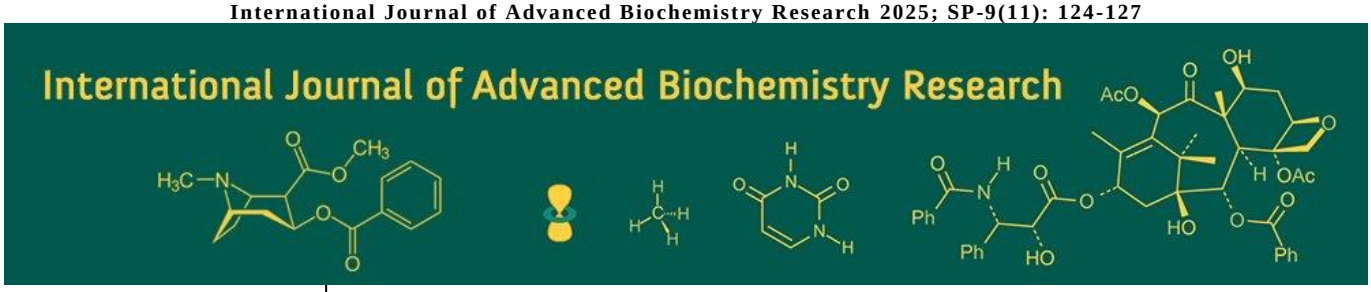

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Effect of different plant growth regulators and nutrient on seed germination and growth of tamarind (*Tamarindus indica* L.)

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Abstract
An investigation to study the "Effect of different plant growth regulators and nutrient on seed germination and growth of Tamarind (*Tamarindus indica* L.)" was carried out during the year 2024-25 in the shade net house of Pt. KLS College of Horticulture and Research Station, Rajnandgaon, Chhattisgarh. The experiment was conducted in Completely Randomized Design (CRD) with 10 treatments i.e., T_0 (Control soaked into distil water), T_1 (NAA @ 100 ppm) seed soaking for 12 hr., T_2 (NAA @ 200 ppm) seed soaking for 12 hr., T_3 (GA_3 @ 100 ppm) seed soaking for 24 hr., T_4 (GA_3 @ 200 ppm) seed soaking for 24 hr., T_5 (KNO_3 @ 0.5%) seed soaking for 3 hr., T_6 (KNO_3 @ 1%) seed soaking for 3 hr., T_7 (Thiourea @ 0.5%) seed soaking for 1 hr., T_8 (Thiourea @ 1%) seed soaking for 1 hr., T_9 (mechanical scarification) removal of hard seed coat. The various observations of different aspects recorded for the seed germination and growth of tamarind were as follows: Days taken to seed germination (5.21 days), days taken to 50% seed germination (16.51 days), germination percentage (93.03%), seedling height of plant (31.98 cm), number of leaves per seedling (18.45), stem girth (2.90 mm), fresh weight of shoot (13.00 g) and dry weight of shoot (5.47 g) among all the other treatments.

Keywords: GA_3, KNO_3, mechanical scarification, NAA, Thiourea and tamarind seedling

1. Introduction
Tamarind (*Tamarindus indica* L.) or Imli, is also called Indian date. It belongs to the family Leguminaceae. It is a diploid species with chromosome number 2n = 24. It is native to tropical Africa, particularly Sudan and also grows well in the tropical and semi-arid parts of India. It is a multipurpose, long-lived tree best known for its fruit. It is a large evergreen tree with an exceptionally beautiful spreading crown and is cultivated throughout the whole of India, except in the Himalayas and western dry regions (Anon., 1993) [2].

There are two types of tamarind, sour type (most common) and sweet type which is mostly found in Thailand. It grows up to 12-14 m with thick trunk of 1.5 2 m across and circumference up to 8 m. Tamarind requires an annual temperature range of 30-37 ℃. It is found up to 1500 MSL in semi-arid areas of tropics region where annual rainfall more than 1500 mm which can be grown well on poor soil especially in degraded areas (Azad *et al.*, 2013) [5]. It can be grown well on variety of soil, Alluvial soil best suited for better growth and yield.

It is currently grown in many African, Australian, Central American and South American countries, as well as in Bangladesh, Malaysia, Thailand, Srilanka, Myanmar, India and other semi-arid regions of Africa and South Asia. Specifically, it is grown in Tamil Nadu, Karnataka, Kerala, Andhra Pradesh, Madhya Pradesh, West Bengal and Chhattisgarh in India. India recorded a total area of 39,000 hectares and a production of 152,000 metric tonnes in 2023 (Anonymous, 2023) [4].

Chhattisgarh occupies an area of 0.028 Mha with an annual production of 0.294 MT of Tamarind. (Anonymous, 2022) [3].

The rural population of Bastar collects tamarind fruits from January to April and engages in activities such as deshelling and deseeding until June. These fruits are rich source of macro- and microminerals, vitamins, fibres, antioxidants and polyphenols benefiting poor people by supplying a nutritional diet in rural areas and generating additional income.

Previous surveys in Chhattisgarh have reported presence of sweet types with low acidity levels, ranging from 3.60 to 17.75%. Tamarind production is crucial for the region, generating 24,000 man-days of employment annually from January to April. The Bastar division, in Southern Chhattisgarh, produces around 21,430 metric tons of tamarind fruit, valued at approximately USD 12.4 million. Jagdalpur Krishi Upaj Mandi, Asia's largest tamarind auction centre, also handles about 5660 tonnes of tamarind seeds worth USD 3.62 million (Gupta *et al.,* 2017) [8].

The tamarind is a fruit that is both nourishing and adaptable. The pulp and seeds make up the majority of the fruit. Tamarind is prized for its pulp, which is used to make food and drinks for both industrial and residential use. The tartaric acid (10%) and decreased sugars (30-40%) that give tamarind fruit its acidic and sweet flavor are its most notable features. The fruit's primary constituents are tartaric acid, reducing sugars, pectin, tannin, fiber and cellulose.

Additionally, the whole seeds contain oil, sugar, carbs and protein. Pulp and seeds contain minerals like sodium, zinc and iron are also good sources of potassium, calcium and phosphorus. Culinary preparations like soups, sauces, chutneys and curries use the acidic pulp. Fruits are higher in vitamin B, protein and tartaric acid.

2. Materials and Methods

The experiment was conducted in the shade net of Horticulture Research Farm in Pt. KLS College of Horticulture and Research Station Rajnandgaon, Chhattisgarh. The experiment was laid out in Completely Randomized Design (CRD) with 10 treatments and three replications. The treatment consists of T_0 Control (soaked into distil water), T_1 NAA @ 100 ppm seed soaking for 12 hr, T_2 NAA @ 200 ppm seed soaking for 12 hr, T_3 GA_3 @ 100 ppm seed soaking for 24 hr, T_4 GA_3 @ 200 ppm seed soaking for 24 hr, T_5 KNO_3 @ 0.5% seed soaking for 3 hr, T_6 KNO_3 1% seed soaking for 3 hr, T_7 Thiourea @ 0.5% seed soaking for 1 hr. T_8 Thiourea @ 1% seed soaking for 1 hr. and T_9 Mechanical scarification.

3. Results and Discussion

3.1 Germination parameters

3.1.1 Days taken to seed germination

The observations pertaining to days taken to seed germination of tamarind seedlings was significantly influenced by different plant growth regulators and nutrient tested under the present investigation, which are presented in Table 1 Treatment T9 (mechanical scarification) recorded significantly, the minimum number of days (5.21 days) taken for seed germination, it was followed by with treatment T_4 (GA3 @ 200 ppm) i.e. (6.12) While, treatment T_0 (control) recorded maximum number of days (11.30) taken for germination.

The decrease in number of days taken to initiate seed germination of tamarind seedlings might be due to the removal of the seed coat, which increased the permeability of air and water through seed, which favours the earliest germination. The result resembles the finding of Rostami and Shasavar (2009) [20] in olive. Similar finding was also observed by Vasantha *et al.* (2014), they found that the tamarind seeds subjected to mechanical scarification recorded the earliest germination (5.21) days.

3.1.2 Days taken to 50 percent seed germination

The examination of data on number of days taken to 50% seed germination of tamarind seeds as influenced by different seed treatments are presented in Table 1. The treatment T_4 Soaking in GA_3 @ 200 ppm for 24 hours recorded the minimum number of days required for 50 percent germination (16.51 days) and it was remained followed by with the treatment T_3 soaking in GA3 @ 100 ppm (17.33 days) and T_0 control the maximum number of days required to 50 percent seed germination (22.43 days) was recorded in the treatment.

It might be due to GA_3 acts directly on embryo relieving them from dormancy through promoting protein synthesis and elongation of coleoptiles and leaves along with the production of ethylene. This ethylene invokes the synthesis of hydrolases especially amylase, which favours the seed germination. Thus, enhanced enzymatic reactions along with the suppression of inhibitors by these growth substances might have acted in faster germination (Stewart and Freebairn, 1969) [22]. Similar result has been reported by Rawat and Pandey (2019) [18] in custard apple and Reshma and Simi (2019) [19] in mango.

3.1.3 Germination percentage

The observations pertaining to germination percentage of tamarind seedlings was significantly influenced by different plant growth regulators and nutrient tested under the present investigation, which are presented in Table 1. Tamarind seed germination percentage data at 30 DAS treatment T_4 (GA_3 @ 200 ppm were recorded significantly, the maximum germination percentages were (93.03%) and it was remained followed by with the treatment T_9 (mechanical scarification) which resulted in 92.60%, respectively. The minimum germination percentages were obtained by treatment T_0 (control) at 77.81%, respectively.

The increase in germination percentage of tamarind seedlings might be due to the fact that the instigative action of GA_3 for germination of seeds as it induces the de novo synthesis of enzymes like α-amylase and ribonuclease. Similar findings were also reported by Achituv and Mendel (1973) [1] in lime and Sharma (2016) [21] in tamarind.

3.2 Growth parameter

3.2.1 Seedling height (cm)

The results are presented in Table 1. The data pertaining to height of plant at 30, 60, 90 and 120 DAS (9.65, 18.17, 25.55 and 31.98 cm respectively) was recorded significantly the maximum in the treatment T_4 GA_3 @ 200 ppm, this was followed by with treatment T_3 GA_3 @ 100 ppm, (9.01, 17.92, 23.51 and 28.27 cm, respectively). The minimum plant height (6.75, 13.15, 18.30 and 23.10 cm respectively) this was recorded in the treatment T_0 (control) soaked into distil water.

Increase in seedling height of tamarind might be due to the action of GA_3 at different stages as it affects the elongation of internodes, as GA_3 is known to enhance cell elongation. They recorded the maximum seedling height and internodes length under 1000 ppm concentration of GA_3. Parameswari and Srimathi (2008) [12] observed maximum shoot length with fortification treatment of GA_3 @ 100 ppm in tamarind. Patil *et al.* (2018) [15] also reported the maximum seedling height of jamun, when seeds were treated in GA_3 @ 200 ppm prior to sowing.

3.2.2 Number of leaves per seedling

The data regarding number of leaves in various treatments were recorded at 30, 60, 90 and 120 DAS presented in Table 1. Significantly, the seed treatments on tamarind as affected by various plant growth regulators and nutrient. At 30, 60, 90 and 120 DAS, the treatment T4 GA3 @ 200 ppm had the highest number of leaves per plant (4.18, 8.92, 13.72 and 18.45, respectively). Which was followed by treatment T3 GA3 @ 100 ppm. (3.85, 8.81, 11.55 and 15.02. leaves per seedling, respectively) and the treatment T_0 control soaked into distil water had the minimum number of leaves (2.63, 6.63, 9.65 and 12.69 respectively).

The increase in number of leaves per seedling in tamarind might be due to the vigorous growth as induced by GA_3, which facilitates better harvest of sunshine by the plants to produce more number of leaves. The result of the present investigation is also supported by Kalalbandi *et al.* (2003). They observed that GA_3 @ 80 ppm concentration was the most effective for number of leaves of Kagzi lime. Gajbhiye and Munde (2010) [7] also observed more number of leaves per seedling in mango under the seeds treated with GA_3 @ 200 ppm, which supported the present results.

3.2.3 Stem girth (mm)

Stem girth (60, 90 and 120 DAS) as responded to various plant growth regulators and nutrient concentration significantly increase the seed treatments on tamarind are presented in Table 1. The treatment T_4 GA_3 @ 200 ppm had the significantly highest girth of the plant at 60, 90 and 120 DAS (2.29, 2.61 and 2.90 mm) respectively. Which was followed by with treatment T_6 KNO_3 @ 1%. (2.12, 2.46 and 2.73 mm respectively). The treatment T_0 direct seed sowing (control) had the minimum stem girth (1.42) mm and T_7 thiourea @ 0.5% (1.59, 1.79) mm respectively).

The result is showed that the pre-sowing seed treatments noticeably improved tamarind stem girth over time. Soaking seeds in GA_3 at 200 ppm for 24 hrs consistently resulted in the thickest stem girth at all stages, promoting cell expansion and cell division. The plant growth hormone likely stimulated morphological development more effectively than other treatments by augmenting cambial activity. Similar results were reported by Hota *et al.*, (2018) [9] in jamun and Manekar *et al.*, (2011) [11] in aonla.

3.2.4 Fresh weight of shoot (g)

The application of various plant growth regulators and nutrient treatments had a substantial impact on the fresh weight of shoots of tamarind seedlings under examination, according to an analysis of the data provided in Table 1 that fresh weight of shoot recorded (120 DAS). The treatment T_4 GA_3 @ 200 ppm had the significantly maximum fresh weight of shoot data at 120 DAS (13.00 g) Which was followed by with treatment T_3 GA_3 @ 100 ppm came (11.79 g). The treatment T_0 control (soaked into distil water) had the minimum fresh weight of shoot, measuring (7.98 g).

The increase in fresh weight of shoots of tamarind seedlings might be due to GA_3, which exhibited profound influence on dry matter accumulation in different plant parts, which could be due to its effect in stimulating cell division, cell elongation, auxin metabolism, cell wall plasticity and permeability of cell membrane leading to enhanced growth. The present result is supported by Choudhary and Chakrawar (1982) [6], they reported that the maximum value of fresh weight rangpur lime shoots under the seed treated with GA_3 @ 40 ppm. Ramteke *et al.* (2015) [17] also found that GA_3 200 ppm was most effective for fresh and dry weight of papaya seedlings. Similar finding were also observed by Patil *et al.* (2017) [16] in jamun.

3.2.6 Dry weight of shoot (g)

The data in relation to dry weight of shoots of tamarind seedlings observed at 120 days after sowing was significantly variated under the different treatments of plant growth regulators and nutrient tested under the present investigation, which are summarized in Table 1. The data pertaining, significantly maximum on dry weight of shoot (5.47 g) was recorded in the treatment T_4 soaking in GA_3 @ 200 ppm, which was followed by with the treatment T_3 GA_3 @ 100 ppm (4.68 g). The minimum dry weight of shoot (3.32 g) was recorded in the treatment T_0 (control) soaked into distil water.

The effect of GA_3 seed treatment may be the cause of the seedling's overall development and longer roots, as increased photosynthesis leads to the assimilation and redistribution of photosynthates inside the seedling, which in turn results in a larger dry weight of the root. Patel *et al.* (2018) [14] reported similar results in tamarind and Parmar *et al.* (2016) [13] found similar results in custard apples.

Table 1: Effect of different pre-sowing treatments on seed germination, seedling growth, and biomass parameters of seedlings at various intervals (30, 60, 90, and 120 DAS).

Treatments	Days taken to seed germination	Days taken to 50% seed germination 30 DAS	Germination percentage 30 DAS	Seedling height (cm)				No. of leaves/seedling				Stem girth (mm)			Fresh weight of shoot (g)	Dry weight of shoot (g)
				30 DAS	60 DAS	90 DAS	120 DAS	30 DAS	60 DAS	90 DAS	120 DAS	60 DAS	90 DAS	120 DAS	120 DAS	120 DAS
Control (T_0)	11.30	22.43	77.81 (8.88)	6.75	13.15	18.30	23.10	2.63	6.63	9.65	12.69	1.42	1.75	2.04	7.98	3.32
NAA 100 ppm (T_1)	9.89	19.44	81.60 (9.09)	7.47	14.29	20.41	26.48	3.67	7.58	10.26	14.24	1.44	1.67	1.97	10.76	3.76
NAA 200 ppm (T_2)	9.15	19.20	82.40 (9.13)	7.97	14.46	20.74	26.66	3.61	7.76	10.56	14.60	1.87	2.11	2.38	10.98	4.11
GA_3 100 ppm (T_3)	6.89	17.33	86.27 (9.34)	9.01	17.92	23.51	28.27	3.85	8.81	11.55	15.02	1.92	2.28	2.36	11.79	4.68
GA_3 200 ppm (T_4)	6.12	16.51	93.03 (9.70)	9.65	18.17	25.55	31.98	4.18	8.92	13.72	18.45	2.29	2.61	2.90	13.00	5.47
KNO3 0.5% (T_5)	8.22	18.58	82.33 (9.13)	8.25	16.20	22.82	27.63	3.25	6.80	9.87	12.82	1.52	1.61	1.81	8.82	3.40
KNO3 1% (T_6)	7.28	18.81	83.51 (9.19)	8.67	17.29	23.06	27.86	3.58	7.60	10.00	13.85	2.12	2.46	2.73	11.05	3.73
Thiourea 0.5% (T_7)	8.71	18.21	82.46 (9.14)	7.05	13.86	19.67	23.79	2.70	6.72	9.71	12.73	1.51	1.59	1.79	8.10	3.38
Thiourea 1% (T_8)	7.19	19.75	83.90 (9.21)	7.35	14.25	20.36	24.95	2.97	6.95	9.91	12.92	1.56	1.63	1.83	9.31	3.46
Machanical scarification (T_9)	5.21	17.68	92.60 (9.67)	8.91	17.48	23.30	28.09	3.81	7.85	11.03	13.00	1.65	1.88	2.23	9.53	3.48
SEm (±)	0.15	0.30	1.34 (0.07)	0.12	0.26	0.39	0.50	0.06	0.14	0.21	0.29	0.03	0.04	0.05	0.17	0.07
C.D. @ 5%	0.44	0.88	3.99 (0.22)	0.36	0.77	1.15	1.49	0.16	0.41	0.62	0.41	0.09	0.11	0.15	0.50	0.21
C.V.%	3.22	2.74	2.75 (1.37)	2.61	2.84	3.09	3.24	2.80	3.14	3.37	3.63	2.92	3.31	3.89	2.87	3.19

Note-SQRT value depicted under brackets

4. Conclusion

The following conclusions can be made Mechanical scarification was found to be significantly superior over other treatments for days taken to seed germination. All other parameters like days taken to 50% seed germination, germination percentage, seedling height (cm), number of leaves per seedling, stem girth (mm), fresh weight of shoot (g) and dry weight of shoot (g), were found significantly superior over other treatments under T_4 GA_3 @ 200 ppm.

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