Annals of Agri-Bio Research **30** (2): 12–16, 2025

Impact Score: **0.4**
(Scopus)

EMS as a Tool for Enhancing Morphological Traits and Chlorophyll Content in Arrowhead (*Syngonium podophyllum*)

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(Received: 23 April 2025; Accepted: 30 July 2025)

ABSTRACT

Syngonium podophyllum, commonly known as arrowhead, is widely used in interior scaping and home gardening due to its attractive, arrowhead-shaped leaves and tolerance for indoor conditions. Mutation breeding in Syngonium is needed to increase its adaptability for commercial multiplication and to develop new cultivars. The current research addressed to employability on various parameters *viz.* Morphological (number of leaves, leaf length (cm), plant height (cm), survival percentage (%) and Physiological (Leaf chlorophyll content, Leaf area index). The experiment was set up using a Completely Randomized Design with six treatments and four replications. The plant roots of Syngonium were treated with different concentrations of Ethyl methane sulphonate (EMS) for four hours, including with control treatment. The experiment results showed that EMS 0.5% treated plants significant increase in leaf number (8.67), leaf length (14.17 cm), chlorophyll content (32.08 SPAD unit, it measures the difference between transmittance of red 650 nm and infrared 940 nm light through the leaf, generarting a three digit spad value), and leaf area index (27.95). Whereas growth was inhibited and survival percentage was decreased in the higher doses of EMS concentrations at (1.0% and 1.5%). The experiments results indicate that EMS induced mutagenesis is an effective method for Syngonium mutation breeding, with controlled concentrations improving plant vigor and photosynthetic efficiency and excessive concentrations affecting growth and viability.

Key words: ethyl methane sulphonate (EMS), *Syngonium podophyllum*, chemical mutagenesis, leaf area index, photosynthetic efficiency

INTRODUCTION

The Syngonium or Arrowhead was originally coined in 1829 by H.W. Schott, then Syngonium was used later in 1851 by the same author to define *S. podophyllum* as a Central American species belonging to the family Araceae (Croat, 1981). Syngonium is an herbaceous, perennial and evergreen vine which is popular selection for hanging basket and ground cover in landscape gardening (Croat and Ortiz, 2020). It is also used in offices, hospitals, shops, shopfronts, conference rooms, commercial properties and hotels. Arrowhead plants are widely used in interior landscaping and home gardening due to its attractive, arrowhead-shaped leaves and tolerance for indoor conditions. The Syngonium having vast potential for improvement through mutagenesis is demonstrated by the extensive range of variation in desirable traits (Henny et al., 1999). New varieties of ornamental plants are always having demand in ornamental and landscaping industries. Therefore, well standardized tools required for developing new ornamental traits for foliage plants. The basic process of evolution is mutation, and the biological sciences have made heavy use of induced mutagenesis to supply the genetic basis of plants and as a tool for functional genomics. Considering the commercial importance of Syngonium ornamental foliage plant, the main aim of this study is to analyze how EMS mutagenic treatments influence mutagenesis at different dosages for the development of new traits. Also to find out induce mutagenic variations in the *Syngonium podophyllum*, which can be helpful for the improvement of new traits. Our research mostly focusing on to check the effect of EMS as mutagenic tool which helps in improving and modifying the morphological characters like number of leaves, plant height, survival percentage, leaf length, Leaf chlorophyll content, Leaf area index in Syngonium, these modifications are the requirements of the many landscaping industries and nurseries. This innovative changes in morphological traits of *Syngonium podophyllum* are also useful for breeders to bring new innovative varities which can be suitable for indoorscaping and outdoor landscape gardenning.

MATERIALS AND METHODS

The current research was conducted under shade net house at Floriculture research farm,

Department of Horticulture, School of Agriculture, Lovely Professional University, Jalandhar, Punjab, India in the year 2024. This study has been caried out at Jalandhar, a historic city in Punjab, falls under six agroclimatic zones of India and is situated in the central plains. The city experiences a humid subtropical climate with warm summers and chilly winters, positioned at 748 feet above sea level at 31.32° N latitude and 75.57° E longitude. Seasonal temperature variations are significant, ranging from 48 °C to 25 °C in summer and 19 °C to −10 °C in winter. The region remains mostly dry except during the southwest monsoon, with an average annual rainfall of around 600 mm. The area predominantly consists of alluvial soil. For this experiment, uniform 3-month-old 10 cm, 200 rooted healthy *Syngonium podophyllum* (Arrowhead) plants were used. Plant material of Syngonium were collected from Floriculture Research Farm, Lovely Professional University Punjab. The plant roots were treated with ethyl methane sulphonate (Sisco Research Laboratories Pvt. Ltd., Mumbai, India) in the morning hours. Freshly prepared EMS (0.2%, 0.5%, 0.8%, 1.0%, and 1.5%) concentrations were prepared by immersing the plant roots in the chemical solutions for 4 h at room temperature for absorption of mutagen. The EMS solution prepared by using distilled water as as a solvent and for the control treatment purely distilled water was used to immerse the plant roots. After the treatment the treated plants were washed thoroughly through running tap water for 2 to 3 times. The treated plants and untreated control plants were planted in growbags which all filled with freshly prepared growing media (cocopeat, vermiculite and perlite). All collected data results was statistically analyzed by a Completely Randomized Design (CRD) with 4 replications. The Chlorophyll content and Leaf area index was observed on the 120th day after transplanting. Number of leaves, Leaf length (cm), Plant height (cm) were measured using a measuring scale from the plant's basal to the tip of the plant at 15 days interval until 120 days. Survival percentage data was collected and calculated after 120 days after transplanting. The data was subjected to analyze by using opstat software (Beta version). To assess the significance of difference between treatments of observable parameters, a one way ANOVA was performed. Additionally, (LSD value, use to determine which specific group differ significantly) least significant difference were calculated at 5% probability level.

RESULTS AND DISCUSSION

The number of leaves in *Syngonium podophyllum* was considerably impacted by Ethyl methane sulphonate (Table 1), with EMS treated plants showing increased leaf production compared to the control. Plants treated with 0.5% EMS (T2) produced the highest number of leaves (8.67), indicating this concentration was the most effective, followed by 0.2% EMS (T1: 8.52 leaves) and 0.8% EMS (T3: 8.05 leaves). In contrast, higher concentrations of EMS 1.0% (T4: 7.73 leaves) and 1.5% (T5: 6.93 leaves) resulted in less number of leaves, suggesting reduced efficacy at higher doses. These findings demonstrate that moderate EMS concentrations (0.2-0.5%) significantly enhance leaf development, likely due to genetic mutations promoting cell growth, while excessive doses (≥1.0%) may inhibit optimal growth. Thus, 0.5% EMS emerges as the most effective mutagenesis agent for improving leaf production in *Syngonium podophyllum*. In lilium Litouween cultivar produced more leaves than Pavia cultivar at 0.2% EMS concentration enhanced leaf number but decreased it at higher doses reported by (Kumar, 2023). However, (Baraiya et al., 2022) reported in gladiolus that low or high doses of EMS have limiting effects, while moderate concentration of 0.3% EMS dose recorded the maximum number of leaves. Also in chrysanthemum var. Poornima white, at 2% EMS dose the maximum number of leaves were observed and at 5% EMS dose minimum number of leaves were recorded (Anitha et al., 2021).

Table 1. Effect of (EMS) on number of leaves (No's) of *Syngonium podophyllum*.

Treatments	Number of leaves (No's)						
	15 DAT	30 DAT	45 DAT	60 DAT	75 DAT	90 DAT	120 DAT
T0 (Control)	6.90	7.03	7.21	7.36	7.42	7.58	8.21
T1 (EMS 0.2%)	7.42	7.55	7.70	7.83	7.94	8.07	8.52
T2 (EMS 0.5%)	7.69	7.79	7.93	8.08	8.25	8.45	8.67
T3 (EMS 0.8%)	6.90	7.00	7.15	7.32	7.44	7.58	8.05
T4 (EMS 1.0%)	6.49	6.58	6.73	6.91	7.01	7.13	7.73
T5 (EMS 1.5%)	5.39	5.54	5.78	5.95	6.14	6.30	6.93

C.D.	0.56	0.56	0.56	0.55	0.56	0.56	0.48
S.E(m)±	0.18	0.18	0.18	0.18	0.18	0.18	0.16
SE (d)	0.26	0.26	0.26	0.26	0.26	0.26	0.23
C.V.	5.55	5.47	5.33	5.13	5.13	5.02	4.05
F value	18.43	17.68	16.49	16.36	15.34	15.68	15.14

DAT—Days after transplanting.

Ethyl methane sulphonate significantly influenced leaf length in *Syngonium podophyllum* (Table 2), with EMS treated plants showing marked improvements over the control. The 0.5% EMS treatment (T2) produced the greatest enhancement, achieving 14.17 cm leaf length, followed by 0.2% EMS (T1: 12.75 cm) and 0.8% EMS (T3: 11.62 cm). Higher concentrations demonstrated reduced effectiveness, with 1.0% EMS (T4) and 1.5% EMS (T5) yielding 10.87 cm and 10.20 cm respectively, indicating a concentration dependent response where excessive EMS levels may suppress growth. These results clearly establish 0.5% EMS as the optimal concentration for maximizing leaf elongation, while confirming EMS role as an effective mutagenic agent for promoting foliar development in *Syngonium podophyllum*, with benefits declining beyond moderate concentrations. In tuberose the moderate EMS concentrations increase in leaf length and the most effective EMS concentration was at 1.0% reported by (Kaur & Kumar, 2018). Similarly, in chrysanthemum higher concentration of EMS reduced the leaf length was observed by (Vaidya et al., 2016).

Table 2. Effect of (EMS) on leaf length (cm) of *Syngonium podophyllum*.

Treatments	Leaf length (cm)						
	15 DAT	30 DAT	45 DAT	60 DAT	75 DAT	90 DAT	120 DAT
T0(Control)	8.65	9.15	9.52	9.88	10.40	10.85	11.73
T1(EMS 0.2%)	9.77	10.25	10.65	10.95	11.37	11.82	12.75
T2(EMS 0.5%)	11.17	11.90	12.10	12.50	12.97	13.54	14.17
T3(EMS 0.8%)	8.20	8.87	9.22	9.67	10.15	10.60	11.62
T4(EMS 1.0%)	7.67	8.27	8.75	8.97	9.55	10.07	10.87
T5(EMS 1.5%)	7.40	7.90	8.30	8.52	8.92	9.37	10.20
C.D.	0.76	0.67	0.73	0.80	0.77	0.79	0.77
S.E(m)±	0.25	0.22	0.24	0.27	0.25	0.26	0.25
SE(d)	0.36	0.32	0.34	0.38	0.36	0.37	0.36
C.V.	5.83	4.81	4.99	5.35	4.89	4.77	4.36
F value	30.90	42.42	32.87	28.70	31.13	31.11	29.56

DAT—Days after transplanting.

Ethyl methane sulphonate treatment significantly reduced plant height in *Syngonium podophyllum* in a concentration dependent manner (Table 3). At 120 DAT, the control plants (T0) reached 15.48 cm, while EMS treated plants showed progressive height reduction with increasing concentrations 0.2% EMS (T1: 12.69 cm), 0.5% EMS (T2: 11.34 cm), 0.8% EMS (T3: 10.86 cm), 1.0% EMS (T4: 9.63 cm), and 1.5% EMS (T5: 9.31 cm). The consistent growth suppression across all developmental stages was particularly evident at higher concentrations (1.0–1.5% EMS), which maintained the shortest plant heights throughout the experiment. Notably, while all EMS treated plants continued gradual growth, their final heights were significantly lower than the control, demonstrating EMS stable mutagenic effect on plant height. These results clearly establish that EMS can effectively control plant height, as concentration increased, suppression intensified. Offering valuable applications for developing compact Syngonium varieties through controlled mutagenesis in breeding programs. Significantly, in Marigold *Tagetes sp.* by the acute treatment with EMS prove that increase EMS concentrations can affect the plant growth and resulting in a decrease in plant height noted by (Lenawaty et al., 2022). Similarly, in petunia treated with higher doses of EMS exhibited the comparable results were recorded by (Berenschot et al., 2008). A same pattern was observed by (Baraiya et al., 2022).

Table 3. Effect of (EMS) on plant height (cm) of *Syngonium podophyllum*.

Treatments	Plant height (cm)						
	15D AT	30 DAT	45 DAT	60 DAT	75 DAT	90 DAT	120 DAT
T0 (Control)	13.97	14.23	14.07	14.49	14.87	15.12	15.48
T1 (EMS 0.2%)	10.85	11.24	9.76	11.60	11.98	12.29	12.69
T2 (EMS 0.5%)	9.32	9.87	8.95	10.34	10.68	11.11	11.34
T3 (EMS 0.8%)	8.85	9.37	8.69	9.73	10.11	10.52	10.86
T4 (EMS 1.0%)	8.00	8.35	7.73	8.75	9.09	9.33	9.63
T5 (EMS 1.5%)	7.65	7.99	7.55	8.34	8.68	8.99	9.31

C.D.	0.97	1.05	0.96	1.02	1.01	0.99	1.06
S.E(m)±	0.32	0.35	0.32	0.34	0.33	0.33	0.35
SE (d)	0.46	0.49	0.45	0.48	0.47	0.47	0.50
C.V.	6.65	6.89	6.81	6.50	6.19	5.92	6.15
F value	51.97	42.85	55.58	43.33	45.24	45.83	40.96

DAT—Days after transplanting.

Impact of EMS mutagen on survival percentage, leaf chlorophyll content, and leaf area index in *Syngonium podophyllum* (Table 4). when comparing different doses of EMS treatment in Syngonium plants, it was found that with increasing concentration, the survival percentage were reduced, and there was less possibility of survival on higher concentrations, when plants treated with 1.5% EMS (T5) showing the most severe decline (25% at 120 DAT) compared to the control (T0: 47.5%). This aligns with findings by (Baraiya et al., 2022) in gladiolus, where higher EMS concentrations decreased survival. Notably, even lower concentrations (0.2% EMS, T1: 41.25%) showed reduced viability, contrasting with (Singh et al., 2015) observations in tuberose where only doses ≥1% affected survival. Tolerance of EMS on plants varies species to species which affects the survival percentage like in *Arabidopsis* 0.25 to 0.5% EMS, in Tomato 0.7 to 1% EMS and in Cucumber 1.5 to 2% EMS (Greene et al., 2003; Minoia et al., 2010) The leaf area index showed an inverse pattern, Similarly, the leaf chlorophyll content was collected by SPAD meter and significantly EMS treatment had an impact on the amount of chlorophyll in the leaves treated with 0.5% EMS (T2) produced the highest values (32.08) while 1.5% EMS (T5) resulted in the lowest (18.84), matching trends reported by (Rodge et al., 2024) in strawberry and (Deepthi and Remesh, 2016) in bhindi, where moderate EMS enhanced chlorophyll but higher doses were detrimental. with controls (T0) exhibiting the highest value (30.97) and 1.5% EMS (T5) the lowest (18.84), consistent with prior studies in strawberry (Rodge et al., 2024) and *Abelmoschus esculentus* (Deepthi and Remesh, 2016). These results demonstrate that while EMS reduces survival proportionally to concentration, its effects on physiological traits like chlorophyll and leaf expansion are non-linear, suggesting optimal mutagenic doses (0.5% EMS for chlorophyll enhancement) must be carefully calibrated in breeding programs. However, the rise in the leaf area index and chlorophyll content at specific EMS concentrations suggests that growth-promoting factors may be stimulated (Rodge et al., 2024). Moreover, in the leaf area index with the highest LAI recorded in the control (30.97) due to highest survival percentage and the lowest in the 1.5% EMS treatment (18.84), suggesting that increasing EMS concentrations negatively affected leaf area development These results aligned with (Rodge et al., 2024), who observed a similar pattern in strawberries, indicating species to specific responses to EMS. The findings suggested that EMS can enhance leaf development up to an optimal level, beyond which higher concentrations may limit growth, as also supported by (Deepthi et al., 2016) in Abelmoschus esculentus.

Table 4. Effect of (EMS) on survival percentage (%), leaf chlorophyll content (SPAD unit) and leaf area index of *Syngonium podophyllum.*

Treatments	Survival percentage (%)			Leaf chlorophyll content		Leaf area index
	30 DAT	60 DAT	90 DAT	120 DAT	120 DAT	120 DAT
T0(Control)	92.5	83.75	68.75	47.5	20.97	30.97
T1(EMS 0.2%)	85	75	63.75	41.25	27.99	23.78
T2(EMS 0.5%)	73.75	65	50	38.75	32.08	27.95
T3(EMS 0.8%)	72.5	62.5	46.25	32.5	26.64	26.12
T4(EMS 1.0%)	70	65	47.5	28.75	24.68	21.34
T5(EMS 1.5%)	60	51.25	37.5	25	18.84	18.84
C.D.	0.77	0.69	0.51	0.30	1.48	2.29
S.E(m)±	0.25	0.23	0.17	0.10	0.49	0.76
SE(d)	0.36	0.32	0.24	0.14	0.70	1.08
C.V.	13.65	13.88	13.1	11.57	3.93	6.16
F value	4.96	5.72	11.53	16.56	94.39	33.47

DAT—Days after transplanting.

CONCLUSIONS

From the above study it can be concluded that the various EMS concentrations had a significant impact on different morphological traits and chlorophyll content in *Syngonium podophyllum* (Arrowhead). EMS 0.5% showed the best concentration among all treatments in growth parameters. This research results demonstrate the possibility of EMS induced mutagenesis for altering plant traits for breeding, suggesting that while high amounts of EMS could reduce growth and survival, while moderate EMS concentrations could increase plant vigor, leaf growth, and photosynthetic activity. This study also recorded information over a duration of 120 days and highlighted the significance of further study to better understand mutations.

CONFLICT OF INTERESTS

The authors declare that there is no any potential conflict of intrest.

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