Acta Agrobotanica

Article ID: 176280
DOI: 10.5586/aa/176280

Publication History
Received: 2023-08-31
Accepted: 2023-12-03
Published: 2024-01-25

Handling Editor
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Authors' Contributions
AK-B, MU-W: Research concept and design; AK-B, MU-W: Collection and/or assembly of data; AK-B, MU-W, GPL, PC: Data analysis and interpretation; AK-B, MU-W: Writing the article; AK-B, MU-W: Critical revision of the article; AK-B, GPL, PC: Final approval of the article

Funding
The publication was co-financed within the framework of the Polish Ministry of Science and Higher Education's program: 'Regional Initiative Excellence' in the years 2019–2023 (No. 005/RID/2018/19), financing amount 12,000,000 PLN.

Competing Interests
No competing interests have been declared.

ORIGINAL RESEARCH PAPER

The longevity of cut *Polygonatum multiflorum* (L.) All. shoots depending on postharvest handling

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Abstract

The experiment was carried out to investigate the possibility of extension of the postharvest longevity of cut shoots of *Polygonatum multiflorum* depending on the type of conditioning. The shoots were collected for three experiments in May, June, and July. The following substances were used for conditioning: gibberellic acid (in May, June, and July) at a concentration of 50 and 100 mg dm^{-3}, benzyladenine (in May) at a concentration of 50 or 100 mg dm^{-3}, and 8-hydroxyquinoline sulfate (in July) at a concentration of 200 mg dm^{-3}. The conditioning was carried out at a temperature of 5 °C or 18 °C (May, June) or 18 °C (July). After conditioning, shoots were stored in a room at a temperature of 18 °C (May, June) or at 18 °C or 22 °C (July). The shoots of *Polygonatum multiflorum* harvested in July and conditioned with gibberellic acid at a concentration of 100 mg dm^{-3} were characterized by extended longevity. Benzyladenine at a concentration of 50 mg dm^{-3} proved to be useful for conditioning. In turn, 8-hydroxyquinoline sulfate had no influence on the longevity of the shoots. The variation in the temperature during conditioning and storage was found not to have a positive impact on longevity.

Keywords

vase life; 8HQS; GA_3; BA; temperature; greenery

1. Introduction

A number of plant species are currently being tested for their suitability as cut greenery. Plants that grow in the ground are particularly recommended for this purpose, especially because cultivation can be carried out in close neighborhoods, thus increasing their availability and reducing costs (Łysiak, 2022; Poniewozik et al., 2020). Compared with cultivation under cover, it can reduce production costs (Abou Obaid et al., 2022).

Polygonatum multiflorum (L.) All. (Asparagaceae) is a plant of high ornamental value (Figure 1). This perennial is found in almost all regions of Europe and Asia (Erhardt et al., 2012; Laukli et al., 2022). Its leafy shoots are up to 0.80 m long and curved at the top. Small white flowers appear in the corners of leaves in May (Erhardt et al., 2012) and June. After flowering, the shoots continue to look attractive (Marcinkowski, 2002).

The shoots of *Polygonatum multiflorum* look very attractive, so they seem suitable for use in floral arrangements. However, the existing literature does not provide any treatment methods influencing the postharvest longevity of *Polygonatum multiflorum* shoots. As noted by Rubinowska et al. (2014) and Pogroszewska et al. (2018), the longevity of cut shoots of *Polygonatum multiflorum* 'Variegatum' harvested from the field ranges from 15 to 22 days.

Figure 1 *Polygonatum multiflorum.*

Conditioning is a method of treatment that involves the application of chemicals for a few hours after cutting the shoots or leaves. Gibberellic acid (GA_3) is the main chemical compound used for this purpose. It prolongs postharvest longevity mainly by delaying leaf yellowing (Aziz et al., 2020; van Doorn et al., 2011).

In addition, two other chemicals - benzyladenine (BA) and hydroxyquinoline sulphate (8HQS) – were initially evaluated to be used for conditioning *Polygonatum multiflorum* shoots. Benzyladenine affects cut greenery by inhibiting leaf yellowing (Abshahi et al., 2016). Stem blockage could be caused by bacteria (Rabiza-Świder et al., 2020). 8HQS is an antibacterial compound that prolongs the postharvest vase life of flowers (Han, 2000; Mirjalili et al., 2018).

Application of the agents is performed indoors at room temperature or in a cold room (Darras & Kargakou, 2019; Janowska & Andrzejak, 2022). Therefore, an attempt was made to evaluate the effect of temperature on the conditioning of *Polygonatum multiflorum*. After conditioning, cut flowers and greenery are placed in a cold room or in a florist's shop at room temperature (Darras & Kargakou, 2019). The question is whether there is a difference in the longevity of shoots kept at room temperature, varied by 4 °C during storage (18 °C and 22 °C), and during conditioning in a cooling room (5 °C) and at room temperature (18 °C).

The harvesting stage has an influence on peony (Sun et al., 2022) and narcissus (Jezdinská Slezák et al., 2022). The aim of this study was also to assess the durability of shoots harvested in different months.

2. Material and methods

2.1. Experimental materials and design

Three experiments were carried out. Leafy shoots of about 0.95–1.00 m in length were obtained from the Botanical Garden of the Adam Mickiewicz University in Poznań, Poland. The shoots were harvested from one place and from different plants from open field cultivation. The plants were grown in the shade.

Gibberellic acid is a very popular chemical for prolonging the longevity of cut greenery. It was used in each experiment. In addition, the other chemicals were tested only once - BA in May and 8HQS in July, as in the preliminary experiment.

2.1.1. The first experiment (in May)

Leafy *Polygonatum multiflorum* shoots were harvested in the flowering phase in May. After harvest, they were treated (conditioned) for 24 hours in a GA_3 solution at a concentration of 50 or 100 mg dm^{-3} or in a BA solution at a concentration of 50 or 100 mg dm^{-3}. Half of the shoots were conditioned at 5 °C, while the other half were conditioned at 18 °C. After the conditioning process, the shoots were placed in a room with a temperature of 18 °C.

2.1.2. The second experiment (in June)

Polygonatum multiflorum shoots were harvested in June. The shoots harvested at that time had only leaves. The experimental design was the same as in the first experiment. Only gibberellic acid (as the main chemical) was used for conditioning purposes for 24 hours. The GA_3 concentration and room temperature were the same as during the first experiment.

2.1.3. The third experiment (in July)

Leafy *Polygonatum multiflorum* shoots were harvested in July. They were conditioned for 24 hours indoors at 18 °C in GA_3 aqueous solutions (50 or 100 mg dm^{-3}) or in 8HQS at a concentration of 200 mg dm^{-3}. After conditioning, half of the shoots were placed in a room at 18 °C, while the remaining shoots were stored at 22 °C.

2.1.4. Procedure carried out in the three experiments

At all dates, the base of shoots (0.1 m) was immersed in a chemical solution. After conditioning (in the dark), the shoots were placed in distilled water, which was changed every three days. The shoots were illuminated with artificial light (fluorescent lamps) for 10 h/d, with a quantum irradiance of 25 µmol m^{-2} s^{-1}. The control sample consisted of unconditioned shoots, which were subsequently placed in distilled water. There were nine shoots in each experiment combination. The experiment combination involved three repetitions with three shoots each.

2.2. Measurements

The vase life of the shoots was measured in days. A decision to remove the shoots from the experiment was taken when yellow or brown spots began to appear on them (Figure 2, Figure 3). Each shoot was weighed at the beginning of the experiment and before removal. A Soil Plant Analysis Development (SPAD) chlorophyll meter was used to indicate the relative chlorophyll content on the lower and upper leaves of each shoot. The SPAD chlorophyll index was recorded on the first and last days of the experiment. These measurements were made using an N-tester (Yara-Poland, Szczecin). Following the experiment, the percentage change in fresh matter mass and the SPAD index were calculated in relation to the initial mass and SPAD index.

Figure 2 The stage of removing shoots from the experiment - yellow spots on leaves.

Figure 3 The stage of removing shoots from the experiment - brown spots on leaves.

The weight of the shoots after the experiment was smaller than the initial weight, and the result indicated the loss of shoot weight.

2.3. Statistical analysis

Statistical calculations were performed using Statistica 13.3 (TIBCO Software Inc., Palo Alto, CA, USA). The results were subjected to multivariate analysis of variance and two-way analysis of variance (shoot conditioning × conditioning temperature or shoot conditioning × storage temperature), while the means were grouped using the Duncan test at the significance level of $p = 0.05$. The Bliss transformation was used for the percentages.

3. Results

3.1. The first experiment (in May)

The longevity of the *Polygonatum multiflorum* shoots depended on the conditioning only (Table 1). There were no interactions between the two experimental factors. In each of the measured features, no correlation was found at the level of $p = 0.05$ or $p = 0.01$. However, a strong effect of the temperature application on the SPAD upper leaf change was found, as well as a large effect of the tested substances on the longevity and loss of mass ($p < 0.01$). The vase life of shoots kept in water was approximately six days (Table 2).The interaction of the experimental factors demonstrated that shoots conditioned in BA at 50 mg dm^{-3} and GA_3 at 100 mg dm^{-3} in a room at 18 °C were

Table 1 Analysis of variance (ANOVA) of the effect of different treatments on traits (the first experiment).

	df	Longevity	SPAD lower leaf change	SPAD upper leaf change	Loss mass of shoots
Temperature (A)	1	3.2^{ns}	26.5^{ns}	207.0^{**}	19.2^{ns}
Treatment (B)	4	19^{**}	20.4^{ns}	276.7^{ns}	1397.1^{**}
A × B	4	6.3^{ns}	43.9^{ns}	285.6^{ns}	163.3^{ns}
Error	80	69.6	815.5	2314.8	2234.9
CV (%)		15.5	−4351.5	931.1	−59.6

* and ** significant difference at 5% and 1% probability level, respectively; ns - not significant, CV (%) - Coefficient of Variation.

Table 2 Effect of conditioning with gibberellic acid and benzyladenine and conditioning temperature on longevity, change in chlorophyll SPAD index on lower and upper leaves, and loss of mass of shoots harvested in May in the first experiment (storage temperature of 18 °C after conditioning).

Treatment	Conditioning temperature		
	18 °C	**5 °C**	**Mean**
	Longevity (days)		
Water	6.44 ab	6.33 a	6.39 a
GA_3 50 mg dm^{-3}	6.56 ab	6.22 a	6.39 a
GA_3 100 mg dm^{-3}	7.33 bc	6.44 ab	6.89 a
BA 50 mg dm^{-3}	8.11 c	7.11 ab	7.61 b
BA 100 mg dm^{-3}	6.33 a	6.78 ab	6.56 a
Mean	6.96 a	6.58 a	
	SPAD lower leaf change (%)		
Water	−1.53 a	0.47 a	−0.53 a
GA_3 50 mg dm^{-3}	0.19 a	1.33 a	0.76 a
GA_3 100 mg dm^{-3}	0.89 a	0.68 a	0.79 a
BA 50 mg dm^{-3}	−1.7 a	0.7 a	−0.49 a
BA 100 mg dm^{-3}	−0.92 a	0.5 a	−0.21 a
Mean	−0.62 a	0.74 a	
	SPAD upper leaf change (%)		
Water	−6.89 a	1.36 b	−2.75 a
GA_3 50 mg dm^{-3}	−1.73 b	3.8 b	1.03 b
GA_3 100 mg dm^{-3}	0.77 b	3.76 b	2.26 b
BA 50 mg dm^{-3}	1.78 b	0.2 b	0.98 b
BA 100 mg dm^{-3}	1.62 b	1.63 b	1.63 b
Mean	−0.88 a	0.98 b	
	Loss mass of shoots (%)		
Water	15.77 ab	10.44 bcd	13.10 a
GA_3 50 mg dm^{-3}	16.75 a	14.66 ab	15.70 a
GA_3 100 mg dm^{-3}	12.24 abc	14.67 ab	13.45 a
BA 50 mg dm^{-3}	7.44 cd	6.67 d	7.06 d
BA 100 mg dm^{-3}	4.99 d	6.14 d	5.57 b
Mean	11.44 a	10.52 a	

Mean values marked with the same letter do not differ at the significance level $p = 0.05$ according to the Duncan's test.

characterised by relatively high longevity, respectively 8.11 and 7.33 days. The values of other experimental combinations did not differ statistically.

The SPAD value measured on the lower leaf was not affected by the temperature or the chemical used for conditioning (Table 1, Table 2). The biggest SPAD index loss on the upper leaf (6.89) was observed in the shoots placed in water at 18 °C (Table 2).

The mass of the shoots decreased in each treatment during the experiment. The mass loss depended solely on the chemical compound used for the treatment (Table 1). The use of 100 mg dm^{-3} benzyladenine at 18 °C vs. water at 18 °C slowed down (10.78%) the loss of fresh mass of *Polygonatum multiflorum* shoots (Table 2).

3.2. The second experiment (in June)

In the experiment carried out in June, an interaction between the experimental factors was found at the level of 1% probability only in the longevity of shoots (Table 3). However, the significance of this interaction had to be the greatest in the course of the treatment, i.e. the compound used and its concentration, because the p value was less than 0.01 only for this factor. The analysis of variance (Table 4) of the experimental factors showed a significant increase (53% vs. shoots in water) in the

Table 3 The influence of experimental factors on leaf features harvested in June (the second experiment).

	df	Longevity	SPAD lower leaf change	SPAD upper leaf change	Lost shoot mass
			p Value		
Temperature (A)	1	0.296^{ns}	0.828^{ns}	0.451^{ns}	0.287^{ns}
Treatment (B)	2	0.009**	0.973^{ns}	0.295^{ns}	0.581^{ns}
A × B	2	0.040*	0.621^{ns}	0.336^{ns}	0.444^{ns}
			Error		
	48	156.0	417.6	358.4	858.1
			CV (%)		
		28.3	231.3	95.3	−203.4

* and ** significant difference at 5% and 1% probability level, respectively; ns - not significant, CV (%) - Coefficient of Variation.

Table 4 Effect of conditioning with gibberellic acid and conditioning temperature on longevity, change in the chlorophyll SPAD index on lower and upper leaves, and loss of mass of the shoots harvested in June in the second experiment (storage temperature of 18 °C after conditioning).

Treatment	Conditioning temperature		
	18 °C	5 °C	Mean
	Longevity (days)		
Water	7.0 a	6.11 a	6.56 a
GA_3 50 mg dm^{-3}	6.44 a	6.67 a	6.56 a
GA_3 100 mg dm^{-3}	7.11 a	9.33 b	8.22 b
Mean	6.85 a	7.37 a	
	SPAD lower leaf change (%)		
Water	0.89 a	1.79 a	1.34 a
GA_3 50 mg dm^{-3}	1.36 a	0.87 a	1.11 a
GA_3 100 mg dm^{-3}	1.7 a	0.76 a	1.23 a
Mean	1.31 a	1.14 a	
	SPAD upper leaf change (%)		
Water	2.99 a	3.99 a	3.49 a
GA_3 50 mg dm^{-3}	2.78 a	1.39 a	2.08 a
GA_3 100 mg dm^{-3}	3.71 a	2.40 a	3.06 a
Mean	3.16 a	2.59 a	
	Loss mass of shoots (%)		
Water	2.37 a	0.10 a	1.24 a
GA_3 50 mg dm^{-3}	3.40 a	1.11 a	2.26 a
GA_3 100 mg dm^{-3}	2.25 a	3.10 a	2.68 a
Mean	2.68 a	1.44 a	

Mean values marked with the same letter do not differ at the significance level $p = 0.05$ according to the Duncan's test.

longevity of *Polygonatum multiflorum* shoots conditioned with 100 mg dm^{-3} GA_3 at 5 °C (the second experiment). Neither conditioning nor storage temperature had a significant impact on the change in the SPAD index and on the loss of mass.

3.3. The third experiment (in July)

The longevity of shoots and the other estimated features did not depend on temperature during the storage of the shoots in the third experiment (Table 5, Table 6). Only the treatment with the chemical compounds and their concentration influenced the vase life of shoots. Conditioning in 100 mg dm^{-3} GA_3 had the most beneficial effect on the shoot longevity (10.44 days) (Table 6). The lower dose of gibberellins (50 mg dm^{-3} GA_3) used at 18 °C contributed to 9.33-day longevity. However, the other compound

Table 5 Analysis of variance (ANOVA) of the effect of different treatments on traits (the third experiment).

	df	Longevity	SPAD lower leaf change	SPAD upper leaf change	Loss mass of shoots
Temperature (A)	1	19.0^{ns}	3.4^{ns}	6.3^{ns}	33.1^{ns}
Treatment (B)	3	400.4^{**}	77.8^{ns}	42.3^{ns}	297.7^{ns}
A × B	3	18.5^{ns}	109.6^{ns}	40.0^{ns}	740.2^{ns}
Error	64	427.1	1470.7	606.7	8336.7
CV (%)		49.8	96.4	174.0	−234.9

* and ** significant difference at 5% and 1% probability level, respectively; ns - not significant, CV (%) - Coefficient of Variation.

Table 6 Effect of conditioning with gibberellic acid and 8-hydroxyquinoline sulfate and storage temperature on longevity, change in the chlorophyll SPAD index on lower and upper leaves, and loss of mass of shoots harvested in July in the third experiment (conditioning temperature of 18 °C).

Treatment	Storage temperature		
	22 °C ± 1 °C	**18 °C ± 1 °C**	**Mean**
	Longevity (days)		
Water	4.44 a	4.78 a	4.61 a
GA_3 50 mg dm^{-3}	6.56 a	9.33 b	7.94 b
GA_3 100 mg dm^{-3}	10.22 b	10.67 b	10.44 c
8HQS 200 mg dm^{-3}	4.78 a	5.33 a	5.06 a
Mean	6.5 a	7.53 a	
	SPAD lower leaf change (%)		
Water	−2.9 a	−4.9 a	−3.9 a
GA_3 50 mg dm^{-3}	−3.6 a	−6.87 a	−5.23 a
GA_3 100 mg dm^{-3}	−6.67 a	−6.46 a	−6.62 a
8HQS 200 mg dm^{-3}	−5.9 a	−2.7 a	−4.3 a
Mean	−4.8 a	−5.23 a	
	SPAD upper leaf change (%)		
Water	−1.76 ab	−2.8 ab	−2.28 a
GA_3 50 mg dm^{-3}	−1.9 ab	−0.58 b	−1.24 a
GA_3 100 mg dm^{-3}	−4.12 a	−1.46 ab	−2.79 a
8HQS 200 mg dm^{-3}	−0.6 b	−1.78 ab	−0.89 a
Mean	−2.09 a	−1.50 a	
	Loss mass of shoots (%)		
Water	1.79 a	6.06 a	3.93 a
GA_3 50 mg dm^{-3}	3.43 a	9.96 a	6.69 a
GA_3 100 mg dm^{-3}	11.76 a	2.12 a	6.94 a
8HQS 200 mg dm^{-3}	0.09 a	4.17 a	2.04 a
Mean	4.22 a	5.58 a	

Mean values marked with the same letter do not differ at the significance level $p = 0.05$ according to the Duncan's test.

(8HQS) did not extend the postharvest longevity of the shoots. The longevity of the cut shoots kept in water did not exceed five days. The chemicals used and the storage temperature had no significant impact on the other characteristics tested. An exception was the small loss of upper leaf SPAD of the shoots stored at 18 °C after conditioning with 50 mg dm^{-3} GA_3 and the shoots stored at 22 °C after conditioning with 200 mg dm^{-3} 8HQS.

4. Discussion

The maximum longevity of the *Polygonatum multiflorum* shoots was approximately 11 days in July after storage at 18 °C and conditioning with 100 mg dm^{-3} GA_3. In this term, the shoots were without flowers. In June, the same kind of shoots had the longest

vase life when they were conditioned with 100 mg dm^{-3} GA_3 at 18 °C. The best longevity of the shoots with flowers harvested in May (approximately eight days) was achieved after conditioning in 50 mg dm^{-3} BA at 18 °C (approximately one day longer than after conditioning with 100 mg dm^{-3} GA_3). This is a satisfactory value for the floristry market. It is comparable to the longevity of other ornamental cut greenery, for example, *Chamelaucium uncinatum* and *Rumohra adiantiformis* (Sacalis, 1998). However, the value is lower than in the experiment conducted by Rubinowska et al. (2014) and Pogroszewska et al. (2018).

The longevity of the shoots placed in water in the first and second experiments was about 6–7 days. In the third experiment, it was shorter by about two days. Probably, the shoots that grew until June were fully developed. However, July was a good time to harvest *Polygonatum multiflorum* shoots. Although the unconditioned shoots collected at that time retained their ornamental values for no longer than five days, their longevity increased 2.2–2.3 times after conditioning in GA_3 at a concentration of 100 mg dm^{-3}. The production of endogenous gibberellins may have been lower at that time. Providing exogenous GA_3 may have improved longevity; however, this was not related to the chlorophyll content.

The positive effect of GA_3 on postharvest longevity was also observed for *Mathiola incana* (Ferrante et al., 2009), *Lilium candidum* (Han, 2000), *Zantedeschia aethiopica* (Skutnik et al., 2001), and *Weigela florida* (Rubinowska et al., 2012). Danaee et al. (2011), who studied *Gerbera jamesonii* 'Good Timing', observed some interesting results. The longest lifespan was observed for shoots conditioned in GA_3 at a concentration of 50 mg dm^{-3}. The increase in the concentration resulted in a shortening of the postharvest longevity; however, even at a concentration of 300 mg dm^{-3}, the ornamental value was maintained longer than in the case of unconditioned shoots. The observations made by Skutnik et al. (2006), who studied two cultivars of *Asparagus densiflorus* 'Myriocladus' and 'Meyerii', are also noteworthy. The former cultivar responded positively to conditioning in GA_3, whereas the latter retained its ornamental values for a considerably shorter time. The response of these cultivars to BA conditioning was similar.

In these experiments, BA had a beneficial effect on the postharvest longevity of *Polygonatum multiflorum*. The same was true for *Lilium candidum* (Han, 2000), *Anthurium andraeanum*, *Heliconia psittacorum* 'Andromeda', and *Alpinia purpurata* (Paull & Chantrachit, 2001), and *Zantedeschia elliottiana* (Skutnik et al., 2001). However, Paull and Chantrachit (2001) observed the opposite effect of BA in an experiment with *Lycopodium* and *Arundina graminifolia*. Experiments conducted in *Solidago canadensis* (Philosoph-Hadas et al., 1996), *Hypericum* × *inodorum* (Janowska & Śmigielska, 2010), and *Weigela florida* (Rubinowska et al., 2012) did not show a positive effect of BA either. Therefore, the effect is likely to depend on the plant species.

Conditioning with 8HQS did not extend the postharvest longevity of *Polygonatum multiflorum*. A negative effect of 8HQS was also reported for *Sedum spectabile* inflorescences (Ulczycka-Walorska & Krzymińska, 2015) and *Viola odorata* leaves (Ulczycka-Walorska & Krzymińska, 2022). Different results were obtained for *Allium* (Krzymińska, 2009), *Lathyrus odoratus* (Elhindi, 2012), *Antirrhinum majus* (Asrar, 2012), and *Sedum aizoon* (Krzymińska et al., 2014). We can hypothesize that the effect of the compound depends on the species of plants.

Conditioning with GA_3 in our experiment affected the SPAD value, as in *Lilium candidum* (Han, 2000), *Asparagus densiflorus*, and *A. setaceus* (Skutnik et al., 2001). Rubinowska et al. (2012) reported that the content of chlorophyll a and b increased after conditioning in both GA_3 and BA. Janowska and Śmigielska (2010), who studied *Hypericum* × *inodorum*, reached similar conclusions. In contrast, the results presented by Skutnik et al. (2001) for *Zantedeschia aethiopica* were radically different. Conditioning in GA_3, according to Philosoph-Hadas et al. (1996) and Ferrante et al. (2009), has no impact on the chlorophyll content in *Solidago canadensis* and *Mathiola incana*.

The 8HQS used for the conditioning of *Polygonatum multiflorum* did not have an effect on the SPAD value, as in *Arum italicum* (Janowska & Schroeter-Zakrzewska, 2008). Janowska and Śmigielska (2010) observed interesting results. The researchers used 8HQS at a concentration of 200 mg dm^{-3}, which led to an increase in the SPAD index

in *Hypericum* × *inodorum*. In turn, an increase in the concentration of the compound had no impact on the SPAD value.

In our experiment, the unconditioned shoots harvested in June (the second experiment) did not show differences in the leaf weight compared to those treated with GA_3 at a lower dose. This is a striking result because Bunya-Atichart et al. (2004) have shown that the application of GA_3 significantly reduces the loss of mass in cut flowers of *Curcuma alismatifolia*. Also, Janowska and Schroeter-Zakrzewska (2008) and Danaee et al. (2011) demonstrated a positive effect of GA_3 on the weight change in *Arum italicum* and *Gerbera jamesonii* 'Good Timing'. Such differences in the behavior of different plants indicate that a genetic factor is involved.

Conditioning in BA slowed down the loss of shoot mass of *Polygonatum multiflorum* and *Gerbera jamesonii* 'Good Timing' (Danaee et al., 2011). 8HQS had no impact on the percentage loss of mass in these experiments. The positive effect of 8-hydroxyquinoline sulfate is confirmed by studies on *Arum italicum* (Janowska & Schroeter-Zakrzewska, 2008), *Lathyrus odoratus* (Elhindi, 2012), and *Antirrhinum majus* (Asrar, 2012).

The temperature for cooling, storing, and transporting florists' greens is species-dependent. The conditioning temperature may be lower (4–5 or higher 18–20 °C) (Janowska & Andrzejak, 2022). The varying temperatures in our experiments had mostly no impact on the shoot longevity. The vase life of shoots, conditioned with 50 mg dm^{-3} BA, was one day longer after using a temperature of 18 °C than 5 °C. Probably, this parameter depends on the plant species.

The storage temperature for cut flowers and greenery affects their longevity and physiological processes (Darras & Kargakou, 2019).According to Fisun et al. (2002), the respiration of cut flowers of gerbera and sunflower increased exponentially with increasing storage temperature. It could be influenced by longevity. Our research did not show any differences in the changes in the lower leaf SPAD value and in the mass of shoots after exposure to temperatures of 18 °C and 22 °C. Probably, the reason was the small temperature range (4 °C). Storage temperature of 18 °C only increased the longevity of the shoots treated with GA_3 at a concentration of 50 mg dm^{-3}. A small loss of the upper leaf SPAD index was noted in shoots stored at 18 °C after conditioning with 50 mg dm^{-3} GA_3 and in shoots stored at 22 °C after the treatment with 200 mg dm^{-3} 8HQS. Based on the results, it can be concluded that cut *Polygonatum multiflorum* shoots may be useful in floristry from May to July but only after conditioning, especially in GA_3.

5. Conclusions

The longevity of cut *Polygonatum multiflorum* shoots kept in water was not more than seven days. The use of GA_3 at a concentration of 100 mg dm^{-3} for application in July and after conditioning at 5 °C in June increased the longevity of the harvested *Polygonatum multiflorum* shoots by about six days compared to the control treatment. The conditioning of the harvested *Polygonatum multiflorum* shoots in BA at a concentration of 50 mg dm^{-3} extended their postharvest longevity in May by 1–2 days compared to the water treatment. The treatment of the harvested *Polygonatum multiflorum* shoots in 8HQS at a concentration of 200 mg dm^{-3} did not prolong their postharvest longevity in July. There was no effect of the use of temperatures of 5 °C and 18 °C during conditioning on the change in the SPAD value or on the loss of mass of *Polygonatum multiflorum*. It was considered appropriate to use the temperature of 18 °C during conditioning with BA at a concentration of 50 mg dm^{-3}. The longevity of cut *Polygonatum multiflorum* shoots stored at 18 ° C or 22 °C after the treatment was the same when 50 mg dm^{-3} GA_3 and 200 mg dm^{-3} 8HQS were used for conditioning. The vase life of shoots treated with GA_3 50 mg dm^{-3} and stored at 18 °C was longer by about three days than at 22 °C.

Practical conclusion

Cut *Polygonatum multiflorum* shoots may be useful in floristry, especially when harvested in July and conditioned at 18 °C in GA_3 at a concentration of 100 mg dm^{-3}.

Acknowledgments

The authors would like to thank the Botanical Garden of the Adam Mickiewicz University in Poznań for providing the research material. We would like to thank Grażyna Naser for her help in preparing the material.

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