)	D_{10}	SA_0 (%)	D_{15}	SA_0 treatment (%)
SA_0	1538±13^{Af}	1535±27^{Cf}	100.0	1452±53^{Cg}	100.0	1348±25^{Ch}	100.0
$SA_{0.5}$	1526±22^{Ag}	1583±22^{Bf}	103.1	1584±52^{Bf}	109.0	1512±57^{Bh}	110.2
$SA_{1.0}$	1524±06^{Ah}	1649±12^{Ag}	107.4	1717±67^{Af}	118.4	1754±37^{Af}	130.2
$SA_{1.5}$	1530±15^{Ag}	1615±12^{Bf}	105.2	1497±65^{BCg}	103.1	1133±61^{Dh}	84.1
$SA_{2.0}$	1534±19^{Af}	1605±14^{Bf}	104.6	1248±73^{Dg}	86.0	0983±24^{Eh}	72.9

Within a column, means followed by the same letter (A, B, C, D, E) are not significantly different according to Duncan's multiple range test (p = 0.05), within a line, means followed by the same letter (f, g, h, i) are not significantly different according to Duncan's multiple range test (p = 0.05), D_0: Before SA application, D_5: Five days after SA application, D_{10}: 10 days after SA application and D_{15}: 15 days after SA application, SA: Salicylic acid, Mean±SD (μg g^{-1} FW)

Table 2: Influence of salicylic acid on total chlorophyll content in *Chrysanthemum* "Mai Vang" leaves (μg g^{-1} FW)

Treatments	D_0	D_5	SA_0 treatment (%)	D_{10}	SA_0 (%)	D_{15}	SA_0 treatment (%)
SA_0	2304±29^{Af}	2300±36^{Cf}	100.0	2223±63^{Bf}	100.0	2014±75^{Cg}	100.0
$SA_{0.5}$	2272±27^{Ag}	2356±11^{Bf}	102.4	2341±52^{Bf}	105.7	2271±44^{Bg}	111.3
$SA_{1.0}$	2319±17^{Ah}	2510±22^{Ag}	109.1	2607±78^{Af}	116.4	2605±49^{Af}	129.4
$SA_{1.5}$	2286±21^{Af}	2385±63^{Bf}	103.7	2255±105^{Bf}	101.4	1706±79^{Dg}	84.7
$SA_{2.0}$	2296±36^{Af}	2384±47^{Bf}	103.7	1925±75^{Cg}	86.6	1520±31^{Eh}	75.5

Within a column, means followed by the same letter (A, B, C, D, E) are not significantly different according to Duncan's multiple range test (p = 0.05), within a line, means followed by the same letter (f, g, h, i) are not significantly different according to Duncan's multiple range test (p = 0.05), D_0: Before SA application, D_5: Five days after SA application, D_{10}: 10 days after SA application and D_{15}: 15 days after SA application, SA: Salicylic acid, Mean±SD (μg g^{-1} FW)

Table 3: Influence of salicylic acid on carotenoids content in leaves (μg g^{-1} FW)

Treatments	D_0	D_5	SA_0 treatment (%)	D_{10}	SA_0 (%)	D_{15}	SA_0 treatment (%)
SA_0	213±09^{Af}	208±11^{Cf}	100.0	188±50^{Cg}	100.0	178±10^{Cg}	100.0
$SA_{0.5}$	229±09^{Af}	247±23^{Bf}	118.5	233±19^{Bf}	123.7	223±08^{Bf}	127.8
$SA_{1.0}$	214±14^{Ah}	295±10^{Af}	141.7	259±10^{Ag}	143.1	252±11^{Ag}	141.0
$SA_{1.5}$	215±10^{Ag}	237±09^{Bf}	114.1	215±08^{Bg}	118.9	161±11^{Ch}	90.5
$SA_{2.0}$	212±11^{Af}	209±10^{Cf}	100.6	217±13^{Bf}	120.1	141±10^{Dg}	79.2

Within a column, means followed by the same letter (A, B, C, D) are not significantly different according to Duncan's multiple range test (p = 0.05), within a line, means followed by the same letter (f, g, h, i) are not significantly different according to Duncan's multiple range test (p = 0.05), D_0: before SA application, D_5: Five days after SA application, D_{10}: 10 days after SA application and D_{15}: 15 days after SA application, SA: Salicylic acid, Mean±SD (μg g^{-1} FW)

(161 μg g^{-1} FW) and $SA_{2.0}$ (141 μg g^{-1} FW) reached relative values of 127.8, 141.0, 90.5 and 79.2%, respectively.

SA treatments had the effect of increasing the chlorophylls content after 5 days of treatment, except $SA_{2.0}$. Particularly, SA at a concentration of 1.0 mM increased chlorophylls and carotenoids content at all times of experiment (D_5, D_{10} and D_{15}). However, compared to D_0, a decrease in the content of these pigments, especially at D_{15} was observed in SA treatments at concentrations of 1.5 and 2.0 mM. This effect may be exerted by improving the synthesis of photosynthetic pigments and/or inhibiting the degradation of these pigments when treated concentrations of SA were optimal[22,23]. Results of this study supported the previous findings from other studies that an increase in the content of photosynthetic pigments was observed in carnation treated with SA at a concentration of 100 mM[24] and in *Salvia coccinea* treated with SA at concentrations of 0.5 and 1.0 mM[25]. However, high concentrated SA might play as a stress factor and could reduce chlorophyll and carotenoid content as observed in wheat[22].

Influence of salicylic acid on Fv/Fm index: In this study, the influence of SA treatments on the maximum quantum yield of photosystem II (Fv/Fm) of *Chrysanthemum* "Mai Vang" was investigated. Results displayed that Fv/Fm decreased from D_0 to D_{15} in all treatments, especially from D_{10} to D_{15} (Fig. 1). $SA_{1.0}$ exhibited the lowest decreased level of Fv/Vm in comparison with other treatments. In addition, SA_0 treatment decreased the reduction of Fv/Fm more than $SA_{0.5}$ treatment. At D_{10} and D_{15}, value of Fv/Fm was recorded in SA treatments, including $SA_{0.5}$ (0.812 at D_{10} and 0.780 at D_{15}, respectively), $SA_{1.0}$ (0.821 at D_{10} and 0.798 at D_{15}, respectively), $SA_{1.5}$ (0.807 at D_{10} and 0.738 at D_{15}, respectively) and $SA_{2.0}$ (0.782 at D_{10} and 0.723 at D_{15}, respectively). Compared to in SA_0 treatment (0.779 at D_{10} and 0.735 at D_{15}, respectively), relative value of Fv/Fm in $SA_{0.5}$, $SA_{1.0}$, $SA_{1.5}$ and $SA_{2.0}$ treatments reached of 104.3, 105.5, 103.7 and 100.4% at D_{10} and 106.2, 108.7, 100.1 and 98.4% at D_{15}, respectively.

Thus, the treatment of SA at concentrations of 0.5 and 1.0 mM had the effect of limiting the reduction of Fv/Fm. The results of this study confirmed the role of SA in protecting the photosynthesis apparatus, limiting the decrease of Fv/Fm in Indian mustard[26], Mung Bean[27]. However, at higher concentrations (1.5 and 2.0 mM), SA decreased the Fv/Fm value in treated plants. This result involved the described decrease of chlorophylls content affected by SA at 1.5 and 2.0 mM which was an oxidative stress factor[28].

Influence of salicylic acid on proline contents in leaves: It was found that SA treatments affected the proline content of *Chrysanthemum* "Mai Vang" leaves (Fig. 2). Compared with the proline content in non-treatment, the proline content in SA treatments showed a more substantial increase from D_0-D_{15} and displayed higher levels every 5 days after treatment. At D_0, the proline content in SA treatments and non-treatment ranged from 237-246 μg g^{-1} FW. These values at D_5 were from 234-323 μg g^{-1} FW. The contents of proline in $SA_{0.5}$ (247 μg g^{-1} FW), $SA_{1.0}$ (296 μg g^{-1} FW), $SA_{1.5}$ (323 μg g^{-1} FW) and $SA_{2.0}$ (316 μg g^{-1} FW) were significantly higher than that at D_0 (234 μg g^{-1} FW), with 23, 32 and 29% of the relative increase. Proline content reached the maximum level at D_{10} in all treatments, including SA_0 (260 μg g^{-1} FW), $SA_{0.5}$ (350 μg g^{-1} FW), $SA_{1.0}$ (443 μg g^{-1} FW), $SA_{1.5}$ (464 μg g^{-1} FW) and $SA_{2.0}$ (364 μg g^{-1} FW). Thereby, the contents of proline in SA treatments at D_{10} were significantly higher than that at D_0, with increases of 46, 84, 89 and 48%, respectively. From D_{10}-D_{15}, the proline content displayed a decreased trend in $SA_{0.5}$, $SA_{1.0}$ and $SA_{2.0}$ but it was still higher than that at D_0.

The results of this study are similar to some other studies that have been reported. Proline accumulation in SA treatment was observed in mustard[26]. The increased accumulation of proline content was due to up-regulating the expression of genes encoding pyrroline-5-carboxylate synthase (P5CSA and P5CSB) and down-regulating the expression of the gene encoding proline dehydrogenase (PDH))[18] or reducing the activity of proline oxidase[26].

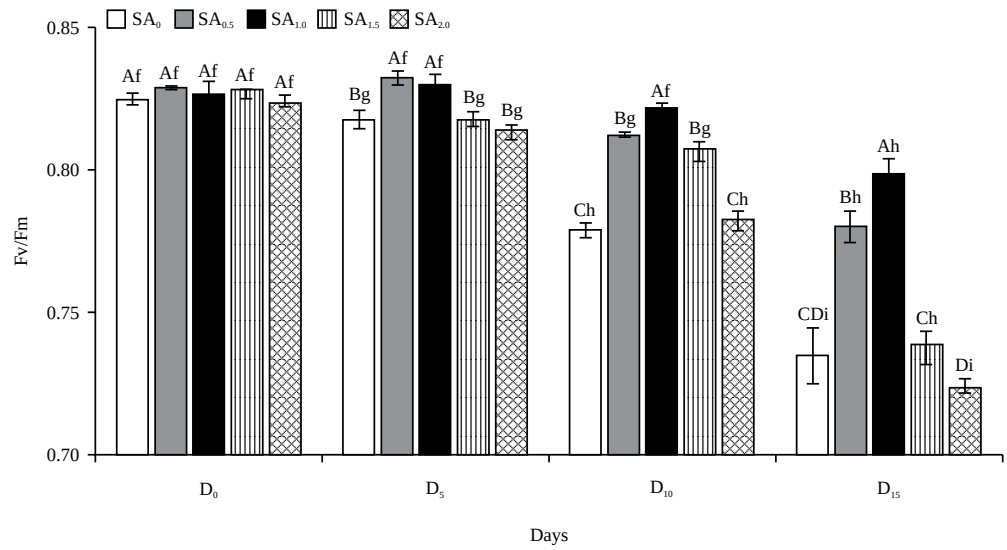

Fig. 1: Influence of salicylic acid on Fv/Fm index

Within a block, means followed by the same letter (A, B, C, D) are not significantly different according to Duncan's multiple range test (p = 0.05), within a series, means followed by the same letter (f, g, h, i) are not significantly different according to Duncan's multiple range test (p = 0.05), D_0: Before SA application, D_5: Five days after SA application, D_{10}: 10 days after SA application and D_{15}: 15 days after SA application

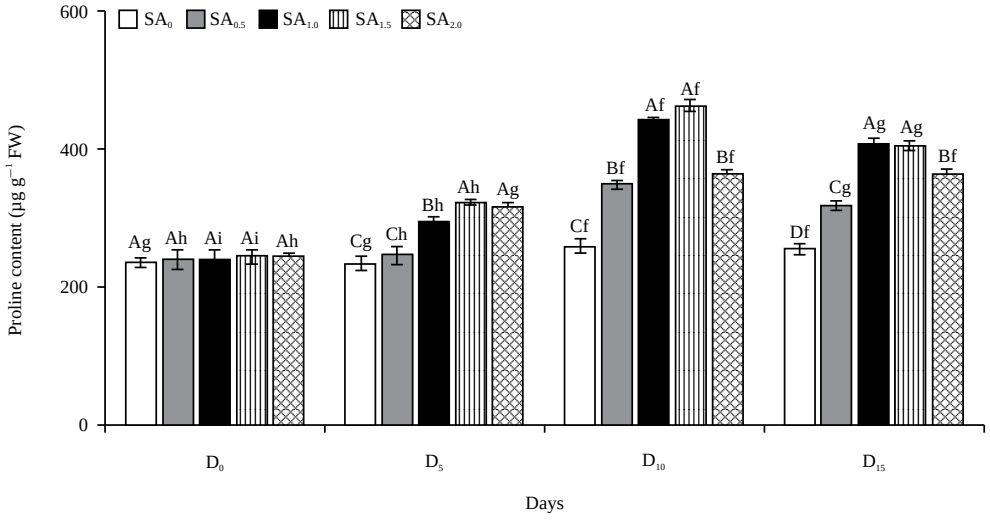

Fig. 2: Influence of salicylic acid on proline contents in leaves

Within a block, means followed by the same letter (A, B, C, D) are not significantly different according to Duncan's multiple range test (p = 0.05), within a series, means followed by the same letter (f, g, h, i) are not significantly different according to Duncan's multiple range test (p = 0.05), D_0: Before SA application, D_5: Five days after SA application, D_{10}: 10 days after SA application and D_{15}: 15 days after SA application, SA: Salicylic acid, Mean±SD (µg g^{-1} FW)

Influence of salicylic acid on malondialdehyde (MDA) contents in leaves: In the present study, in comparison with SA_0 treatment (control), a higher increase of MDA content was observed in $SA_{1.5}$ and $SA_{2.0}$ treatments at all three points of D_5, D_{10} and D_{15}, respectively (Fig. 3). An increase of MDA content from D_0-D_{15} was recorded in $SA_{0.5}$ and $SA_{1.0}$ treatment but this increase was lower than in SA_0 treatment (Fig. 3). At D_5, the level of MDA content was not significantly different from D_0 in SA_0, $SA_{0.5}$ and $SA_{1.0}$ treatments. However, the contents of MDA in $SA_{1.5}$ and $SA_{2.0}$ treatment at D_5 were higher than that at D_0. MDA content reached the maximum level at D_{15} in all treatments. From D_0-D_{15}, MDA content showed a significant increasing trend.

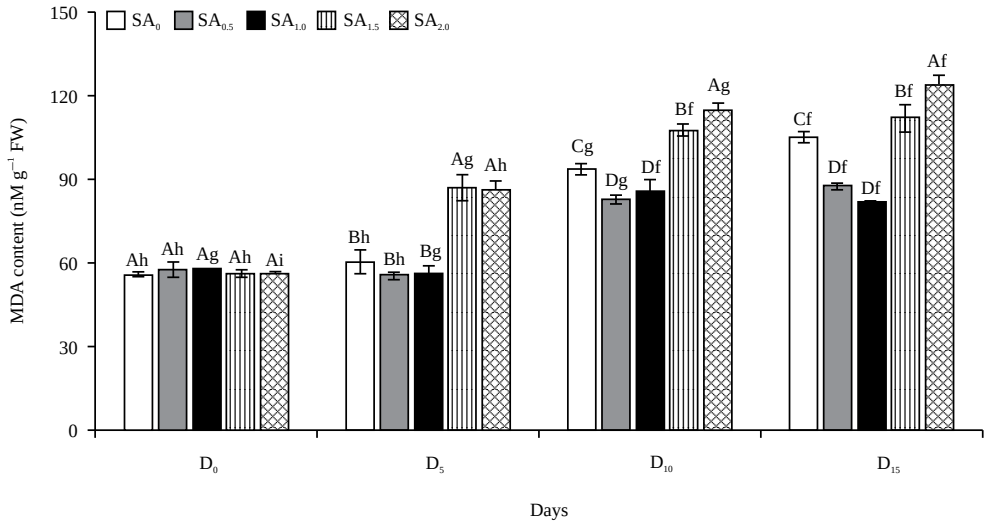

Fig. 3: Influence of salicylic acid on malondialdehyde (MDA) contents in leaves

Within a block, means followed by the same letter (A, B, C, D) are not significantly different according to Duncan's multiple range test (p = 0.05), within a series, means followed by the same letter (f, g, h, i) are not significantly different according to Duncan's multiple range test (p=0.05), D_0: Before SA application, D_5: Five days after SA application, D_{10}: 10 days after SA application, and D_{15}: 15 days after SA application, SA: Salicylic acid, Mean±SD (nM g^{-1} FW)

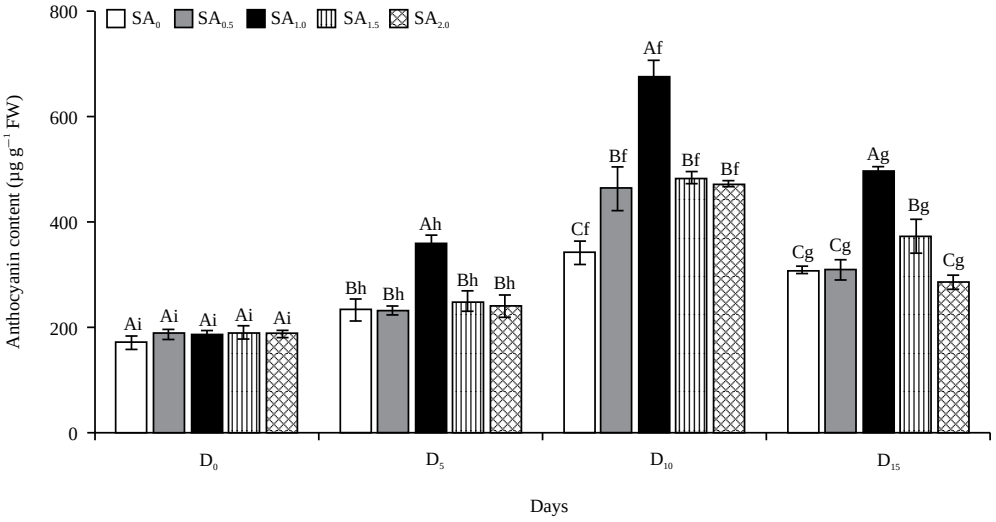

Fig. 4: Influence of salicylic acid on anthocyanin contents in florets

Within a block, means followed by the same letter (A, B, C) are not significantly different according to Duncan's multiple range test (p = 0.05), within a series, means followed by the same letter (f, g, h, i) are not significantly different according to Duncan's multiple range test (p = 0.05), D_0: Before SA application, D_5: Five days after SA application, D_{10}: 10 days after SA application, and D_{15}: 15 days after SA application, SA: Salicylic acid, Mean±SD (µg g^{-1} FW)

Thus, SA treatments at the concentration of 0.5 and 1.0 mM had the effect of reducing MDA accumulation in *Chrysanthemum* leaves compared to untreated. In contrast, SA treatments at concentrations of 1.5 and 2.0 mM increased level MDA accumulation in leaf tissue. This result was consistent with the reported investigation in parsley (*Petroselinum crispum* L.). SA treatment at a concentration of 50 mM reduced MDA content compared to untreated D_{15}. Kazemi *et al.*[10] reported that SA treatment inhibited the MDA increase in rose.

Influence of salicylic acid on anthocyanin contents in florets: Anthocyanin contents of SA-treated and non-treated *Chrysanthemum* "Mai Vang" are showed in Fig. 4. MDA content in leaves of all treated and non-treated plots showed an increasing trend from D_0-D_{10} and then declined

at D_{15}. SA at a concentration of 1.0 mM significantly increased anthocyanin content compared to the control at all time points (D_5, D_{10} and D_{15} with a relative increase of 1.5, 2.0 and 1.6-fold, respectively). At D_{10}, the anthocyanin content following all SA treatments (463, 676, 484 and 473 μg g^{-1} FW in $SA_{0.5}$, $SA_{1.0}$, $SA_{1.5}$ and $SA_{2.0}$, respectively) reached the maximum and was significantly higher than that following SA_0 treatment (342 μg g^{-1} FW). At D_{15}, only two SA treatments at a concentration of 1.0 and 1.5 mM resulting in enhanced anthocyanin content compared to control. Similar to current results, exogenously applied SA at 50 μM increased the accumulation of anthocyanin in parsley leaves (*Petroselinum crispum* L.)[15]. The result of the present study is in agreement with recent studies in *Pistacia chinensis* 6-month-old seedlings following the application of salicylic acid at a concentration of 0.07, 0.14 and 0.21 g L^{-1} [29].

CONCLUSION

This study allows investigating the effectiveness of SA on the physiological characteristics of *Chrysanthemum* Mai Vang. Photosynthetic pigments content displayed a higher value in $SA_{0.5}$ and 1.0 treatments but lower in $SA_{1.5}$ and $SA_{2.0}$ treatments than that in control. In contrast, MDA content was enhanced by $SA_{1.5}$ and $SA_{2.0}$ treatments while decreased by $SA_{0.5}$ and $SA_{1.0}$ treatments compared to water treatment. All SA treatments exhibited higher content of proline in leaves than control. In addition, plants treated by SA at 0.5 and 1.0 mM exhibited higher Fv/Fm value than untreated and other SA treated ones. Particularly, SA at 1.0 mM had the highest positive effect on the content of photosynthetic pigments, proline, anthocyanin and maximum quantum yield of photosystem II (Fv/Fm) while decreased significantly MDA content in comparison with control.

SIGNIFICANCE STATEMENT

This study showed the influence of SA at different concentrations (0.5, 1.0, 1.5 and 2.0 mM) on some physiological response of *Chrysanthemum* "Mai Vang". Results demonstrated SA at 1.0 mM had a positive effect on photosynthetic pigments, proline and anthocyanin accumulation. Moreover, $SA_{0.5}$ and $SA_{1.0}$ treatments decreased MDA content in leaves. These results allowed suggesting SA at 1.0 mM could be used to protect potted *Chrysanthemum* "Mai Vang". This study will help the researchers to uncover the critical areas of preservation techniques that many researchers were not able to explore.

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