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# EFFECTS OF PRE-HARVEST TREATMENTS OF METHYL JASMONATE, POTASSIUM SILICATE AND SALICYLIC ACID ON IMPROVING FRUIT QUALITY OF POMEGRANATE CV. 'WONDERFUL'

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## ABSTRACT

In Egypt, Pomegranate is one of the most important fruit crops used for local consumption as well as for export. The present investigation was conducted during 2019-2020 in a commercial pomegranate orchard at ElBehera governorate, Egypt to investigate the effect of pre-harvest treatments of methyl jasmonate, potassium silicate and salicylic acid on improving yield and fruit quality of pomegranate cv. 'Wonderful'. The experiment was arranged in randomized complete block design (RCBD) with eight treatments including control, 100 ppm methyl jasmonate (MJ), 1% potassium silicate (PS) 48% K2O, 100 ppm Salicylic acid (SA), and the combinations among them. The obtained result reveled that all treatments with Salicylic acid (SA) surpassed the rest of the treatments in their positive effect on the yield and quality attributes followed by methyl jasmonate (MJ) and potassium silicate (PS) treatments. The treatment (T7) MJ at 100ppm + PS at 1% + SA at 100ppm was the most effective treatments for producing the greatest values of yield (8.35 t/fed.), fruit weight (331.2g), aril weight (257.85 g), fruit diameter (10.97cm), total soluble solids (23.59%), total sugars (19.5%), vitamin C (24.32 mg/100ml) and anthocyanin content (42.41 and 52.78 mgCy 3-glu/100 g fresh fruit) in both peel and juice, respectively. Previous treatment could be recommended under similar experimental conditions.

**Keywords:** Pomegranate, anthocyanin, methyl jasmonate, potassium silicate, salicylic acid, quality.

## 1. INTRODUCTION

In Egypt, Pomegranate (*Punica granatum* L.) is considered as the 5th largest fruit crops as total cultivated area, following citrus, grapes, mango and banana. The total area of pomegranate increased up to 80098 feddan, producing 650000tons with average of 8.5 tons/feddan according to the statistics of Egyptian, Ministry of Agriculture and Land Reclamation (Bulletin of the Agricultural Statistics, 2019). Due to the health benefits of pomegranate fruits, consumers have shown a strong interest in them in recent years (Opara et al. 2009; Viuda-Martos et al. 2010b and Hellen et al. 2014).

The acceptability of a pomegranate to the consumer and processor is determined by a combination of several quality attributes related to physicochemical properties such as attractive skin, small seeds in the aril, skin colour, smoothness, sugar, vitamin C, and anthocyanin content (Al- Said et al. 2009). A remarkable promotion was observed on growth aspects, nutritional status of the trees, yield and fruit quality in different fruit crop species due to applications of methyl jasmonate, salicylic acid and potassium silicate (Osman, 2014; Ayed, 2014; Abd El-Rady 2015;Martínez-Esplá et al. 2014; Ahmed et al. 2015; Serrano et al., 2018a and García-Pastor

et al. 2019b). Wang et al. (2008) found that using methyl jasmonate (MJ) increased the red colour, anthocyanin, β-carotene contents, and several phenolic compounds in pomegranate and blackberry fruits (*Rubus sp*.). Moreover, El- Gioushy (2016) reported that using of potassium silicate and salicylic acid improved yield and fruit quality of Washington navel orange.

Therefore, this study aimed to investigate the effect of pre-harvest treatments of methyl jasmonate, potassium silicate and salicylic acid on improving yield and fruit quality of pomegranate cv. 'Wonderful'.

## 2. MATERIALS AND METHODS

### 2.1. Study Site:

This study was carried out during 2019-2020 on ten year old uniform cv. Wonderful pomegranate trees grown in a commercial orchard in 64 km on the Cairo-Alexandria desert road, ElBehera governorate, Egypt (latitude 30.47 ˚N, longitude 30.09˚E, and 94.5 m above sea level). Physical and chemical properties of the plantation soil and water are shown in Tables (1 and 2).

**Table 1.** Some physical and chemical characteristics in initial state of the plantation soil, Bihera governorates.

| Parameter | Value | Parameter | Value |
|---|---|---|---|
| **Particle size distribution %** | | Soluble cations (meq/$L^{-1}$) | |
| **Sand** | 90 | N | 0.1 |
| **Salt** | 5 | P | 0.44 |
| **Clay** | 5 | $Ca^{2+}$ | 8.88 |
| **Texture class** | Sandy | $K^{+}$ | 0.98 |
| **Bulk Density (g/$cm^{-3}$)** | 1.68 | $Na^{+}$ | 12.8 |
| **Organic matter %** | 0.06 | $Mg^{2+}$ | 7.65 |
| **Field Capacity (%)** | 12.6 | Soluble anions (meq/$L^{-1}$) | |
| **Wilting Point (%)** | 4.38 | $Cl^{-}$ | 14.9 |
| **$CaCO_3$** | 17.5 | $SO_4^{2-}$ | 3.6 |
| **pH** | 8.2 | $HCO_3^{-}$ | 11.8 |
| **E.C. (dS$m^{-1}$)** | 1.5 | $CO_3^{2-}$ | |

**Table 2.** Chemical characteristics of the plantation irrigation water, Bihera governorates.

| Parameter | Value |
|---|---|
| **pH** | 6.5 |
| **E.C. dS$m^{-1}$** | 6.44 |
| **Soluble cations (meq/$L^{-1}$)** | |
| **$Ca^{2+}$** | 20.4 |
| **$Mg^{2+}$** | 8.95 |
| **$Na^{+}$** | 33 |
| **$K^{+}$** | 2.01 |
| **Soluble anions (meq/$L^{-1}$)** | |
| **$CO3^{2-}$** | - |
| **$HCO_3^{-}$** | 20.5 |
| **$Cl^{-}$** | 39.3 |
| **$SO4^{2-}$** | 4.59 |

The trees are planted in a sandy soil at 3 x 3 m apart, under drip irrigation system and were subjected to cultural practices which usually done in this orchard. All spraying treatments were applied three times at the end of March, full fruit set and one month later for each season. Each treatment was repeated three times (three trees per each one). The experiment was arranged in randomized complete block design (RCBD) with eight treatments including control, 100 ppm methyl jasmonate (MJ), 1% potassium silicate (PS) 48% $K_2O$, 100 ppm salicylic acid (SA), and the combinations among them. At harvest time when fruits become fully colored (third week of October) in both seasons, samples of five fruits per tree were collected randomly for the following Measurements:

## 2.2. Yield and Fruit Physical Properties:

Average total yield were calculated as t/fed., in a fruit sample of five fruits from each tree; fruit weight (g), peel weight (g), aril weight (g), and fruit diameter (cm) were measured. Also fruit peel color (one measurement at one point on the equatorial region of each individual fruit) was assessed, using Minolita Chroma Meter CR-2000 on the basis of the CIELAB color system (L*, a*, b*, C*), L*, a* and b* describe a three-dimensional color space, where L* (Lightness) is the vertical axis and its value varies from 100, for perfect white to zero, for black. Chroma (C*) describes the length of the color vector. C* and ho values are calculated based on a* and b* values according to the Eq. Chroma (C*) = $(a*2+b*2)^{0.5}$.

## 2.3. Fruit Chemical Properties:

In a fruit sample of five fruits from each tree; percentage of total soluble solids (TSS), total sugars (%) Acidity, total sugars and vitamin (C) were measured. Total soluble solids (TSS %) was determined in the pulp juice using a digital refractometer according to (A.O.A.C., 1995). Total titratable acidity (TA%) as malic acid in the pulp juice was determined by titra-tion with 0.1 N of NaOH solution using phenol-phethalein (1%) as an indicator according to (A.O.A.C., 1995), TSS/TA ratio (calculated by divining TSS by TA) and total sugars were determined according to the method described by (A.O.A.C., 1995). Vitamin C was determined by titration with 2,6-dichlorophenolindophenol blue dye as mg ascorbic acid/100ml juice according to the A.O.A.C (1995). Total anthocyanin content was determined according to the method of Martinez and Favret (1990). Results were expressed as milligram of cyanidin-3-glucoside (Cy 3-glu) equivalents per gram of fresh weight.

## 2.4. Statistical Analysis:

The obtained data in both seasons were subjected to analysis of variance, using Statistix 9.0 program (Analytical Software, Tallahassee, FL. USA). Mean values were compared by the Duncan's multiple range test at 0.05 % level (Duncan 1955).

# 3. RESULTS AND DISCUSSION

## 3.1. Yield and Fruit Physical Characters:

Data obtained in both seasons showed that yield and fruit physical characters (fruit weight, peel weight, aril weight, and fruit diameter) were significantly affected by the tested treatments in comparison with the water sprayed control (Table 3). The results cleared that all the treatments containing salicylic acid (SA) increased yield, fruit weight, aril weight, and fruit diameter as compared with methyl jasmonate (MJ), potassium silicate (PS) treatments and control. In this respect, the treatment T7 (MJ at 100ppm + PS at 1% + SA at 100ppm) gave the highest values of yield ( 8.35 t/fed.), fruit weight (331.2g), aril weight (257.85 g), and fruit diameter (10.97cm), respectively. While the lowest values of yield (8.01t/fed.), fruit weight (328.23g), aril weight (127.71 g) and fruit diameter (9.54cm) were recorded in the treatment T2 (T2= PS at 1%), respectively. The present results was attributed to beneficial effects of salicylic acid in enhancing the tolerance of fruit crop species to biotic and abiotic stresses and the biosynthesis of sugars, amino acid and plant pigments and the promoting effect of salicylic acid on cell division. These results are in harmony with those reported by and Mohamed-Attiat, 2016 on grapevine and Abdel Aziz et al. 2017 on cv Manfalouty Pomegranate. They reported that yield and yield characteristics were improved by the salicylic acid treatments.

**Table 3:** Effect of (MJ), (PS) and (SA) spraying on yield and fruit physical properties: fruit weight (g), peel weight (g), aril weight (g), and fruit diameter (cm) of cv. Wonderful pomegranate during 2019and 2020 seasons.

| Treatment | Yield t/fed. | Fruit weight (g) | Peel weight (g) | Aril weight (g) | Fruit diameter (cm) |
|---|---|---|---|---|---|
| **Control = water only** | 8.00d | 323.65f | 203.64a | 120.01e | 9.53cd |
| **T1 = MJ 100ppm** | 8.01d | 331.2d | 197.44a | 133.76cd | 9.61cd |
| **T2= PS at 1%** | 8.02d | 328.23f | 200.52a | 127.71e | 9.54cd |
| **T3= SA at 100ppm** | 8.11c | 372.55b | 191.32ab | 181.23b | 10.20b |
| **T4= M J at 100ppm + PS at 1%** | 8.08d | 343.33c | 188.12ab | 143.11c | 9.72bc |
| **T5= MJ at 100ppm + SA at 100ppm** | 8.27b | 429.00a | 178.92c | 250.15a | 10.96a |
| **T6= PS at 1% + SA at 100ppm** | 8.22b | 426.03a | 185.08ab | 250.15a | 10.88a |
| **T7= MJ at 100ppm + PS at 1% + SA at 100ppm** | 8.35a | 433.58a | 169.68cd | 257.85a | 10.97a |

Averages in the same column followed by the same letter(s) are not statistically different at 0.05% level according to Duncan's multiple range test.

## 3.2. Fruit Chemical Properties:

Data in Table (4) represented the effect of spraying various treatments on fruit chemical properties (total soluble solids (TSS), total sugars (%) acidity and vitamin C) of cv. Wonderful pomegranate during 2019and 2020 seasons. The results revealed that the treatments with salicylic acid (SA) alone or with methyl jasmonate (MJ) and potassium silicate (PS) had significantly improved fruit chemical properties as compared with the other treatments. Trees treated with combined application of MJ at 100ppm + PS at 1% + SA at 100ppm displayed highest values of total soluble solids (23.59%), total sugars (19.5%) and vitamin C (24.32 mg/100ml) in the fruit of cv. Wonderful pomegranate.

A positive influence of salicylic acid on fruit chemical characteristics of cv. Wonderful pomegranate are in agreement with those reported by Abdel Aziz et al. 2017 on cv Manfalouty pomegranate and Saqib et al. 2016 on mango. Moreover, Salama et al. 2020 observed that constituent levels of vitamin C, T.S.S., and Total sugars of pomegranate fruits treated with salicylic acid concentrations were higher than those of control fruit. The titratable acidity decreases in fruit due to the break-up of acids to sugars during respiration.

**Table 4:** Effect of (MJ), (PS) and (SA) spraying on fruit chemical properties: percentage of total soluble solids (TSS), total sugars (%) acidity and vitamin (C) of cv. Wonderful pomegranate during 2019and 2020 seasons.

| Treatment | TSS% | Total sugars (%) | Acidity % | Vitamin (C) mg/100ml |
|---|---|---|---|---|
| **Control = water only** | 15.34de | 13.82d | 1.72a | 11.26d |
| **T1 = MJ 100ppm** | 16.56cd | 14.55bcd | 1.68a | 12.81d |
| **T2= PS at 1%** | 15.78d | 13.97d | 1.71a | 11.71d |
| **T3= SA at 100ppm** | 19.55b | 16.22b | 0.98c | 16.79b |
| **T4= M J at 100ppm + PS at 1%** | 17.73c | 15.43bc | 1.30b | 14.81c |
| **T5= MJ at 100ppm + SA at 100ppm** | 23.15a | 19.35a | 0.94d | 23.87a |
| **T6= PS at 1% + SA at 100ppm** | 22.20a | 18.77a | 0.97dc | 22.77a |
| **T7= MJ at 100ppm + PS at 1% + SA at 100ppm** | 23.59a | 19.50a | 0.93d | 24.32a |

Averages in the same column followed by the same letter(s) are not statistically different at 0.05% level according to Duncan's multiple range test.

There was an increase in the anthocyanin content in both the peel and juice of the pomegranate fruits compared to the control during the two seasons of study table 5. In addition, the treatments of salicylic acid (SA) surpassed the rest of the treatments in their effect on the anthocyanin content followed by methyl jasmonate (MJ) and potassium silicate (PS) treatments, whereas, the treatment T2=potassium silicate (PS) at 100ppm gave the lowest values. The treatment (T7) MJ at 100ppm + PS at 1% + SA at 100ppm gave the highest value of anthocyanin content (42.41 and 52.78 mgCy 3-glu /100 g fresh fruit) in both peel and juice of pomegranate fruits, respectively. On the other side, the treatment T2 (PS at 1%) gave the lowest values 27.97 and 43.21 mgCy 3-glu /100 g fresh fruit in both peel and juice of pomegranate fruits, respectively. Similar to our findings on increasing anthocyanin content on pomegranate were results on plums (Serrano et al. 2018), on grape (García-Pastor 2020) and on apricot (Wang et al. 2015). The increases in anthocyanin content were attributed to an increase in the activity of phenylalanine ammonia lyase (PAL), which is the main enzyme involved in the biosynthetic phenolic pathway (García-Pastoret al. 2020b).

**Table 5.** Effect of (MJ), (PS) and (SA) spraying on anthocyanin content of peel and juice (mg Cy 3-glu /100 g fresh weight) of cv. Wonderful pomegranate during 2019and 2020 seasons.

| Treatment | Anthocyanin content (mg Cy 3-glu /100 g fresh fruit) | |
|---|---|---|
| | Peel | **Juice** |
| **Control = water only** | 27.82cde | 43.12cde |
| **T1 = MJ 100ppm** | 29.33c | 44.11c |
| **T2= PS at 1%** | 27.97cd | 43.21cd |
| **T3= SA at 100ppm** | 34.3b | 48.41b |
| **T4= M J at 100ppm + PS at 1%** | 30.93c | 45.19c |

| | | |
|---|---|---|
| **T5= MJ at 100ppm + SA at 100ppm** | 42.26a | 52.69a |
| **T6= PS at 1% + SA at 100ppm** | 40.93a | 51.79a |
| **T7= MJ at 100ppm + PS at 1% + SA at 100ppm** | 42.41a | 52.78a |

Averages in the same column followed by the same letter(s) are not statistically different at 0.05% level according to Duncan's multiple range test.

## 3.3. Color Dimensional of Peel and Juice:

The color attributes (L*, a*,b* and Chroma) of both of the peel fruits and juice differed among the tested treatments as seen in tables 6 and 7 and figure 1. All treatments with salicylic acid (SA) surpassed the rest of the treatments in their positive effect on the colour attributes followed by methyl jasmonate (MJ) and potassium silicate (PS) treatments. The treatment (T7) MJ at 100ppm + PS at 1% + SA at 100ppm gave the highest value of colour attributes (L*, a*,b* and Chroma) in both peel and juice of pomegranate fruits. On the other side, the treatment T2 (PS at 1%) gave the lowest values.

In the CIELab system, fruit color is measured using different parameters, where L* represents the lightness of a surface, while parameters such as a* and C* represent the green-red coordinates and color purity respectively. Hue angle (h°) indicates the proximity to specific colors, where the values closer to 0 or to 360 indicate a purer red. In the case of Salicylic acid treated fruit, the parameters of L*, a* and C* increased their values, while the values of h° decreased significantly.

The decrease observed in h° could be attributed to an increase of anthocyanin content, as has been reported previously (Serrano et al. 2009). These authors found a direct negative correlation between the levels of anthocyanins (cyanidin-3-glucoside) and hue angle in sweet cherry fruits and related species. In our study, MeJA applications differentially affected the color parameters, particularly in lightness. The values of a* and C* were higher in all hormonal treatments (salicylic acid and methyl jasmonate) compared to the potassium silicate treatment and control, while the value of h° was lowest. These results indicate that salicylic acid applications affect fruit color properties.

**Table 6.** Effect of (MJ), (PS) and (SA) spraying on peel colors of cv. Wonderful pomegranate during 2019and 2020 seasons.

| Treatment | L* | a* | b* | Hue angle | Chroma |
|---|---|---|---|---|---|
| **Control = water only** | 29.32cd | 11.15c | 13.07c | 47.26a | 17.17c |
| **T1 = MJ 100ppm** | 30.51c | 11.61c | 13.98c | 47.83a | 18.17c |
| **T2= PS at 1%** | 29.55cd | 11.32c | 13.42c | 47.50a | 17.55c |
| **T3= SA at 100ppm** | 34.44b | 15.93b | 16.55b | 44.54b | 22.97b |
| **T4= M J at 100ppm + PS at 1%** | 31.93c | 12.24c | 14.24c | 47.10a | 18.77c |
| **T5= MJ at 100ppm + SA at 100ppm** | 40.75a | 21.17a | 20.94a | 43.37c | 29.77a |
| **T6= PS at 1% + SA at 100ppm** | 39.79a | 20.88a | 20.38a | 43.04c | 29.17a |
| **T7= MJ at 100ppm + PS at 1% + SA at 100ppm** | 40.98a | 21.34a | 21.29a | 43.57c | 30.14a |

Averages in the same column followed by the same letter(s) are not statistically different at 0.05% level according to Duncan's multiple range test.

**Table 7.** Effect of (MJ), (PS) and (SA) spraying on juice colors of cv. Wonderful pomegranate during 2019and 2020 seasons.

| Treatment | L* | a* | b* | Hue angle | Chroma |
|---|---|---|---|---|---|
| **Control = water only** | 35.45cd | 21.15c | 23.07c | 45.67a | 23.92c |
| **T1 = MJ 100ppm** | 35.92cd | 21.61c | 23.98c | 46.06a | 24.34c |
| **T2= PS at 1%** | 35.57cd | 21.32c | 23.42c | 45.83a | 24.19c |
| **T3= SA at 100ppm** | 42.82b | 25.93b | 26.55b | 44.20b | 29.25b |
| **T4= M J at 100ppm + PS at 1%** | 36.51cd | 22.24c | 24.24c | 45.66a | 25.04c |
| **T5= MJ at 100ppm + SA at 100ppm** | 50.66a | 31.17a | 30.94a | 43.46b | 35.01a |
| **T6= PS at 1% + SA at 100ppm** | 50.31a | 30.88a | 30.38a | 43.24b | 34.86a |
| **T7= MJ at 100ppm + PS at 1% + SA at 100ppm** | 50.78a | 31.34a | 31.29a | 43.60b | 35.29a |

Averages in the same column followed by the same letter(s) are not statistically different at 0.05% level according to Duncan's multiple range test.

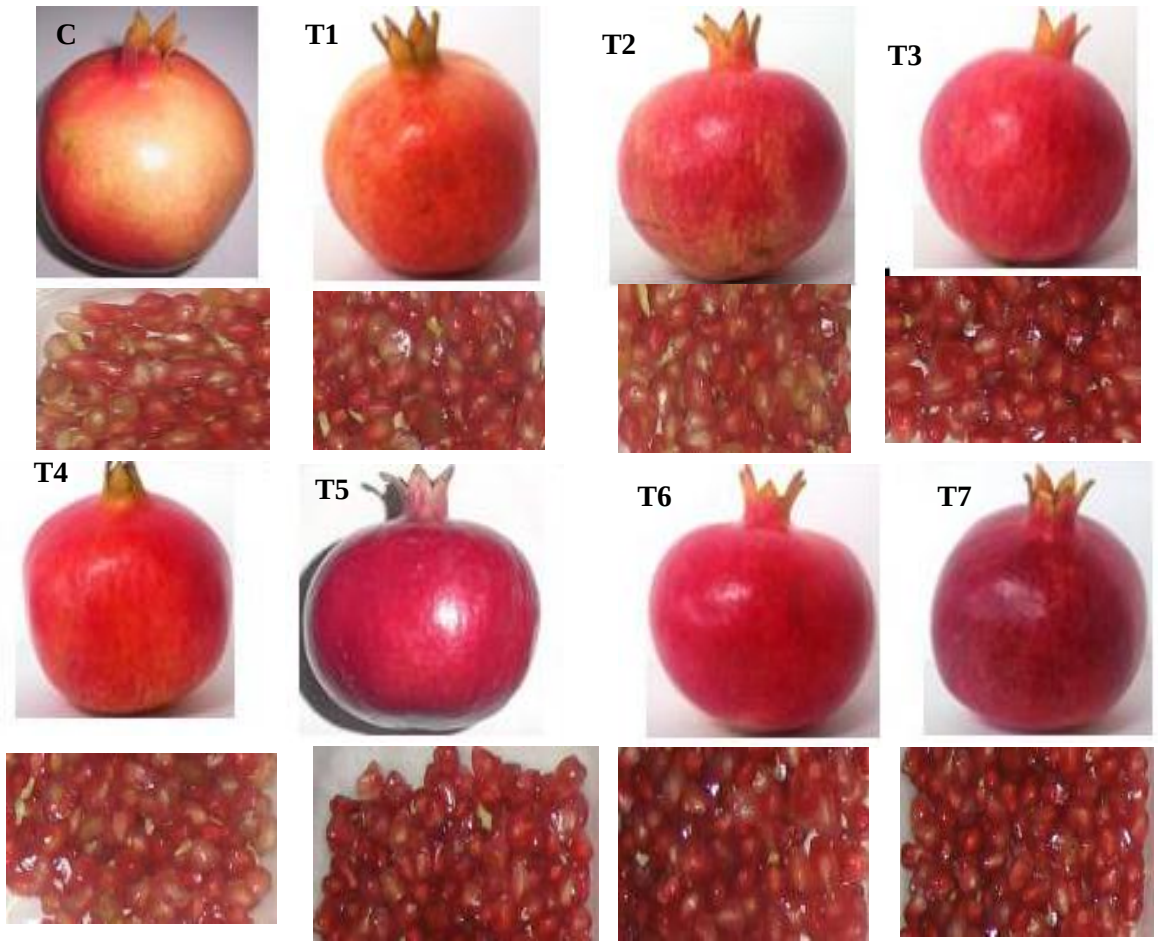


**Figure 1.** Effect of (MJ), (PS) and (SA) spraying on peel and arils colors of cv. Wonderful pomegranate during 2019and 2020 seasons.

## 4. CONCLUSIONS

It is obvious from the obtained data that all treatments with salicylic acid (SA) surpassed the rest of the treatments in their positive effect on the yield and quality attributes followed by methyl jasmonate (MJ) and potassium silicate (PS) treatments. The treatment (T7) MJ at 100ppm + PS at 1% + SA at 100ppm were the most effective treatments for producing the greatest values of yield (8.35 t/fed.), fruit weight (331.2g), aril weight (257.85 g), fruit diameter (10.97cm), total soluble solids (23.59%), total sugars (19.5%), vitamin C (24.32 mg/100ml) and anthocyanin content (42.41 and 52.78 mgCy 3-glu/100 g fresh fruit) in both peel and juice, respectively. Previous treatment could be recommended under similar experimental conditions.

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