*J. Farm Sci.*, 38(3): (316-321) 2025

**RESEARCH PAPER**

# Effect of pre-sowing seed treatments on germination and initial growth attributes of *Mimusops elengi* Linn.

K. S.VENUGOPALAGOWDA AND M. HANUMANTHA

Department of Forest Products and Utilization, College of Forestry, Sirsi
University of Agricultural Sciences, Dharwad - 580 005, India
*E-mail: venugopalagowdaks@gmail.com

*(Received: August, 2024 ; Accepted: July, 2025)*

DOI: 10.61475/JFS.2025.v38i3.25

**Abstract:** *Mimusops elengi* L. (Bakul) commonly known as spanish cherry is an evergreen tree native to South and South-east Asia. This species known for its importance as the tree provides fruit and fodder, planted as ornamental and used in traditional medicine practices. Many parts of the species have high medicinal properties and fruits are edible in nature and also seeds are valuable source for extraction of non essential oils. It is mainly propagated through seeds but due to its hard seed coat possess inherent dormancy and germination process is medium. Keeping these facts into consideration the present investigation was carried at College of Forestry, Sirsi to evaluate the effect of pre-sowing seed treatments on germination and initial growth parameters of *Mimusops elengi*. The experiment was designed with ten different pre-sowing treatments such as water soaking, hot water soaking, seed mud ball, cow dung slurry, $KNO_3$ and $GA_3$ at different concentrations. Among these, the seeds treated with 100 ppm $GA_3$ ($T_9$) showed the highest per cent germination (58.89%) with higher rate of germination (10.88), mean daily germination (0.99), peak value (1.11) and germination value (1.10). The lowest per cent germination (24.45%) with low rate of germination (3.85), mean daily germination (0.41), peak value (0.49) and germination value (0.21) was recorded in the seeds treated with mud ball ($T_5$). Initial growth parameters varied significantly among different treatments; seeds treated with 100 ppm $GA_3$ ($T_9$) produced vigorous seedlings with maximum plant height (6.21 cm), collar diameter (1.46 mm) and leaves (2.33) followed by seeds treated with 200 ppm $GA_3$ ($T_{10}$). Hence, $GA_3$ is an effective pre-sowing treatment for removal of seed dormancy and for the production of vigorous and good quality seedlings in *Mimusops elengi*. These treatments are crucial for optimizing nursery practices and also improving the success rate of seedling establishment.

**Key words:** $GA_3$ (Gibberellic acid), *Mimusops elengi*, Pre-sowing treatments, Seed dormancy, Seed germination

## Introduction

India, a rich biodiversity hotspot, hosts many indigenous fruit-bearing trees, including *Mimusops elengi* (bakul tree) which is native to the Western Ghats. This tree belongs to the family Sapotaceae and is valued for its edible fruit, fodder and ornamental use. It also holds importance in traditional medicine. *Mimusops elengi* has successfully spread beyond its native range to other tropical and subtropical regions worldwide, where it adapts to diverse environments (Baliga *et al*., 2011). *Mimusops elengi* is considered as small to medium-sized evergreen tree that grows up to 30-40 meters tall, with a trunk diameter of up to 100 cm. The trunk may be unbranched for 15-20 meters or split into large branches, sometimes with buttresses up to 2 meters high. The deeply fissured bark ranges from grey and brown to dark red or blackish, while the inner bark is fibrous and pink or reddish, exuding a sparse, watery, or white sticky latex (Jerline *et al*., 2009). Due to its significant medicinal value and pharmacological properties, the tree has been heavily exploited at its natural habitats. As a result, the species was classified as threatened in the 2018 IUCN red list assessment. The main threat is illicit harvesting for its timber and fruit collection, which adversely affects germination in its natural environment. In Sri Lanka, the species is currently listed as near threatened. In response to these threats, over 35 ex-situ collections have been established, including at least five from India. (Kadam *et al*., 2012).

Dormancy is also reported in many tropical and sub-tropical tree species and is classified into seed coat imposed, embryo and combination of these two. Physical seed coat dormancy is the most predominant in many species (Hanumantha *et al.,* 2014). For efficient germination adequate moisture, appropriate gaseous balance and light is very essential (Hanumantha *et al.,* 2003). *Mimusops elengi* seeds have physical dormancy due to a hard endocarp, restricting moisture and air, leading to low germination rates and short viability. Pre-sowing treatments, such as scarification or mechanical abrasions have break dormancy by improving water absorption and oxygen exchange, which enhances the germination and seedling establishment. These methods are crucial for achieving healthy nursery stock and overcoming germination challenges in this species. (Bahar, 2016). To achieve success in any plantation programme a good start is essential from the germination stage. In several important species germination process can be enhanced to some extent by appropriate seed pre-treatment methods (Heydecker, 1972; Hanumantha *et al.,* 2002). It was found from the literature review that no extensive research work was carried out on pre-sowing treatments in seed germination of *Mimusops elengi*. Hence, the current investigation was carried with the objective of using different methods in breaking the dormancy and enhances the seed germination and initial growth parameters in *Mimusops elengi.*

## Material and methods

The research was conducted in a poly house located at College of Forestry in Sirsi, Uttara Kannada district. The area is

Table 1. Details of pre-sowing seed treatments

| Treatment | Treatment details |
|---|---|
| $T_1$ | Control |
| $T_2$ | Soaking in cold water for 12 hrs |
| $T_3$ | Soaking in cold water for 24 hrs |
| $T_4$ | Soaking in hot water for 5 min |
| $T_5$ | Seed mud ball method |
| $T_6$ | Soaking in cow dung slurry for 24 hrs |
| $T_7$ | Soaking in 1.0 per cent $KNO_3$ for 24 hrs |
| $T_8$ | Soaking in 2.0 per cent $KNO_3$ for 24 hrs |
| $T_9$ | Gibberellic acid of 100 ppm |
| $T_{10}$ | Gibberellic acid of 200 ppm |

situated within the hill zone (Zone 9) of Karnataka State, positioned in the Central Western Ghats. The specific coordinates of the site are approximately 14° 26' N latitude, 74° 50' E longitude, with an altitude of 619 meters above sea level. The present experiment was carried out in the nursery with three replications. The raised type of nursery bed was prepared by using soil, sand and FYM in a 2:1:1 ratio. The experiment included ten different treatments with three replications each. Completely Randomized Design (CRD) with three replications was followed for the experiment. In each replication 30 seeds were sown with a total of 90 seeds per treatment.

In the experiment, different treatments were applied to *Mimusops elengi* seeds to improve germination and seedling growth (Table 1 and Plate 1). $T_1$ was the control with no treatment. $T_2$ and $T_3$ involved soaking seeds in cold water for 12 and 24 hours, respectively. $T_4$ used hot water treatment at 80°C for 5 min. $T_5$ involved coating seeds with a mixture of clay, compost and water (mud ball). $T_6$ used cow dung slurry, while $T_7$ and $T_8$ soaked seeds in 1.0 per cent and 2.0 per cent $KNO_3$ solutions, respectively for 24 hours. $T_9$ and $T_{10}$ treated seeds with 100 ppm and 200 ppm $GA_3$ solutions for 30 mins.

a). Soaking in cold water for 12 hrs

b). Soaking in cold water for 24 hrs

c). Soaking in hot water for 5 min

d). Seed mud ball method

e). Soaking in cow dung slurry for 24 hrs

f). Soaking in 1.0 per cent $KNO_3$ for 24 hrs

g). Soaking in 2.0 per cent $KNO_3$ for 24 hrs

h). Gibberellic acid of 100 ppm

i).Gibberellic acid of 200 ppm

Plate 1. Different pre-sowing seed treatments imposed for seeds of *Mimusops elengi*

The number of seeds germinated daily was noted up to a period of 60 days and emergence of plumule above the soil was taken as the criterion for germination. Based on daily germination counts, the following parameters were computed

**Germination per cent:** All the seeds germinated normally till the end of the study period were counted and cumulative germination was expressed as percentage of the total number of seeds sown. The germination per cent was worked out by using following formula prescribed by ISTA- International Seed Testing Association (Anon, 2011)

$$\text{Germination Per cent} = \frac{\text{Number of seeds germinated}}{\text{Total number pf seeds sown}} \times 100$$

**Mean Daily Germination (MDG):** Total germination was expressed as mean daily germination calculated by the cumulative percentage of full seed germination at the end of the test. Mean daily germination was estimated by adopting formula prescribed by ISTA (Anon, 2011).

$$\text{Mean daily germination} = \frac{\text{Final germination (per cent)}}{\text{Total number of days test}}$$

**Peak Value (PV):** Peak value refers to maximum mean daily germination reached at any stage of germination period and calculated using the formula given by Czabator (1962)

$$\text{Peak value} = \frac{\text{Peak germination (per cent)}}{\text{Days on which maximum germination occured}}$$

**Germination rate:** It is calculated using formula given by Czabator (1962)

Rate of germination = $n_1/d_1 + n_2/d_2 + n_3/d_3 + \ldots + n/d$

Where, 'n' is the number of seeds germinated on days 'd'

**Germination value (GV):** The concept of germination value, as defined by Czabator (1962), aims to combine in a single figure an expression of total germination at the end of the test period

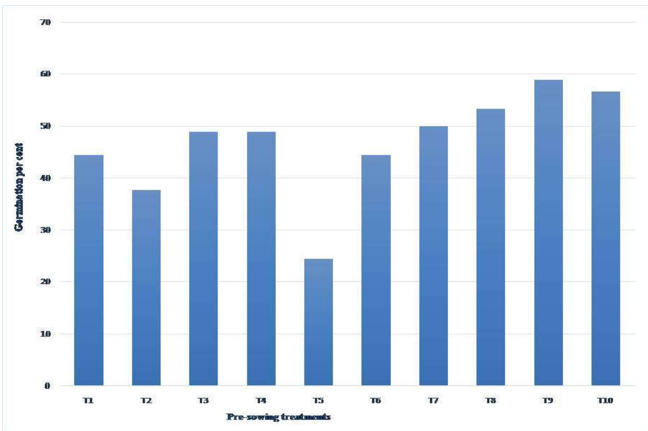


Fig 1. Effect of pre sowing on germination per cent in *Mimusops elengi*

with an expression of germination energy or speed of germination. It is an index combining speed and completeness of germination. It was calculated using the formula given by Czabator (1962)

Germination value (GV) = PV x MDG

**Results and discussion**

The results pertaining to various germination and early growth parameters of *Mimusops elengi* as influenced by various treatments are represented in Table 2 (Fig 1 and 2) and 3 (Plate 2). In this experiment, pre-sowing treatment such as soaking of seeds in 100 ppm of $GA_3$ for 30 min enhanced the germination parameters of the seeds and early growth parameters.

**Effect of pre-sowing seed treatments on germination and germination parameters**

**Germination per cent**

The germination per cent varied significantly with respect to various pre-sowing seed treatments and ranged from 24.45 to 58.89 per cent with an average of 46.78 per cent. Significantly maximum germination was recorded in soaking of seeds in 100 ppm of $GA_3$ for 30 min ($T_9$-58.89%) followed by soaking of seeds in 200 ppm $GA_3$ for 30 min ($T_{10}$-56.68%), soaking of seeds in 2.0 per cent $KNO_3$ for 24 hrs ($T_8$-53.33%) and least was found in seed mud ball method ($T_5$-24.45%) and cold water soaking for 12 hrs ($T_2$-37.78%)

**Germination rate (GR)**

There was a significant difference in rate of germination due to various pre-sowing treatments. Soaking of seeds in 100 ppm of $GA_3$ for 30 min gave maximum germination rate (10.88) followed by soaking of seeds in 200 ppm of $GA_3$ for 30 min (8.47), whereas least was found in seed mud ball method (3.85) and soaking of seeds in cold water for 12 hrs (4.83). $T_9$ found to be highly significant at 0.05 level presented in Table 2.

**Mean Daily Germination (MDG)**

Mean daily germination exhibits a significant variation among the ten different treatments and ranges between 0.41 and 0.99 with an average of 0.78. The highest MDG was recorded in $T_9$ (0.99), followed by $T_{10}$ (0.94), $T_8$ (0.89), $T_7$ (0.83) and minimum was recorded in $T_5$ (0.41) followed by $T_2$ (0.63) and $T_6$ and $T_1$(0.74). However, $T_9$ found to be highly significant at 0.05 level as indicated in Table 2.

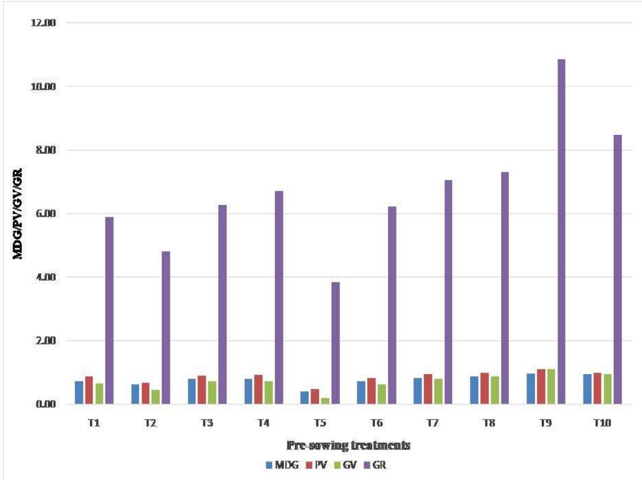


Fig 2. Effect of pre-sowing treatments on germination parameters in *Mimusops elengi*

**Peak value (PV)**

With respect to peak value, it exhibited a significant variation among the ten different pre-sowing treatments and ranges between 0.49 and 1.11 with an average of 0.88. The highest peak value was observed in $T_9$ (1.11), followed by $T_{10}$ (0.99), $T_8$ (0.99), $T_7$ (0.96), $T_4$ (0.92)and minimum was recorded in $T_5$(0.49) followed by $T_2$(0.71) and $T_6$(0.83).

**Germination value (GV)**

The pre sowing treatments showed a significant difference with respect to germination value and ranged from 0.21 to 1.10 with an average of 0.72. Whereas, the highest germination value was found in $T_9$(1.10), followed by $T_{10}$ (0.94), $T_8$ (0.88), $T_7$ (0.81), $T_4$ (0.75)and minimum was observed in $T_5$(0.21) followed by $T_2$(0.47) and $T_6$(0.62).

The gibberellic acid treatment enhanced seed germination parameters may be attributed to the role of $GA_3$ in activating cytological enzymes, increasing cell wall plasticity and

Table 2. Effect of pre-sowing seed treatments on germination parameters of *Mimusops elengi*

| Treatments | Germination Per cent | Rate of germination | Mean daily germination | Peak value | Germination value |
|---|---|---|---|---|---|
| $T_1$ (Control) | 44.44 (41.75) | 5.90 | 0.74 | 0.88 | 0.67 |
| $T_2$ (Water soaking for 12 hrs) | 37.78 (37.80) | 4.83 | 0.63 | 0.71 | 0.47 |
| $T_3$ (Water soaking for 24 hrs) | 48.89 (44.35) | 6.27 | 0.81 | 0.91 | 0.75 |
| $T_4$ (Hot water soaking for 5 min) | 48.89 (44.36) | 6.72 | 0.81 | 0.92 | 0.75 |
| $T_5$ (Seed mud ball | 24.45 (29.47) | 3.85 | 0.41 | 0.49 | 0.21 |
| $T_6$ (cow dung slurry for 24 hrs) | 44.44 (41.80) | 6.23 | 0.74 | 0.83 | 0.62 |
| $T_7$ (1.0 per cent $KNO_3$ for 24 hrs | 50.00 (45.00) | 7.07 | 0.83 | 0.96 | 0.81 |
| $T_8$ (2.0 per cent $KNO_3$ for 24 hrs | 53.33 (46.91) | 7.32 | 0.89 | 0.99 | 0.88 |
| $T_9$ ($GA_3$ of 100 ppm) | 58.89 (50.15) | 10.88 | 0.99 | 1.11 | 1.10 |
| $T_{10}$ ($GA_3$ of 200 ppm) | 56.68 (48.84) | 8.47 | 0.94 | 0.99 | 0.94 |
| Mean | 46.78 (43.05) | 6.75 | 0.78 | 0.88 | 0.72 |
| S Em± | 3.91 | 0.72 | 0.06 | 0.08 | 0.11 |
| C.D. @ 5% | 11.62 | 2.14 | 0.19 | 0.23 | 0.32 |

*Values in parenthesis indicates arc sine transformed values

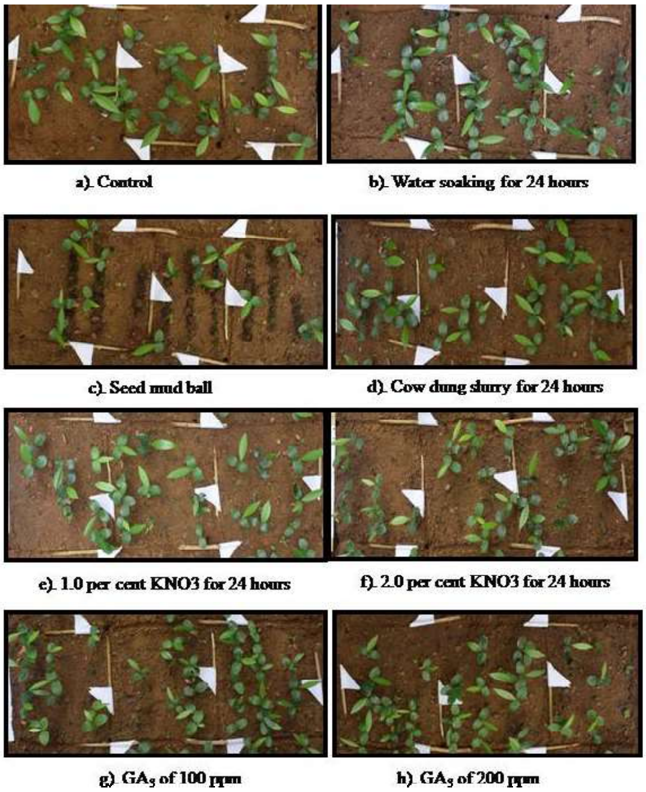


Plate 2. Effect of pre-sowing treatments on germination per cent and early growth parameters of *Mimusops elengi*

improving water absorption. Additionally, it aids in ethylene production, which stimulates the synthesis of hydrolases, particularly amylase, facilitating seed germination (Stewart and Freebairn, 1969). $GA_3$ also promotes seed germination by inducing the formation of á-amylase enzymes, which convert insoluble starch into soluble sugars and by removing metabolic blocks to initiate radicle growth, as noted by Gillard and Walton (1973). Similar findings were reported by Rai *et al*. (2018) in *Manilkara hexandra*, where maximum germination per cent (85.80) and enhanced vigor parameters were observed with a 100 ppm $GA_3$ treatment. Chaya (2014) observed a significantly higher seed germination per cent (17.33), mean daily germination (0.29), peak value (0.76) and germination value in *Lagerstroemia lanceolata* when the seeds were treated with 100 ppm $GA_3$. These findings are consistent with the current study. Samir *et al*. (2015) also recorded the highest germination (69.64), peak value (3.78), mean daily germination (3.24) and germination value (12.25) with $GA_3$ @ 100 ppm in *Manilkara hexandra*. These outcomes are in agreement with the current study.

In contrast, Swaminathan *et al*. (2020) found that the highest seed germination per cent (80.00) in *Mimusops elengi* was achieved through water soaking. This difference may be due to factors such as the age of the tree at the time of seed collection, as well as the specific geographical and agroclimatic conditions at the collection site. The seed mud ball treatment led to lower germination per cent (24.45) and reduced vigor parameters in *Mimusops elengi* due to several potential factors. The mud coating could have created a physical barrier that hindered the seed's access to essential elements like water and oxygen, which

Table 3. Influence of pre-sowing treatments on initial growth attributes of *Mimusops elengi* seedlings

| Treatments | Plant height (cm) | Collar diameter (mm) | Number of leaves |
|---|---|---|---|
| | 60 DAS | 60 DAS | 60 DAS |
| $T_1$ (Control) | 3.59 | 1.05 | 2.02 |
| $T_2$ (cold water soaking for 12 hrs) | 4.16 | 1.13 | 2.04 |
| $T_3$ (cold water soaking for 24 hrs) | 4.35 | 1.19 | 2.09 |
| $T_4$ (Hot water soaking for 5 min) | 4.53 | 1.23 | 2.10 |
| $T_5$ (Seed mud ball | 4.29 | 1.19 | 2.03 |
| $T_6$ (cow dung slurry for 24 hrs) | 4.75 | 1.30 | 2.12 |
| $T_7$ (1.0 per cent $KNO_3$ for 24 hrs) | 4.33 | 1.29 | 2.08 |
| $T_8$ (2.0 per cent $KNO_3$ for 24 hrs) | 5.23 | 1.33 | 2.18 |
| $T_9$ ($GA_3$ of 100 ppm for 30 min) | 6.21 | 1.46 | 2.33 |
| $T_{10}$ ($GA_3$ of 200 ppm for 30 min) | 5.64 | 1.37 | 2.23 |
| Mean | 4.71 | 1.25 | 2.12 |
| S. Em± | 0.17 | 0.02 | 0.03 |
| C.D. @ 5% | 0.51 | 0.06 | 0.10 |

* DAS - Days After

are crucial for initiating and sustaining germination as reported by Taylor and Harman (1990). Hanumantha *et al.* (2014) reported significant variation among different pre-sowing seed treatments for germination and seedling attributes in *Bauhinia purpurea.* They recorded 55.67 per cent germination, 2.23 mean daily germination with 2.54 peak value for the seeds treated with 500 ppm GA3. Similarly, Divakara (2022) opined that $GA_3$ @ 100 ppm enhanced germination (17.41%) and also speed of germination (1.25) in *Helicteres isora.*

**Effect of pre-sowing seed treatments on early growth parameters**

Pre-sowing treatments are essential for enhancing seedling quality parameters, particularly in species where germination and early growth stages are challenging. These treatments often involve the application of growth regulators, chemical scarification or soaking in water or nutrient solutions, all of which can significantly improve germination rates, seedling vigor and uniformity. By breaking seed dormancy, enhancing water uptake, and stimulating enzymatic activities, pre-sowing treatments ensure a more robust establishment of seedlings, leading to better survival rates and overall plant health (Rao and Singh, 2019).

**Plant height (cm)**

The plant height after 60 days after sowing varied significantly with respect to various pre-sowing seed treatments (Table 3) and ranged from 3.59 to 6.21 cm with an average of 4.71 cm. Significantly maximum plant height was recorded in soaking of seeds in 100 ppm of $GA_3$ for 30 min ($T_9$-6.21 cm) followed by soaking of seeds in 200 ppm $GA_3$ for 30 min ($T_{10}$-5.64 cm), soaking of seeds in 2.0 per cent $KNO_3$ for 24 hrs ($T_8$- 5.23 cm) and least was found in control ($T_1$- 3.59 cm) and cold water soaking for 12 hrs ($T_2$- 4.16 cm).

**Collar diameter (mm)**

Significant variation for collar diameter 60 days after sowing was observed among the various pre-sowing seed treatments (Table 3). Collar diameter was ranged from 1.05 to 1.46 mm with an mean of 1.25 mm. Significantly highest collar diameter was recorded in soaking of seeds in 100 ppm of $GA_3$ for 30 min ($T_9$- 1.46 mm) followed by soaking of seeds in 200 ppm $GA_3$ for 30 min ($T_{10}$- 1.37 mm), soaking of seeds in 2.0 per cent $KNO_3$ for 24 hrs ($T_8$- 1.33 mm) and least was found in control ($T_1$- 1.05 mm) and cold water soaking for 12 hrs ($T_2$- 1.13 mm).

**Number of leaves**

Similar trend was noticed for number leaves among the different treatments. Significant variation for number of leaves after 60 days of sowing was observed among the various pre-sowing seed treatments (Table 3). Number of leaves recorded at this stage is less; which were ranged from 2.02 to 2.33 with a mean of 2.12. Significantly highest number of leaves were recorded in soaking of seeds in 100 ppm of $GA_3$ for 30 min ($T_9$- 2.33) followed by soaking of seeds in 200 ppm $GA_3$ for 30 min ($T_{10}$- 2.23), soaking of seeds in 2.0 per cent $KNO_3$ for 24 hrs ($T_8$- 2.18 mm) and least was found in control ($T_1$- 2.02) and seed mud ball treatment ($T_5$- 2.03 mm).

$GA_3$ treatments resulted in increased growth parameters, which can be explained by the hormone's capacity to improve osmotic nutrient uptake. This process causes cell elongation, which in turn leads to increased plant height and collar diameter. The enhanced cell proliferation and elongation in the stem area is might have responsible for increase in collar diameter (Sen *et al*., 1990). The increased number of leaves could be attributed to $GA_3$ activity at the apical meristem, which promotes the synthesis of nucleoproteins that drive leaf initiation and expansion. $GA_3$ treated seeds may also experience accelerated auxin translocation and assimilation, which contributes to improved root growth and vegetative characteristics through improved nutrient assimilation and redistribution within the plant. Furthermore, $GA_3$ promotes gluconeogenic enzyme activity during seed germination, resulting in increased root length and vigor.

These findings are consistent with studies by, Pampanna and Sulikeri (1999) in sapota and Manekar *et al*. (2011) in aonla. Consistent results were observed by Rai *et al*. (2018) in *Manilkara hexandra*, where plant height, number of leaves and seedling vigour index were observed maximum with 100 ppm $GA_3$ treatment. In *Manilkara zapota* 100 ppm $GA_3$ significantly improved seedling attributes such as plant height, leaf number and overall biomass as reported by Patil and Kadam (2022). Similar kinds of results were presented significant variation among different pre-sowing treatments. by Hanumantha *et al.* (2014). They reported significant variation among different pre-sowing seed treatments for plant height collar diameter and number of leaves in seeds of *Bauhinia purpurea* after 45 days of sowing. They recorded 21.97 cm plant height, 2.97 mm collar diameter and 6.87 leaves for the seeds treated with 500 ppm $GA^3$; higher values of the plant growth attributes may be due to higher concentration of $GA_3$.

**Conclusion**

The present investigation was carried to study the effect of pre-sowing seed treatments on germination and early growth attributes of *Mimusops elengi*. Significantly higher germination per cent (58.89) was recorded in 100 ppm $GA_3$ soaked seeds for 30 mins followed by 200 ppm $GA_3$ soaked seeds for 30 mins (56.68); while the lowest germination was recorded in seed mud ball treatment (24.45) which is lower than control (44.44). Similarly, soaking of seeds in 100 ppm $GA_3$ recorded higher value of germination vigor parameters like rate of germination (10.88), mean daily germination (0.99), peak value (1.11) and germination value (1.10); while least rate of germination (3.85), mean daily germination (0.41), peak value (0.49) and germination value (0.21) recorded in seed mud ball treatment. Similar trend was noticed for early growth parameters also; soaking of seeds in 100 ppm of $GA_3$ for 30 min recorded higher plant (6.21 cm), collar diameter (1.46 mm) and number of leaves (2.33). Hence, application of $GA_3$ (Gibberellic Acid) significantly improves seed germination and helps in production of quality seedlings in *Mimusops elengi*. Hence, $GA_3$ treatments are crucial for optimizing nursery practices and improving the success rate of seed germination and early vigour in *Mimusops elengi*.

**References**

Anon, 2011, International rules for seed testing. *Seed Science and Technology*, 24: 1-335

Bahar N B, 2016, Effect of fruit maturation on germination and vigour of Bakul (*Mimusops elengi* Linn) seeds. *Indian Forester*, 142 (9): 858-861.

Baliga M S, Pai R J, Bhat H P, Palatty P L and Boloor R, 2011, Chemistry and medicinal properties of the Bakul (*Mimusops elengi* Linn): A review. *Food Research International*, 44(7): 1823-1829.

Chaya K B, 2014, Standardization of nursery techniques in *Lagerstromia lanceolata* Wall. *M. Sc.Thesis,* University of Agricultural Sciences, Dharwad, Karnataka, India.

Czabator F J, 1962, Germination value: An index combining speed and completeness of pine seed germination. *Forest Science*, 8(4): 386-396.

Divakara C, 2022, Influence of pre-sowing seed treatments on germination and its parameters in Indian screw tree *(Helicteres isora* L.). *Ph.D. Thesis,* Junagadh Agricultural University, Junagadh, Gujarat, India.

Gillard D F and Walton D C, 1973, Germination of *Phaseolus vulgaris*: Patterns of protein synthesis in excised axes. *Plant physiology*, 51(6):1147-1149.

Hanumantha M, Girish Shahapurmath, Doddabasaa, Roopa S Patil and Vasudeva R, 2003, Effect of different pre-sowing treatments on seed germination and seedling quality parameters in *Acacia nilotica. My Forest,* 39(2): 193-198.

Hanumantha M, Nayak B G and Gaaniger B S, 2002, Effect of pres-sowing treatments on few growth attributes of *Albizia lebbeck* (L.) Benth. *My Forest,* 38(2): 139-143.

Hanumantha M, Rajesh P. Gunaga, Suma S. Biradar, Roopa S. Patil and Shankar P, 2014. Enhancement of seed germination in stored seeds using different pre-sowing treatments in *Bauhinia purpurea* L. *Journal of Applied and Natural Science,* 6(2): 707-710.

Heydecker W, 1972, Vigour In: viability of seeds (ed. E. H. Rooberts). Chaapman and Hall, London. p. 209-262.

Jerline M, Jothi G and Brindha P, 2009, Effect of *Mimusops elengi* Linn. Bark extract on alloxan induced hyperglycaemia in albino rats. *Journal of Cell and Tissue Research,* 9: 1985-1988.

Kadam P V, Yadav K N, Deoda R S, Shivatare R S and Patil M J, 2012, *Mimusops elengi*: A review on ethno-botany, phyto-chemical and pharmacological profile. *Journal of Pharmacognosy and Phytochemistry,* 1(3): 20-23.

Manekar R S, Sable P B and Rane M M, 2011, Influence of different plant growth regulators on seed germination and subsequent seedling growth of Aonla (*Emblica officinalis* Gaertn.). *Green Farming*, 2(4): 477-478.

Pampanna Y and Sulikeri G S, 1999, Growth of sapota (*Manilkara achras* (Mill.) Foseberg) seedlings as influenced by pre-sowing seed treatment with growth regulators. *Seed Resources*, 27(1): 49-53.

Patil S V and Kadam S R, 2022, Influence of gibberellic acid ($GA_3$) on growth parameters in sapota (*Manilkara zapota*). *The Pharma Innovation Journal,* 11(2): 435-439.

Rai R, Samir M, Srivastava R and Uniyal S, 2018, Improving seed germination and seedling traits by pre-sowing treatments in Khirni (*Manilkara hexandra*). *Environment Pharmacology Life Science*, 7(4): 77-81.

Rao S R and Singh M, 2019, Impact of Pre-sowing seed treatments on germination and seedling growth in *Eucalyptus* Species. *Journal of Forestry Research,* 30(2): 507-515.

Samir M, Rai R and Prasad B, 2015, Seed germination behaviour as influenced by pre-sowing treatments in khirni. *Journal of Hill Agriculture*, 6(1): 132-135.

Sen S K, Hore I K and Bandhopadhyay A, 1990, Pre-sowing seed treatment and its role in germination, seedlings growth and longevity of papaya. *Orissa Journal of Agricultural Research,* 2(4): 160-164.

Stewart E R and Freebairn H T, 1969, Ethylene, seed germination, and epinasty. *Plant Physiology*, 44(7): 955-958.

Swaminathan V, Senthil K and Swaminathan C, 2020, Improving seed germination in *Mimusops elengi* L. *International Journal of Current Microbiology and Applied Sciences*, 9(6): 39-47.

Taylor A G and Harman G E, 1990, Concepts and technologies of selected seed treatments. *Annual Review of Phytopathology,* 28(1): 321-339.