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Effect of plant growth regulator on seed germination and seedling growth of Aonla (*Emblica officinalis* G.)

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ABSTRACT

The present investigation entitled “Effect of plant growth regulator on seed germination and seedling growth of Aonla (*Emblica officinalis* Gaertn.)” was conducted at the Instructional-cum-Horticulture Farm and Nursery, Department of Horticulture, Mahatma Phule Krishi Vidyapeeth, Rahuri, Maharashtra, during 2025–26. The experiment was carried out to identify a suitable concentration of gibberellic acid (GA₃) and soaking duration for improving seed germination and seedling growth of aonla. The experiment was laid out in a Factorial Completely Randomized Design with two soaking durations, viz., 12 and 24 hours, and seven GA₃ concentrations comprising control, GA₃ at 200, 300, 400, 500 and 600 ppm, and warm water soaking, with two replications. The results revealed that soaking duration and GA₃ concentration significantly influenced seed germination and most of the seedling growth parameters. Seed soaking for 24 hours recorded the minimum days for germination (9.21), higher germination (84.61%), seedling survival (70.32%), number of leaves (11.04), seedling height (22.23 cm), compared with 12 hours soaking. Among the GA₃ concentrations, GA₃ @ 200 ppm recorded the minimum days for germination (7.50), highest germination percentage (92.88%), superior survival percentage at 90 days (80.38%) and number of leaves (14), and produced greater seedling height (26.95 cm). The interaction between 24 hours soaking and GA₃ @ 200 ppm recorded the the minimum days for germination (6.50), highest germination percentage (94.50%), maximum number of leaves per seedling (15.80) and maximum seedling height at 90 days (28.09 cm). Overall, pre-sowing treatment with GA₃, particularly 200 ppm for improving germination and early seedling growth and proved beneficial for raising vigorous aonla seedlings under the conditions of the present investigation.

Keywords: Aonla, *Emblica officinalis*, GA₃, Seed germination, Seedling growth, Seed soaking, Nursery management

Introduction

Aonla (*Emblica officinalis* Gaertn.) belongs to the family Phyllanthaceae and is an important fruit crop valued for its nutritional, medicinal and therapeutic properties (Ganachari *et al.*, 2010) [1]. It is commonly known as Amla, Nelli, Amlika, Dhatri, *Emblica* and Usuri in different regions of India (Barathkumar, 2019) [2]. The crop is hardy, productive and well adapted to diverse environmental conditions, including saline, sodic, dry and arid regions. Seedling-grown aonla plants generally require 6–8 years to commence bearing, whereas vegetatively propagated plants can be brought into commercial production earlier (Radha *et al.*, 2007) [3].

The fruit is highly nutritious and particularly valued for its high vitamin C content, besides containing pectin, minerals and other bioactive compounds. Its medicinal importance has been widely recognized, with Khan (2009) [4] reporting hypolipidemic, hypoglycemic and antimicrobial properties, while De *et al.* (2020) [5] associated aonla consumption with improved immune function. Because of its nutritional and medicinal value, aonla has considerable importance in the pharmaceutical, cosmetic and food-processing industries.

Aonla can be propagated through both sexual and asexual methods, although commercial propagation is mainly carried out through patch budding (Negi *et al.*, 2010) [6]. The success of budding largely depends on the availability of healthy and vigorous rootstock seedlings. However, freshly harvested aonla seeds often exhibit poor germination because of seed dormancy (Srimathi, 2000) [7]. Poor germination may be associated with physiological factors of the embryo and morphological barriers such as the hard and thick seed coat (Mousavi *et al.*, 2011) [8].

The slow growth of aonla seedlings and the extended period required to attain the buddable stage make efficient nursery management essential. Water soaking and hot-water treatments have been used to overcome seed-coat impermeability and improve germination. Plant growth regulators are also widely used to enhance seed germination and subsequent root and shoot development (Lal *et al.*, 2013) [9]. Suitable plant growth regulator treatments can improve germination percentage as well as accelerate seedling growth (Lal *et al.*, 2017) [10].

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Among the plant growth regulators, gibberellic acid (GA₃) plays an important role in promoting seed germination by stimulating the mobilization of stored food reserves. The enhanced germination of GA₃-treated seeds may be associated with activation of starch hydrolysis, resulting in better nutrient translocation and seedling development (Kumari, 2006) [11]. Therefore, optimization of pre-sowing treatment is important for improving germination and producing vigorous root-stock seedlings for aonla propagation. Hence, the present investigation was undertaken to determine a suitable concentration of GA₃ and soaking duration for improving seed germination and seedling growth of aonla.

Materials and Methods

The present investigation was conducted at the Instructional-cum-Horticulture Farm and Nursery, Department of Horticulture, Mahatma Phule Krishi Vidyapeeth, Rahuri, Maharashtra, during February 2025 to study the effect of plant growth regulator on seed germination and seedling growth of aonla (*Emblia officinalis* Gaertn.). The experiment was laid out in Factorial Completely Randomized Design (FCRD) with two soaking durations and seven seed treatments, replicated twice. A total of 14 treatment combinations were evaluated with 200 seeds per treatment.

The experimental material consisted of healthy and viable aonla seeds collected from fully ripe fruits obtained from the orchard of the Department of Horticulture, MPKV, Rahuri. The fruits were sun-dried for four weeks and the hard stones were cracked to extract the seeds. Viable seeds were selected by the water floatation method, in which seeds that settled at the bottom were considered suitable for sowing, while floating seeds were discarded.

The treatments comprised two soaking durations, viz., T₁ – 12 hours and T₂ – 24 hours, and seven GA₃ concentrations, viz., C₁ – control, C₂ – GA₃ @ 200 ppm, C₃ – GA₃ @ 300 ppm, C₄ – GA₃ @ 400 ppm, C₅ – GA₃ @ 500 ppm, C₆ – GA₃ @ 600 ppm and C₇ – water soaking. A stock solution of GA₃ (1000 ppm) was prepared by dissolving 1 g (1000 mg) of GA₃ in 5–10 ml of ethyl alcohol and making the volume up to 1000 ml with distilled water. From this stock solution, the required concentrations of 200, 300, 400, 500 and 600 ppm were prepared using the dilution formula $C_1V_1 = C_2V_2$. For each concentration, the calculated quantity of stock solution was measured and the volume was made up to 100 ml with distilled water. Thus, 20, 30, 40, 50 and 60 ml of the 1000 ppm stock solution were used to prepare 100 ml of 200, 300, 400, 500 and 600 ppm GA₃ solutions, respectively. The aonla seeds were soaked in the respective GA₃ solutions for 12 and 24 hours as per the treatment.

The treated seeds were sown in 200-gauge polythene bags (5 × 8 inch) containing potting mixture, cocopeat and fungicide, with one seed per bag at a depth of 2–2.5 cm. The treatment combinations were maintained separately and labelled properly. The seedlings were watered regularly and other cultural practices were followed as required. The observations were recorded as given below.

(A) Seed germination

Days taken for initiation of germination

Initiation of germination was recorded from the date of sowing till the first seed germinated and days taken to germinate were recorded.

Germination (%)

The germination count was taken daily, starting from initiation of germination after sowing of seeds and continued till cessation of germination. It was calculated by dividing total number of seeds germinated out of total number of seeds sown and was multiplied by 100.

$$\times \quad 100$$

Germination (%) = No. of seed germinated
Total seed sown

(B) Seedling survival and vegetative growth

Survival percentage

The survival of seedlings in each treatment was calculated by counting the number of seedlings present in polybags at 30, 60 and 90 days after sowing. The mean survival percentage of seedlings was calculated from number of seedlings survived and total initial seedlings germinated after sowing

$$\times \quad 100$$

Survival percentage = No. of seedlings survived
Total seed sown

Number of leaves per seedling

The number of leaves present on each seedling was counted and the average number of leaves per seedling was worked out. The observation was recorded after 90 days after sowing.

Seedling height (cm)

The height of the randomly selected observational seedlings were measured from the base just above the soil to the crown region and average length was worked out at 30, 60 and 90 days after sowing and was expressed in centimeter.

The data obtained were statistically analysed according to the procedure prescribed by Panse *et al.* (1985) [12]. The significance of treatment effects was tested using the Critical Difference (CD) at 5 per cent level of significance.

Results and Discussion

(A) Seed germination

Days to seed germination

The effect of different soaking durations and GA₃ concentrations on the number of days required for seed germination was evaluated through statistical analysis. The corresponding results are presented in Table 1.

The minimum number of days required for germination was recorded with 24 hours soaking (9.21 days), compared with 9.79 days under 12 hours soaking. Among GA₃ treatments, 200 ppm recorded the earliest germination (7.50 days), whereas the control required the maximum time (12.00 days). The interaction was significant, with T₂C₂ (24 h + GA₃ 200 ppm) recording the minimum germination period of 6.50 days, compared with 12.50 days in T₁C₁ (control). Prolonged soaking for 24 hours may have enhanced GA₃ absorption and its physiological efficacy, stimulating embryo growth, hydrolytic enzyme activity, and mobilization of stored reserves. This may have facilitated radicle protrusion and accelerated seedling emergence, thereby reducing the time required for germination. These findings are in conformity with the observations of Bhujbal (1975) [13], Pawshe *et al.* (1997) [14], Gholap *et al.* (2000) [15], Rajamanickam *et al.* (2002) [16], and Chiranjeevi *et al.* (2017) [17].

Germination %

The data pertaining to germination (%) as influenced by different soaking durations and GA₃ concentrations were recorded and statistically analysed. The results are presented in Table 2.

Germination percentage was also significantly improved by treatment. Twenty-four hours soaking recorded higher germination (84.61%) than 12 hours soaking (81.46%). GA₃ @ 200 ppm recorded the highest mean germination (92.88%), compared with 71.50% in the control. The highest interaction value was recorded with T₂C₂ (94.50%), while T₁C₁ recorded the lowest germination (68.75%). The improvement in germination may be associated with enhanced GA₃-mediated enzyme activity, mobilization of stored reserves and improved embryo growth. This is analogous to the findings of Bhujbal (1975) [13], Pawshe *et al.* (1997) [14], Wagh *et al.* (1998) [18], Gholap

et al. (2000) [15], Rajamanickam *et al.* (2002) [16] and Chiranjeevi *et al.* (2017) [17].

Table 1. Effect of soaking durations and GA₃ concentrations on days to seed germination of Aonla.

	T ₁ - 12 hr	T ₂ - 24 hr	Mean
C ₁ - Control	12.50	11.50	12.00
C ₂ - 200 ppm	8.50	6.50	7.50
C ₃ - 300 ppm	9.50	9.00	9.25
C ₄ -400 ppm	8.50	7.00	7.75
C ₅ -500 ppm	10.00	9.00	9.50
C ₆ - 600 ppm	9.00	10.50	9.75
C ₇ - water Soaked	10.50	11.00	10.75
Mean	9.79	9.21	9.50
	T	C	TxC
SEm(±)	0.17	0.16	0.46
CD at 5%	0.53	0.49	1.40

(B) Seedling survival and vegetative growth

Survival percentage at 30, 60 and 90 days after seed germination

Survival percentage at 30 days after seed germination

Soaking duration significantly influenced seedling survival at 30 days after germination. The highest mean survival percentage was recorded with 24 hours soaking (80.43%), while 12 hours soaking (77.75%) recorded the lowest. Among GA₃ concentrations, 200 ppm resulted in the highest mean survival (89.13%), whereas the control (C₁) recorded the lowest (67.00%). The interaction effect was significant, with T₂C₂ (24 hours soaking + 200 ppm GA₃) recording the highest survival (90.75%), while the lowest was observed under T₁C₁ (control; 64.50%).

Table 2. Effect of soaking durations and GA₃ concentrations on germination (%) of Aonla.

	T ₁ - 12 hr	T ₂ - 24 hr	Mean
C ₁ - Control	68.75 (56.02)	74.25 (59.51)	71.50 (57.76)
C ₂ - 200 ppm	91.25 (72.81)	94.50 (76.45)	92.88 (74.63)
C ₃ - 300 ppm	85.75 (67.82)	82.25 (65.08)	84.00 (66.45)
C ₄ -400 ppm	84.75 (67.07)	88.50 (70.39)	86.63 (68.73)
C ₅ -500 ppm	83.25 (65.89)	86.25 (68.24)	84.75 (67.06)
C ₆ - 600 ppm	82.75 (65.46)	81.75 (64.71)	82.25 (65.09)
C ₇ - water Soaked	73.75 (59.18)	84.75 (67.21)	79.25 (63.20)
Mean	81.46 (64.89)	84.61 (67.21)	83.04 (63.20)
	T	C	TxC
SEm(±)	0.68	0.63	1.79
CD at 5%	2.06	1.92	5.45

Survival percentage at 60 days after seed germination

At 60 days after germination, soaking duration significantly affected seedling survival, with 24 hours soaking (T₂) recording a higher mean survival (75.50%) than 12 hours soaking (74.11%). Among GA₃ treatments, 200 ppm (C₂) recorded the highest mean survival (85.25%), compared with 62.50% under the control. The interaction effect was significant, and T₂C₂ (24 hours soaking + 200 ppm GA₃) recorded the highest survival (86.75%), whereas the lowest value was observed under T₁C₁ (control; 74.00%).

Survival percentage at 90 days after seed germination

At 90 days after germination, 24 hours soaking (T₂) recorded the highest mean survival (70.32%), compared with 68.71% under 12 hours soaking (T₁). Among GA₃ concentrations, 200 ppm (C₂) resulted in the highest mean survival (80.38%), while the control recorded the lowest (56.88%). The interaction effect was significant, with T₂C₂ (24 hours soaking + 200 ppm GA₃) recording the highest survival (82.50%), whereas the lowest was observed under the control treatment combination. The superior survival with GA₃ @ 200 ppm may be attributed to enhanced seed vigour, root establishment, photosynthetic efficiency and stress tolerance. The beneficial effect of 24-hour soaking may be due to greater GA₃ absorption, stimulating metabolic activity and seedling establishment. Vigorous seedlings with stronger root systems and greater carbohydrate reserves consequently exhibited better survival during the nursery period. The present findings are in close conformity with those reported by Jain *et al.* (2017) [19], Dilip *et al.* (2017) [20], Lalitha *et al.* (2020) [21] Singh and kaur (2020) [22] and Yadav *et al.* (2018) [23].

Number of leaves after 90 days after seed germination

The number of leaves was significantly influenced by both factors. Twenty-four hours soaking produced 11.04 leaves per seedling compared with 10.24 under 12 hours soaking. GA₃ @ 200 ppm recorded the highest mean number of leaves (14.00), while the control recorded 9.00. The maximum value was recorded in T₂C₂ (15.80) leaves per seedling. Higher leaf number under GA₃ treatment, particularly at 200 ppm, may be attributed to enhanced cell division, elongation and meristematic activity. GA₃ may also improve nutrient uptake, assimilate translocation and photosynthetic efficiency, promoting vigorous vegetative growth. The superior response with 24-hour soaking may be due to greater GA₃ absorption and enhanced metabolic activity, resulting in increased leaf initiation. Greater leaf production provides a larger photosynthetic surface, thereby supporting improved seedling growth and development. The present findings are in agreement with those reported by Supe *et al.* (2012) [24], Chiranjeevi *et al.* (2017) [17], Kumari *et al.* (2007) [25], and Lalitha *et al.* (2020) [21].

Seedling height at 30, 60 and 90 days after seed germination

The data pertaining to seedling height recorded at 90 days after seed germination was significantly influenced by soaking duration, GA₃ concentration and their interaction. The data are presented in Table 3.

Seedling height at 30 days after seed germination

At 30 DASG, 24-hour soaking (T₂) recorded significantly higher mean seedling height (8.37 cm) than 12-hour soaking (7.49 cm). Among GA₃ concentrations, 200 ppm (C₂) produced the tallest seedlings (8.98 cm), while the control recorded the shortest (6.99 cm). The interaction was significant, with T₂C₂ (24-hour soaking + 200 ppm GA₃) recording the maximum height (9.24 cm), whereas T₁C₁ recorded the minimum (6.92 cm).

Seedling height at 60 days after seed germination

At 60 DASG, seedlings from 24-hour soaking (T₂) attained greater mean height (16.83 cm) than those from 12-hour soaking (15.78 cm). GA₃ @ 200 ppm (C₂) recorded the highest mean height (18.17 cm), statistically at par with 400 ppm (18.07 cm), while the control recorded the lowest (12.99 cm). The maximum height under interaction was observed in T₂C₂ (19.82 cm), whereas T₁C₁ recorded the minimum (12.34 cm).

Seedling height at 90 days after seed germination

At 90 DASG, 24-hour soaking (T₂) resulted in higher mean seedling height (22.23 cm) than 12-hour soaking (21.26 cm). Among GA₃ concentrations, 200 ppm (C₂) recorded the maximum mean height (26.93 cm), compared with 17.57 cm in the control. The interaction showed the highest seedling height in T₂C₂ (28.09 cm), statistically at par with T₁C₂ (25.82 cm), while the lowest was recorded in T₁C₁ (16.89 cm). The superior response at 200 ppm GA₃ may be attributed to enhanced cell division and elongation in the sub-apical meristem

atic regions. GA₃ also stimulates growth-promoting enzymes and proteins, facilitating internodal elongation and vegetative development. Improved germination and establishment under GA₃ treatment may further enhance nutrient and photosynthate utilization, resulting in

greater seedling height. Gholap *et al.* (2000) [15], Kumari *et al.* (2007) [25], Chiranjeevi *et al.* (2017) [17], Lalitha *et al.* (2020) [21], Singh and kaur (2020) [22] also reported similar results.

Table 3. Effect of soaking durations and GA₃ concentrations on seedling height (cm) at 30, 60, 90 days after seed germination of Aonla.

	T ₁	T ₂	Mean	T ₁	T ₂	Mean	T ₁	T ₂	Mean
C ₁ - Control	6.92	7.07	6.99	12.34	13.63	12.99	16.89	18.24	17.57
C ₂ - 200 ppm	8.72	9.24	8.98	16.53	19.82	18.17	25.82	28.09	26.95
C ₃ - 300 ppm	7.27	8.86	8.07	17.06	16.59	16.83	21.75	24.02	22.89
C ₄ - 400 ppm	7.19	8.35	7.77	17.31	18.83	18.07	23.60	22.55	23.08
C ₅ - 500 ppm	7.32	8.59	7.96	16.10	18.16	17.13	20.73	22.92	21.83
C ₆ - 600 ppm	7.32	9.14	8.23	15.82	16.31	16.07	21.37	19.10	20.23
C ₇ - Water soaked	7.67	7.31	7.49	15.30	14.46	14.88	18.67	20.67	19.67
Mean	7.49	8.37	7.93	15.78	16.83	16.30	21.26	22.23	21.74
	T	C	TxC	T	C	TxC	T	C	TxC
SEm(±)	0.11	0.10	0.30	0.22	0.21	0.59	0.29	0.27	0.76
CD at 5%	0.35	0.33	0.93	0.68	0.64	1.81	0.88	0.82	2.32

Conclusion

The results indicated that 24 hours soaking combined with GA₃ application produced superior seed germination, seedling survival and vegetative growth. GA₃ @ 200 ppm was particularly effective for germination, survival, leaf production and seedling height. The treatment combination T₂C₂ (24 hours soaking + GA₃ @ 200 ppm) was particularly promising for germination and early seedling growth.

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