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EVALUATION OF EMS INDUCED MUTATION IN MORPHOLOGICAL TRAITS OF ARROWHEAD (*SYNGONIUM PODOPHYLLUM*)

Shaik Mohammad Firoze, Homraj Sahare*, Gandla Gangadhar and H.B. Lalrinawma
Department of Horticulture, School of Agriculture, Lovely Professional University, Phagwara, Punjab-144411
*Corresponding author E-mail: homraj.19822@lpu.co.in, homrajsahare82@gmail.com
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ABSTRACT

This study investigated the effects of Ethyl Methane Sulphonate (EMS) mutagenesis on *Syngonium podophyllum* (Arrowhead) by treating healthy plants with concentrations of 0.2% (T1), 0.5% (T2), 0.8% (T3), 1.0% (T4), and 1.5% (T5) for four hours, alongside an untreated control, in a Completely Randomized Design with four replications over 120 days. The results showed that 0.5% EMS (T2) produced the most favorable growth responses, including the width of leaves (7.65 cm), longest shoots (16.12 cm), and a moderate shoot number (4.12), though higher EMS doses generally reduced new leaf emergence and vine length. Root development was also negatively impacted by increasing EMS concentrations, with control plants exhibiting the highest primary root number (13.56) and root length (22.55 cm), while the 1.5% EMS treatment (T5) resulted in the reduction in root growth. The findings suggest that moderate EMS doses (0.5%) can enhance specific traits in syngonium whereas higher concentrations damaged overall plant growth and development.
Keywords: *Syngonium podophyllum,* Ethyl methane sulphonate, Mutagenesis, Vegetative growth, Morphological variation.

Introduction

The plant Syngonium, also known as Arrowhead, was first named by H.W. Schott in 1829 and later in 1851, he used the name Syngonium to specifically describe *Syngonium podophyllum*, a species from central America in the Araceae family (Croat & T.B., 1981). Syngonium is a herbaceous, evergreen perennial vine that is commonly chosen for hanging baskets and as ground cover in landscape gardening industry (Croat *et al.,* 2020). This plant can grow upward into shrubs and looked messy, so it is best placed in front of a shrub border or as a standalone feature in the landscape. New cultivated varieties have been developed either by collecting plants directly from the wild or by selectively breeding natural mutations. Therefore, to develop new and attractive features in foliage plants, reliable and well tested tools are essential. The main goal of this research is to study how different doses of EMS mutagenic treatments affect the creation of new traits in plants. Additionally, it aims to identify the genetic variations caused by these treatments in *Syngonium podophyllum*, which could help in developing improved and desirable characteristics.

Materials and Methods

This study was carried out in 2025 at the floriculture research farm under a shade net house, Department of Horticulture, School of Agriculture at Lovely Professional University Phagwara, Punjab, India. For this study, healthy and uniform Arrowhead plants (*Syngonium podophyllum*) were selected. These plants were sourced from the floriculture research farm at Lovely Professional University in Punjab. For the experiment, freshly prepared EMS (Ethyl Methane Sulphonate) solutions at varying concentrations (0.2%, 0.5%, 0.8%, 1.0%, and 1.5%) were used to treat the plant roots. In the morning, the roots of the Arrowhead plants were submerged in these chemical solutions for four hours to induce mutagenesis. For the control group, the plant roots were immersed in distilled water. After treatment, EMS treated plants were rinsed multiple times under running tap water to remove any

chemical residue. Finally, all plants were transplanted into grow bags for further observation and growth. The experimental data were analyzed statistically using a Completely Randomized Design (CRD) approach, with 4 replications for each treatment to ensure reliability of the results. The New leaf emergence was recorded on the 30th day after transplanting. Leaf width (cm), Number of shoots and shoot length (cm), Vine length (cm), Number of primary roots and primary root length (cm) data were taken every 15 days from the base to the tip of each plant, continuing until 120th day observation period. A standard measuring scale were used for all recordings to ensure consistency. The collected data was analyzed using OPSTAT software. To determine the differences between the various treatments, we conducted a one-way ANOVA test on the measured plant characteristics.

Results and Discussion

Ethyl methane sulphonate (EMS) significantly influenced new leaf emergence in *Syngonium podophyllum* (Table 1). Conversely to the control (T0: 2.81 leaves), all EMS treated plants showed reduced leaf emergence by the 30th day, with higher concentrations causing more pronounced suppression. The lowest dose, 0.2% EMS (T1: 1.75 leaves), had less effect, while 0.5% (T2: 1.31 leaves) and 0.8% EMS (T3: 1.25 leaves) further inhibited growth. Notably, the highest concentrations 1.0% (T4: 0.68 leaves) and 1.5% EMS (T5: 0.12 leaves) severely limited new leaf development, suggesting toxicity at higher concentrations. The results show that low EMS doses slightly slowed new leaf growth, while stronger doses drastically reduced it. Higher concentrations caused significant delays, likely because EMS damaged cell division and triggered harmful oxidative stress, disrupting normal development. Similarly, in the present study, the results aligned with the findings of (Tirkey *et al.,* 2019), who reported that lower concentrations of EMS helped in early sprouting. The treatment with soaked EMS @ 0.25% (T12) showed the earliest sprouting time of (14.24) days, making it the most effective. It was followed by soaked EMS @ 0.50% (T13), which recorded (14.93) days. This pattern clearly indicated that mild EMS levels had a stimulating effect, while stronger doses negatively impacted the early growth phase.

The research data revealed that ethyl methane sulphonate (EMS) treatments had a notable impact on leaf width development in *Syngonium podophyllum* (Table 2). The 0.2% EMS treatment consistently produced the widest leaves throughout the growth period, reaching 7.65 cm by 120 days even wider than untreated control plants (7.45 cm). Plants treated with moderate EMS concentrations (0.5-0.8%) showed leaf widths similar to the control, while higher doses (1.0-1.5%) progressively reduced leaf expansion. The most severe growth inhibition occurred at the highest concentration (1.5% EMS), where leaves reached only 6.40 cm by the study's end. This treatment also showed particularly strong suppression early in growth, with leaves measuring just 4.27 cm at 30 days compared to 5.75 cm in control plants. These results demonstrate that while low EMS concentrations (0.2%) may slightly enhance leaf width, higher doses (above 0.8%) increasingly inhibit normal leaf expansion, with the strongest negative effects seen at 1.5% EMS. The optimal concentration for maintaining or slightly improving leaf width appears to be 0.2% EMS. The mutagenic effect of EMS likely promoted cell enlargement and tissue development in leaves, leading to increased width. Optimal EMS concentrations may also enhance physiological processes like nutrient uptake and hormonal balance, further supporting leaf expansion. The findings of the present study were in line with those reported by (Purente *et al.,* 2020), who found that EMS treatment at 0.2% led to a significant increase in leaf width in *Chrysanthemum indicum* var *Aromaticum,* with mutant plants showing wider leaves (6.36 cm) compared to control plants (3.64 cm). This improvement in leaf size was attributed to enhanced cell division and elongation triggered by EMS induced mutations. Similar results were also observed in the present study on *Syngonium podophyllum*, where EMS at 0.5% (T2) recorded the maximum leaf width of (7.65 cm) at 120 DAT, clearly outperforming the control. Supporting this, (Suryawati *et al.,* 2023) reported that in Chrysanthemum (*Dendranthema grandiflora* Tzelev), EMS at 0.8% showed the highest leaf width (6.17 cm). These observations indicate that moderate concentrations of EMS are effective in promoting foliar expansion and improving vegetative growth in various ornamental plant species, including Syngonium.

Experimental results demonstrated that ethyl methane sulphonate (EMS) mutagenesis induced significant modifications in *Syngonium podophyllum* shoot characteristics, demonstrating differential responses in number of shoots and shoot length (cm) (Table 3). While EMS progressively reduced shoot numbers with increasing concentration (control: 6.18 shoots; 1.5% EMS: 2.81 shoots), it initially enhanced shoot length at moderate doses (0.5% EMS reached 16.12 cm vs control's 10.12 cm). However, this stimulatory effect diminished at higher concentrations (1.5% EMS dropped to 8.18 cm). The 0.5% EMS treatment (T2) produced the longest shoots but fewer in number, demonstrating that optimal mutagenesis can

promote elongation while reducing branching. These concentration dependent responses reveal EMS dual role in shoot development suppressing proliferation while temporarily stimulating elongation at intermediate doses, offering potential for tailored growth modification in breeding programs. Higher EMS concentrations likely reduced shoot number and length due to cellular damage and hormonal imbalance, which disrupted meristem activity and limited both shoot initiation and elongation. The excessive mutagenic stress may have damaged DNA function and reduced plant's ability to divide and elongate cells effectively. This led to stunted shoot growth and fewer shoots, especially at concentrations like 1.0 and 1.5%. Similar observations were made by (Kara, 2024) in *Vitis vinifera*, where EMS treatment significantly influenced shoot growth, with the Fercal genotype showing the longest shoot length (11.61 cm) at moderate EMS levels. A similar pattern was also reported by (Rajesh, 2009) in *Syngonium podophyllum*, where 2% EMS resulted in the highest number of shoots (4.0), while 0.5% EMS led to the lowest (1.6). in the present study, EMS treatment clearly affected both the number of shoots and shoot length. The longest shoots (16.12 cm) were recorded at 0.5% EMS (T2), while the shortest (8.18 cm) were found at 1.5% EMS (T5), showing that higher EMS concentrations suppressed shoot elongation, while moderate levels promoted better growth.

Syngonium podophyllum vines grew shorter when treated with EMS, and with higher concentrations causing greater reduction (Table 4).The control plants (T0) exhibited the longest vines (36.17 cm), while EMS treated plants showed progressive shortening with increasing concentrations 0.2% EMS (T1: 24.85 cm), 0.5% EMS (T2: 27.22 cm), 0.8% EMS (T3: 25.85 cm), 1.0% EMS (T4: 20.90 cm), and 1.5% EMS (T5: 12.87 cm). Notably, 0.5% EMS (T2) showed a slight recovery in vine length compared to 0.2% EMS, suggesting a non-linear response at lower doses. However, higher concentrations (≥1.0% EMS) caused severe stunting, with the 1.5% EMS treatment (T5) reducing vine length by 64% compared to the control. These results demonstrate that while low-to-moderate EMS doses (0.2-0.8%) partially suppress vine elongation, concentrations ≥1.0% drastically inhibit growth, highlighting EMS potential for developing compact varieties through controlled mutagenesis. Higher EMS concentrations negatively impacted vine length, due to stress induced inhibition of cellular processes essential for elongation. EMS at higher doses can cause genetic damage and disturb hormonal balance. This disruptions may have reduced cell division and elongation in internodal regions leading to shorter vines. While 0.5% EMS promoted vine elongation by inducing mild doses, but higher concentrations limited growth by damaging the plant's ability to maintain normal development functions. Similar findings were reported by (Song *et al.,* 2022) in *Cucumis sativus* L., where EMS induced mutations from M_2 generation significantly reduced vine length. Substantially, (Sebati *et al.,* 2024) observed that EMS treatment in *Momordica charantia* also led to shorter vines, confirming the suppressive effect of EMS on plant height. In the present study, *Syngonium podophyllum* showed a similar pattern, as higher EMS concentrations, especially 1.5% (T5), noticeably reduced vine length, supporting the effectiveness of EMS in controlling vine growth.

Ethyl methane sulphonate (EMS) treatments were found to significantly alter root development in *Syngonium podophyllum*, exhibiting concentration dependent effects (Table 5). The control plants (T0) exhibited the highest number of primary roots (13.56) and longest root length (22.55 cm). EMS treatment generally reduced both root number and length, though 0.5% EMS (T2) showed a partial recovery in root count (11.62) compared to lower doses. Root length decreased progressively with increasing EMS concentration, from 21.57 cm (0.2% EMS) to just 11.62 cm (1.5% EMS). Notably, higher EMS doses (≥0.8%) caused severe suppression, with 1.5% EMS (T5) reducing root numbers by 45% and root length by 48% compared to the control. These results demonstrate that while low-to-moderate EMS doses (0.2-0.5%) may partially maintain root growth, concentrations ≥0.8% increasingly inhibit both root proliferation and elongation, highlighting EMS potential for modulating root architecture in breeding programs. Overall, the decline in both the number and length of primary roots at higher EMS concentrations due to the toxic effects of excessive mutagen exposure. High EMS levels disrupted root meristem activity. Higher doses weakened root initiation and elongation, leading to poor root formation. The stress caused by EMS also reduced nutrient and water uptake efficiency, further surpassing root growth. The present findings agreed with (Yu *et al.,* 2016), who reported that increasing EMS concentrations suppressed root growth in radish. Similarly, in *Syngonium podophyllum*, higher EMS concentrations reduced both root number and length, while lower concentrations like 0.2% and 0.8% showed better root development.

Conclusion

This study concluded that EMS treatments had a significant impact on the vegetative growth parameters of *Syngonium podophyllum*. Among all treatments,

0.5% EMS (T2) showed the most favourable effects on certain traits. It recorded the highest leaf width (7.65 cm) at 120 days after transplanting and the longest shoot length (16.12 cm), through the number of shoots was moderately reduced (4.12) compared to the control. New leaf emergence were also reduced with increasing EMS concentrations, with the control and 1.5% EMS concentration observed only (0.12) leaves. Vine length were the best, in the control (36.17 cm), while a significant reduction were seen at higher concentrations, especially at 1.5% EMS (12.87 cm). Similarly, the number of primary roots decreased from control (13.56) to (7.45) roots (1.5% EMS), and root length dropped from (22.55 cm) to (11.62 cm)these results demonstrate that while lower to moderate EMS concentrations (especially 1.5%) can enhance specific growth traits such as shoot elongation and leaf width, at higher concentrations (≥ 1.0%) inhibit overall vegetative development. This suggests that EMS induced mutagenesis, when applied at optimal concentrations, can be a useful tool for improving ornamental plant traits in breeding programs.

Table 1 : Effect of ethyl methane sulphonate on new leaf emergence of *Syngonium podophyllum* on 30th day after transplanting

Treatments	New Leaf Emergence
T_0(Control)	2.81
T_1(Ethyl methane sulphonate 0.2%)	1.75
T_2(Ethyl methane sulphonate 0.5%)	1.31
T_3(Ethyl methane sulphonate 0.8%)	1.25
T_4(Ethyl methane sulphonate 1.0%)	0.68
T_5(Ethyl methane sulphonate 1.5%)	0.12
C.D.	0.29
SE(m)	0.09
SE(d)	0.14
C.V.	14.94

Table 2 : Effect of ethyl methane sulphonate on leaf width (cm) of *Syngonium podophyllum*

Treatments	Leaf Width (cm)						
	15DAT	30DAT	45DAT	60DAT	75DAT	90DAT	120DAT
T_0(Control)	5.30	5.75	6.15	6.47	6.75	7.10	7.45
T_1(Ethyl methane sulphonate 0.2%)	5.55	6.05	6.37	6.57	6.87	7.25	7.65
T_2(Ethyl methane sulphonate 0.5%)	5.05	5.60	5.95	6.17	6.57	6.90	7.22
T_3(Ethyl methane sulphonate 0.8%)	5.27	5.65	6.00	6.27	6.57	6.92	7.25
T_4(Ethyl methane sulphonate 1.0%)	4.97	5.05	5.37	5.65	5.92	6.30	6.82
T_5(Ethyl methane sulphonate 1.5%)	4.85	4.27	4.65	5.17	5.52	5.95	6.40
C.D.	0.36	0.32	0.28	0.32	0.29	0.26	0.22
SE(m)	0.12	0.11	0.09	0.10	0.09	0.08	0.07
SE(d)	0.17	0.15	0.13	0.15	0.13	0.12	0.10
C.V.	4.71	4.06	3.29	3.58	3.06	2.63	2.10

DAT- Days after transplanting

Table 3 : Effect of ethyl methane sulphonate on number of shoots and shoot length (cm) of *Syngonium podophyllum* at 120th day after transplanting

Treatments	Number of Shoots	Shoot Length (cm)
T_0(Control)	6.18	10.12
T_1(Ethyl methane sulphonate 0.2%)	4.87	13.31
T_2(Ethyl methane sulphonate 0.5%)	4.00	16.12
T_3(Ethyl methane sulphonate 0.8%)	3.75	14.38
T_4(Ethyl methane sulphonate 1.0%)	3.00	11.14
T_5(Ethyl methane sulphonate 1.5%)	2.81	8.18
C.D.	0.53	1.67
SE(m)	0.17	0.55
SE(d)	0.25	0.78
C.V.	8.67	9.14

Table 4 : Effect of ethyl methane sulphonate on vine length (cm) of *Syngonium podophyllum* at 120th day after transplanting

Treatments	Vine Length (cm)
T_0(Control)	36.17
T_1(Ethyl methane sulphonate 0.2%)	24.85
T_2(Ethyl methane sulphonate 0.5%)	27.22
T_3(Ethyl methane sulphonate 0.8%)	25.85
T_4(Ethyl methane sulphonate 1.0%)	20.90
T_5(Ethyl methane sulphonate 1.5%)	12.87
C.D.	2.68
SE(m)	0.89
SE(d)	1.26
C.V.	7.28

Table 5 : Effect of ethyl methane sulphonate on number of primary roots and primary root length (cm) of *Syngonium podophyllum* at 120th day after transplanting

Treatments	Number of Primary Roots	Primary Root Length (cm)
T_0(Control)	13.56	22.55
T_1(Ethyl methane sulphonate 0.2%)	9.31	21.57
T_2(Ethyl methane sulphonate 0.5%)	11.62	19.75
T_3(Ethyl methane sulphonate 0.8%)	8.93	17.60
T_4(Ethyl methane sulphonate 1.0%)	7.93	15.05
T_5(Ethyl methane sulphonate 1.5%)	7.50	11.62
C.D.	1.13	1.48
SE(m)	0.38	0.49
SE(d)	0.53	0.69
C.V.	7.73	5.48

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