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Effect of different pre-sowing seed treatment for enhancing the germination and seedling growth in aonla (*Emblica officinalis Gaertn*.)

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Abstract
The present investigation entitled "Effect of pre-sowing seed treatments for enhancing the germination and seedling growth in aonla (*Emblica officinalis Gaertn.*) was conducted at College of Horticulture, Dapoli. Dist. Ratnagiri (M.S.) academic year 2024-25. The experiment comprised of ten different pre-sowing seed treatments including GA3 at concentrations 250 ppm, 500 ppm, 750 ppm for 12 hrs; KNO3 at 0.5%, 1.0%, 1.5% levels for 12 hrs; Acid scarification for 30 secs; Warm water soaking with 50° C temperature for 50 min; Tap water soaking treatment for 12 hrs and control (with-out any pre-sowing treatment). Among the various treatments under study, the seeds treated with GA3 750ppm for 12 hrs was significantly superior over rest of the treatments in all germination and growth parameters under study *viz.* days required for germination (8.87days); 50% germination (11.47days); germination percentage (87.81); survival percentage (85.52), plant height (105.54cm); Girth (9.51mm); No. of leaves (35.76), fresh weight of shoot (59.62 g); dry weight of shoot (26.61 g); length of primary root (58.62 g); number of secondary roots (15.53); fresh weight of root (47.68 g); dry weight of root (22.91 g); vigour index I (9267.46); Vigour index II (2358.20).

Keywords: Aonla, pre-sowing seed treatments, germination, GA3, KNO3

1. Introduction

The Aonla (*Emblica officinalis* Gaertn.) or Indian gooseberry is a valuable minor fruit crop in arid areas and wastelands belonging to the *Euphorbiaceae* family. It is believed to be native to China, Malaysia, Ceylon, and India. The Aonla is found throughout tropical India from the base of the Himalayas to Ceylon, Malaysia and South China. In India aonla is cultivated for many generations (Firminger, 1947). Depending on the region, the fruit is known by various regional names, including *aonla, nelli, amla, amlika, dhotri, emblica, usuri, amali, ambala, and amalakamu* (Radha and Mathew, 2007) [21]. The aonla fruit is known to have laxative, cooling, diuretic, acidic and acrid properties (Gopalan and Mohanram, 1996) [9]. It is a unique edible material that is beneficial when creating ayurvedic medications because it contains high tannins and ascorbic acid (Kalra, 1988). Aonla can be used to make a variety of value-added products, such as chawanprash, pickles, sweets, triphala churna, murabba, etc. In addition to the fruit, the leaves, bark, and seeds have multiple uses. Presently, the area and production of aonla in 2023–2024 cropping year in India indicate that area approximately 91,000 hectares under cultivation, with a total production of around 9.8 lakh tonnes. In maharashtra area under aonla is 4000 ha. and production 5,600 MT. Due to nutritional and medicinal awareness, area under aonla cultivation is also increasing in India day by day. Few but promising efforts have been made to boost seed germination and seedling growth. The various studies have demonstrated that the use of plant growth regulators and chemicals as pre-sowing treatments, such as gibberellic acid (GA_3), thiourea, potassium nitrate (KNO_3) and scarification can significantly increase the germination percentage, shorten the time to germination and improve seedling vigour (Dhankar and Singh, 1996; Pawshe *et al*., 1997; Gholap *et al*., 2000; Rajamanickam *et al*., 2002) [7, 18, 10, 20]. These findings highlight the need for systematic research to optimize these treatments efficacy for broad use in nurseries.

2. Material and Methods

The trial was carried out at nursery no. 10 College of Horticulture, Dr. B.S.S.K.V. Dapoli, from february 2024 to febuay 2025. The seeds was collected from kadam nursery, Kudal, Dist- Sindhudurg. The aonla seeds were soaked in different growth regulators, chemicals and water for 12 hrs. The seeds after treatments were directly sown in 6" × 8" polybag having soil + vermicompost media with proportion 3:1. The experiment was designed in a randomized block design (RBD). The treatments incorporated were GA3 at concentrations of (T_1) 250 ppm for 12 hrs, (T_2) 500 ppm for 12 hrs, (T_3) 750 ppm for 12 hrs, and KNO3 at concentrations of (T_4) 0.5% for 12 hrs, (T_5) 1.0% for 12 hrs, (T_6) 1.5% for 12 hrs, (T_7) was Acid scarification for 30 secs. (T_8) Warm water at 50 Č for 50 mins, (T_9) Tap water for 12 hrs and (T_{10}) Control. A set of 100 seedlings per treatment per replication was produced as a unit by averaging the data collected from the ten tagged seedlings in each treatments/ replication. The observations viz., germination parameters including days required for germination, days required for 50% germination (days), germination percentage (%), survival percentage (%); growth parameters including seedling height (cm), seedling girth (mm), number of leaves; shoot parameters including fresh weight of shoot (g), dry weight of shoot (g); root parameters including primary root length (cm), , number of secondary roots, fresh weight of root (g), dry weight of root (g) and included vigour index-I is (Germination percentage X length of seedlings) The data generated from the studies were subjected to analysis by using standard method suggested by Panse and Sukhatme (1985).

$$\text{Germination percentage (\%)} = \frac{\text{No. of seeds germinated}}{\text{Total no. of seeds sown}} \times 100$$

$$\text{Survival percentage (\%)} = \frac{\text{Number of seedlings survived}}{\text{Total number of seed sown}} \times 100$$

3. Result and Discussion

3.1 Germination parameters

3.1.1 Days required for germination

The number of days required for germination was significantly affected by the various seed treatments under study. Based on the data in table no. 1, the minimum days required for germination in aonla seeds was recorded in (T3) GA3 750 ppm for 12 hrs (8.87 days) and the maximum days required for germination in aonla seeds was recorded in (T_{10}) Control (22.10). The fact that seeds treated with GA_3 @ 150 ppm emerged noticeably earlier may be due to gibberellic acid, which is crucial for encouraging enzyme activity during germination. GA_3 is known to promote the production of α-amylase, which breaks down stored starch into simple sugars that provide the energy needed for physiological and metabolic processes (Palepad *et al*., 2017; Hota *et al*., 2018) [19, 13].

3.1.2 Days required for 50% germination

The data revealed that the days required for 50% germination of aonla seeds varied significantly across the different seed treatments under study. The treatment T_3 (GA_3 at 750 ppm) exhibited the earliest 50% seed germination with an average of 11.47 days. In contrast, the longest time to initial germination was noted in the control (T_{10}) at 29.58 days. The seeds treated with 750 ppm GA_3 germinated 50% earlier because the hormone started the enzyme activity required for germination. GA_3 is known to promote the synthesis of α- amylase, an enzyme that converts stored starches into simpler sugars, which supplies the energy required for various metabolic and physiological processes (Palepad *et al.*, 2017; Hota *et al.*, 2018) [19, 13].

Table 1: Effect of different per-sowing seed treatments on various germination parameters in aonla

Treatment No.	Treatment details	Days required for germination	Days required for 50% germination	Germination percentage	Survival percentage	Vigour index-1
T_1	GA3 250 ppm	13.63	16.30	67.98	63.58	6529.25
T_2	GA3 500 ppm	9.72	12.78	81.12	81.26	8220.01
T_3	GA3 750 ppm	8.87	11.47	87.61	85.52	9267.46
T_4	KNO3 0.5%	12.30	18.60	64.76	61.20	6110.07
T_5	KNO3 1%	11.13	17.72	73.28	72.33	7284.15
T_6	KNO3 1.5%	10.09	15.57	76.49	73.24	7698.6
T_7	Acid scarification	18.33	25.78	54.03	50.63	4832.16
T_8	warm water (50 Č)	15.67	21.36	58.94	53.69	5381.62
T_9	Tap water	20.29	27.80	49.11	45.27	4195.35
T_{10}	Control	22.10	29.58	45.60	39.06	4084.98
Range		8.87 – 22.10	11.47 - 29.58	87.61- 45.60	85.52- 39.06	4084.98- 9267.46
Mean		14.21	19.69	65.89	0.123	6345.27
SE.m±		0.335	0.145	0.287	0.366	0.631
C.D. @ 5%		0.996	0.431	0.851	62.58	1.874

3.1.3 Germination percentage

The highest germination percentage was recorded in T_3 – GA_3 @ 750 ppm (87.61%) whereas the lowest germination percentage was found in T_{10} – Control (45.60%). The increased germination in GA_3-treated seeds may be due to the hormone's role in activating cytological enzymes and encouraging the synthesis of amylase, which converts insoluble starch into soluble sugars and provides energy for germination. GA_3 also promotes the growth of radicles by removing metabolic barriers, which may allow germination inhibitors to seep out during soaking (Palepad *et al.*, 2017) [19]. Additionally, GA_3 breaks seed dormancy and encourages early germination by mimicking endogenous gibberellins (Gurung *et al.*, 2014) [12].

3.1.4 Survival percentage

The highest survival percentage (85.52%) was recorded in treatment T_3 – GA_3 @ 750 ppm. In contrast, the lowest survival percentage (39.06%) was observed in T_{10} – Control. The enhanced survival observed in GA_3-treated seedlings is due to gibberellic acid's growth-regulating properties, which also promote balanced root and shoot development, increase seedling vigor, and improve tolerance to environmental stress. These findings are consistent with previous research in other fruit crops. For instance, Ramteke (2015) [22] reported a survival rate of 78.78% in papaya, Dilip *et al.* (2017) [6] recorded 82.00% in Rangapur lime, Palepad *et al.* (2017) [19] noted 72.81% in custard apple, and Lalitha *et al.* (2020) [16] observed 72.12% in aonla. Collectively, these studies reinforce the effectiveness of GA_3 in improving seedling survival across a variety of horticultural species.

3.1.5 Vigour index I
According to the data in table 1, the various pre-sowing seed treatments under study had a substantial impact on the Vigour Index-I of the aonla seedling measured at 270 days after sowing.

The different pre-germination treatments resulted in notable differences in the aonla's seedling vigour index-I data. The highest seedling vigour index-I (9267.46) was noted for seeds treated with GA3 at 750 ppm for 12 hours (T_3). better than the (T_{10}) control (4084.98). The GA3 treatment had the highest seedling vigour index-I based on germination percentage and seedling height. The longer seedlings and higher germination rate could be the cause of the higher seedling vigor index-I. This result was consistent with studies by Sharma *et al*. (2021) in Aonla, Barathkumar (2019) [5], Lalitha *et al*. (2020) [16], and Yadav *et al*. (2022) [27] in Jatti Khatti.

3.2 Growth parameters
3.2.1 Seedling height (cm)
At 270 days after sowing, the seedling height was significantly affected by the different seed treatments. The greatest seedling height (105.54 cm) was noted in treatment T_3 – GA_3 at 750 ppm. The shortest seedlings (73.18 cm) were observed in the control treatment (T_{10}). Exogenous application of GA_3 promotes cell elongation and division, thereby accelerating seedling growth and increasing plant height (Kumari *et al*., 2007) [14]. These results align with the findings of Gurung *et al*. (2014) [12], who reported that GA_3 stimulates growth by enhancing cellular activity. Furthermore, GA_3 may contribute to increased amino acid synthesis indirectly facilitating plant growth as observed in citrus species (Meshram *et al*., 2015) [17].

Table 2: Effect of different pre-sowing seed treatments on various growth parametes (Seedling height, seedling girth, no of leaves/ seedlings) in aonla seedlings.

Treatments	Seedling height (cm)			Girth in (mm)			No of leaves/seedlings		
	90 DAS	180 DAS	270 DAS	90 DAS	180 DAS	270 DAS	90 DAS	180 DAS	270 DAS
T_1	47.46	72.92	96.42	3.21	6.01	8.80	11.92	33.66	28.49
T_2	53.25	79.45	101.32	3.41	6.20	8.90	15.35	38.91	33.9
T_3	55.92	81.22	105.54	4.10	7.01	9.51	18.51	40.23	35.76
T_4	39.33	69.62	94.35	3.60	5.40	9.11	12.59	31.52	26.41
T_5	49.66	75.36	99.37	3.81	6.4	9.32	13.26	35.87	30.57
T_6	51.67	77.42	100.36	3.9	6.8	9.41	17.71	36.52	31.8
T_7	38.6	64.36	88.47	2.7	4.9	8.4	9.51	26.7	23.27
T_8	40.53	67.53	91.38	2.9	5.92	8.61	10.76	29.79	25.87
T_9	36.39	61.39	85.46	2.5	5.51	8.3	8.93	25.32	22.69
T_{10}	30.53	53.64	73.18	2.3	4.32	5.06	7.61	22.01	20.75
Range	55.92- 30.53	81.22- 53.64	105.54- 73.18	4.10-2.3	7.01-4.32	9.51-5.06	18.51-7.61	40.23-22.01	35.76-20.75
Mean	44.31	70.30	93.78	3.24	6.05	8.74	12.64	33.68	27.95
S.E.m (±)	1.315	0.128	0.099	0.007	0.008	0.011	0.022	0.019	0.023
C. D. @ 5%	4.013	0.381	0.293	0.022	0.025	0.031	0.064	0.056	0.069

3.2.2 Seedling girth (mm)
At 270 days after Sowing, significant differences in collar girth were noted among the various seed treatments under study. The average collar girth recorded was 8.74 mm. The highest girth (9.51 mm) was observed in treatment T_3 – GA_3 @ 750 ppm, whereas the lowest girth (5.6 mm) was recorded in the control treatment (T_{10}). The increase in girth may be attributed to the stimulation of the cambium and subsequent cell proliferation, as well as enhanced cell elongation and division in the stem (Kumari *et al*., 2007) [14]. The higher endogenous levels of GA3 likely promoted these cellular activities, resulting in increased girth at the collar region (Kalyani and Bharad, 2017) [15]. Similar findings were reported by Singh *et al*. (2017) [23] in soursop and by Hota *et al*. (2018) [13], who observed increased girth in jamun seedlings treated with GA3 at 450 ppm (5.78 mm).

3.2.3 Number of leaves
The number of leaves varied significantly at 270 DAS. At this crop growth stage, the highest number of leaf (35.76) was noticed in the treatment T_3 (GA3 @ 750 ppm) as against the lowest number of leaves (20.75) was observed in the treatment (T_{10}) Control as affected by various pre sowing seed treatments under study. GA_3 treatment accelerates photosynthetic carbon assimilation by raising chlorophyll content and improving stomatal conductance. As a result, more photosynthates are synthesized and distributed to growing tissues like leaves. This increase in available energy and building blocks enables faster leaf primordia initiation, faster leaf expansion, and higher leaf area. While, Meshram *et al*. (2015) [17] reported similar results in acid lime, where GA_3 at 200 ppm produced a leaf count of 34.93, Bajaniya *et al*. (2018) [3] demonstrated an increase in leaf number (11.02) in khirni treated with GA_3 at 200 ppm.

3.3 Effect of different seed treatments on shoot parameters in Aonla seedlings
3.3.1 Fresh weight of shoot (g)
The fresh shoot weight data of aonla seedlings taken at 270 DAS showed significant difference among the various pre-sowing seed treatments under study. At this crop growth

stage among the various treatments, the treatment T_3 (soaking seeds in GA3 @ 750 ppm concentration for 12 hours) had the highest fresh weight (59.62 g) of aonla seedling shoot. While the treatment T_{10} (control) had the lowest fresh weight (13.43 g).

The results displayed in Table 6 indicate that the fresh weight of the shoot in aonla seedlings was significantly impacted by the pre-sowing seed treatments under study. The seeds treated with GA3 750 ppm for 12 hours produced the aonla seedlings with the highest fresh shoot weight. This might be due to the gibberellic acid seed treatment raises the plant height, number of leaf and stem diameter.

These factors all help the plant grow quickly and, eventually, increase the maximum fresh shoot weight of seedlings. The results are in line with those of Boricha *et al.* (2020) [4] for guava and Gurung *et al*. (2014) [12] for passion fruit.

3.3.2 Dry weight of shoot (g)

At 270 DAS, the average dry weight of shoot in aonla seedlings was noticed to be 14.00g as influenced by the various pre sowing seed treatments under study. By taking into consideration the highest dry shoot weight (26.61g) was observed in treatment T_3 where the seeds were soaked the in GA3 750 ppm for 12 hours. In contrast, the aonla seedlings recorded the lowest dry shoot weight (5.62 g) in treatment T_{10} that omitted the pre-sowing seed treatment.

The seeds treated with 750 ppm GA3 for 12 hours produced the aonla seedlings with the highest dry shoot weight. One possible explanation for this could be that the highest fresh shoot weight, which in turn results in the highest dry weight of shoots, is associated with gibberellic acid seed treatment. The results align with the findings of Boricha *et al.* (2020) [4] for guava, Gurung *et al.* (2014) [12] for passion fruit and Gawade (2008) [11] for custard apple.

Table 3: Effect of different pre-sowing seed treatments on various shoot & root parameters in aonla seedlings

Treatment No.	Treatment details	Fresh weight of shoot (g)	Dry weight of shoot (g)	Primary root length (cm)	Number of secondary roots	Fresh weight of root (g)	Dry weight of root (g)
T_1	GA3 250 ppm	47.75	14.71	40.58	11.63	37.49	13.41
T_2	GA3 500 ppm	57.48	22.67	53.47	13.52	44.52	20.54
T_3	GA3 750 ppm	59.62	26.61	58.62	15.53	47.68	22.91
T_4	KNO3 0.5%	42.50	12.17	38.73	9.92	35.64	11.23
T_5	KNO3 1%	49.27	16.24	47.50	12.70	39.20	15.48
T_6	KNO31.5%	55.81	19.7	51.67	10.59	40.68	18.52
T_7	Acid scarification	33.59	6.45	25.79	7.71	30.59	10.02
T_8	warm water (50 °C)	38.73	9.53	32.44	8.58	32.02	12.51
T_9	Tap water	17.57	5.79	18.50	6.40	25.40	9.5
T_{10}	Control	13.43	5.62	13.49	5.66	23.61	8.25
Range		13.43-59.62	5.62-26.61	13.49-58.62	5.66-15.53	23.61-47.68	8.25-22.91
Mean		41.58	14.00	38.07	10.22	35.68	14.24
SE.m±		0.075	0.101	0.069	0.092	0.050	0.078
C.D. @ 5%		0.224	0.301	0.204	0.273	0.147	0.232

3.4 Effect of different seed treatments on root parameters in Aonla seedlings

3.4.1 Length of primary root(cm)

At 270 DAS, treatment T_3 (soaking seeds in GA3 750 ppm for 12 hours) had the longest primary root length (58.62 cm) whereas the treatment T_{10} (control, without pre-sowing seed treatment) had the shortest primary root length (13.49 cm).

The length of the root is a more important factor to consider when assessing the roots' growth and ultimately the plant's vigour. Data on the primary root length of seedlings as influenced by different pre-sowing seed treatments are provided in table 10 and fig no.11. The data was significantly impacted by the different pre-sowing aonla seed treatments. At 270 DAS, treatment T_3 (soaking seeds in GA3 750 ppm for 12 hours) had the longest primary root length (58.62 cm) whereas the treatment T_{10} (control, without pre-sowing seed treatment) had the shortest primary root length (13.49 cm).

The principal root (tap root) grew longer after being exposed of GA3, for the reason for this was that the hormone increased osmotic uptake of nutrients which caused cells in the sub-apical region of roots to elongate (Shanmugavelu, 1966) [24]. Similar results were found in papaya by Ananthakalaiselvi and Dharmalingam (1998) [1], Boricha *et al.* (2020) [4], Palanisamy and Ramamurthy (1987), Vijayakumar and Palanisamy (1991) [26], and Anburani and Shakila (2010) [2].

3.4.2 Number of secondary roots

The number of secondary roots in aonla seedlings at 270 DAS was statistically significant among the different pre-sowing seed treatments under study.

According to the data in table 3, the aonla seedings exposed to the treatment T_3 (soaking seeds in GA3 750 ppm for 12 hours) produced the the highest numbers of secondary roots (15.53) at 270 DAS. This was superiorly significant over all other treatment under study. On the other hand, the lowest numbers of secondary roots (5.66) were recorded by the treatment T_{10} (control, without pre-sowing seed treatment).

The results presented in table 3 indicate that the pre-sowing seed treatments significantly affects the numbers of secondary roots of aonla seedlings. The seed treatment with GA3 750 ppm for 12 hours increases the number of secondary roots per seedling resulting in better growth because auxins are translocated and assimilated. Boricha *et al*. (2020) [4] observed similar results in guava and Patil *et al.* (2017) [18] in jamun.

3.4.3 Fresh weight of root (g)

The fresh root weight of aonla seedlings measured at 270 days after sowing indicates that the different pre-sowing seed treatments under study had a significant impact as shown by the data presented in table 13 and shown in fig no.14.

The fresh root weight of aonla seedlings in treatment T_3 (soaking seeds in GA3 750 ppm for 12 hours) was found to be significantly highest (47.68 g) at 270 DAS, while the fresh root weight of seedlings in treatment T_{10} (control-without pre-sowing seed treatment) was observed to be the lowest (23.61 g) among the various treatments under study.

The data presented in table 8 indicate that the fresh weight of root in aonla seedlings was significantly impacted by the various pre-sowing seed treatments under study. The highest fresh weight of roots was found in aonla seedlings treated with GA3 750 ppm concentration for 12 hours. This may be due to the fact that gibberellins in roots, like in shoots, cause the cells in the subapical region to elongate, lengthening the roots and increasing their fresh weight. The results align with those of Gawade (2008) [11] for custard apple, Gurung *et al*. (2014) [12] for passion fruit and Boricha *et al*. (2020) [4] for guava.

3.4.4 Dry weight of root

According to the data in table 3, the various pre-sowing seed treatments under study had a substantial impact on the dry root weight of the aonla seedling measured at 270 days after sowing.

Importantly at 270 DAS, the Aonla seedlings with the highest dry root weight (22.91 g) were observed in treatment treated with T_3 (soaking seeds in GA3 750 ppm for 12 hours). In contrast, the aonla seedlings with the lowest dry root weight (8.25 g) were found to be in treatment T_{10} (control, without pre-sowing seed treatment) among the various treatments under study.

The dry weight of root aonla seedlings was significantly impacted by the pre-sowing seed treatments, as indicated by the data in Table 13. The seeds treated with GA3 750 ppm for 12 hours produced the aonla seedlings with the highest dry weight of roots. The highest fresh weight of the roots was recorded along with the maximum dry weight of the roots, suggesting that the gibberellic acid seed treatment may have caused this because it increased cell elongation, which in turn led to maximum root growth. The results align with those of Gawade (2008) in custard apple, Gurung *et al.* (2014) [12] in passion fruit, and Boricha *et al*. (2020) [4] in guava.

4. Conclusion

The present study entitled " Effect of different pre-sowing seed treatments for enhancing the germination and seedling growth in Aonla (*Emblica officinalis Gaertn*.)" revealed that the various pre sowing seed treatments under study significantly promoted early germination and accelerated the seedling growth in aonla. Each growth metric showed a discernible improvement over the control. With the lowest values for first germination time (8.87 days) and days required for 50% germination (11.47 days) along with the highest values for germination (87.61) and seedling survival (85.52) percentages the treatment T_3 (GA_3 at 750 ppm) performed better among the various treatments under study. Similarly, the seeds exposed to the treatment T_3 produced the tallest seedlings (105.54 cm) having the thickest girth (9.51 mm) with the maximum values for number of leaves (35.76), fresh weight of shoot (59.62 g), dry weight of shoot (26.61 g), length of primary root (58.62 cm), number of secondary roots (15.53), fresh weight of root (47.68 g), dry weight of root (22.91 g). Additionally, the highest seedling vigour index I (9267.46) and seedling vigour index II (2358.20) this treatment was also favourable.

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