

Enhancing dragon fruit (*Hylocereus undatus*) seed germination and seedling development with PGRs

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ABSTRACT

The exotic super fruit known as dragon fruit (*Hylocereus undatus* (Haworth) Britton and Rose) was brought to India. Stem cuttings and seeds may be used to spontaneously reproduce it. In order to increase the effectiveness of seed germination and seedling development in dragon fruit utilizing PGRs, the current research was conducted from 2018 to 2021 at the Main Horticultural Research and Extension Center (MHREC), College of Horticulture, University of Horticultural Sciences, Bagalkote, Karnataka. The findings demonstrated that the different treatments differed significantly from one another. In terms of germination percentage (87.00%), shoot length (10.27 cm), root length (8.06 cm), number of roots (6.20), seedling length (18.33 cm), fresh weight (3.26 g), dry weight (1.22 g), and survival percentage (48%) at 90 days after sowing (DAS), treatment 100 ppm GA₃ was found to be the best treatment.

Keywords: Benzyl adenine, Dragon fruit, Gibberellic acid, Seed germination, Seedling growth

Introduction

Due to its organoleptic qualities, nutraceutical qualities, antioxidants, vitamins, and minerals, early bearing, ease of agronomic practices and maintenance, and lower incidence of pests and diseases, dragon fruit (*Hylocereus undatus* (Haworth) Britton and Rose), an introduced fruit crop belonging to the Cactaceae family, has gained popularity in India (Mercado-Silva 2018, Le et al. 2021). Gujarat, Maharashtra, Karnataka, Kerala, Tamil Nadu, Odisha, West Bengal, Andhra Pradesh, Telangana, and the Andaman and Nicobar Islands are among the Indian states where it is expanding rapidly (Nangare et al. 2020).

Dragon fruit seeds are more adaptable and less likely to spread illness (Elobeidy 2006). They also provide a variety of genetic information that may be used to pick genotypes with desired traits. There is no better variety for commercial farming, and molecular and genomics research on dragon fruit is behind that on staple crops. Therefore, there is a pressing need to produce dragon fruit variants. According to Sheng et al. (2016) and Vishnupriya et al. (2019), seeds that are kept at a low temperature of 10°C for a week exhibit delayed germination and a reduced germination percentage because of the ovule's distinct structure.

1 Horticultural Sciences University, Bagalkote, Karnataka; 2 Horticultural Sciences University, Munirabad, Koppal, Karnataka. *The author's email address is anaghapk2018@gmail.com. Previous research on dragon fruit germination employed gibberellins (GA₃) and benzyl adenine (BA) (Dhurve 2016, Sheng et al. 2016). Gibberellins are employed to accelerate fruit setting, stem and internode elongation, enzyme synthesis during germination, and seed germination (Davies 1995). Although BA is mostly utilized in tissue culture for callus growth and seed germination, it may also enhance seed performance in the field. There is currently no widely accessible information on a systematic set of protocol for the establishment of direct seeding methods for enhancing dragon fruit seed germination. Previous studies (Sheng et al. 2016, Vishnupriya et al. 2019) tried to improve the seed germination of dragon fruit by using BA and auxins in an in vitro culture system. Therefore, it seems that a technique for increasing seed germination efficiency via the use of plant growth regulators is required in order to accomplish this goal.

MATERIALS AND METHODS

The trials were carried out at the fruit nursery's shade house at the Main Horticultural Research and Extension Center (MHREC), College of Horticulture, University of Horticultural Sciences, Bagalkote, Karnataka, from 2018 to 2021.

Plant material source and seed extraction: In September 2019, healthy red-skinned, white-fleshed fruits were collected from a farmer's field in Bagalkot, Karnataka. During this time, the average maximum and minimum temperatures

were 33.4°C and 21.5°C, respectively, with an average ANAGHA ET AL.

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56.8% relative humidity. Slice the fresh, ripe fruit in half, remove the seeds, and scoop out the pulp. Due of their fragility, the seeds were treated with care. Rinsed till the water is almost colorless (Dahanayake and Ranawake 2012). The seeds started to separate from the plate as they dried. The drying process takes around five days. Once completely dry, place the seeds in an envelope and keep them in a dry place.

Gibberellic acid (GA3) solution preparation: The necessary quantity of HiMedia gibberellic acid (Assay≥90%) was dissolved in distilled water to create a stock solution of 100 ppm gibberellic acid. Gibberellic acid solutions at five different concentrations (10, 25, 50, 75, and 100 ppm) were made by serial dilution with distilled water. Benzyl adenine (BA) solution preparation: The necessary quantity of HiMedia benzyl adenine (Assay≥98%) was dissolved in distilled water to create a stock solution of 20 ppm benzyl adenine (6-Benzyl amino purine). The four benzyl adenine solution concentrations (1, 5, 10, and 15 ppm) were made by serial dilution with distilled water. Using a pipette, the necessary amount of stock solution was removed from the test tube and diluted with distilled water to the necessary concentration.

Seed treatment and sowing: To avoid infections, 50 medium-sized pots were filled with a 1:1 mixture of coco peat and sand and soaked in 2 g/L of Bavistin. Growth regulators (GA3 and BAP) were applied to seedlings for about 15 minutes before to seeding. At the nursery, treated seeds were shade-dried for ten minutes. After that, each pot was filled with 50 seeds, softly watered with a rose can, and topped with a thin layer of dirt. Pots were covered with cardboard for a dark incubation period of two days after seeding. On alternating days, watering was done. For three months, shoot parameters were recorded on a monthly basis.

Days required for germination: The amount of time between the day of planting and the day the seedling emerges above the medium.

Germination percentage (%): The proportion of seeds that sprouted out of the 50 seeds that were sowed.

$$\text{Germination percentage (\%)} = \frac{\text{Number of germinated seeds}}{\text{Total number of seeds}} \times 100$$

Shoot length (cm): Shoot height was measured from the tip of the shoot to the collar region of the seedling.

Seedling length (cm): Seedling height was measured from tip of the shoot to tip of the root.

Root length (cm): Length of root was measured from the collar region of the roots to the tip of the longest root.

Number of roots per seedling: The total number of roots was counted for each seedling and the mean of the five plants per replication is considered for analysis.

Fresh weight of seedling (g): Fresh weight of the seedling was recorded immediately after uprooting the seedling.

Seedling dry weight (g): The dry weight of the seedling was taken after drying in hot air oven at 55°C.

Survival percentage (%):

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

Statistical analysis: Using Fischer's technique of analysis of variance, the data from all of the aforementioned experiments were tabulated in three replications and given to statistical analysis (ANOVA) using fully randomized design (CRD). The findings were assessed at a 5% significance level. Using CD at the 5% level of significance, the difference between the means of two treatments was compared to determine the treatments' significance.

RESULTS AND DISCUSSION

Days required for germination: The GA3 100 ppm treatment showed the earliest germination (10.60 days), which was statistically comparable to the GA3 75 and 50 ppm and BA (15 ppm) treatments (Table 1). This could be because GA3 directly affects the embryo by promoting protein synthesis and the elongation of coleoptiles, and it is involved in the activation of cytological enzymes along with an increase in cell wall plasticity and increased water absorption in the seeds (Stewart and Freebairn 1969). The presence of GA3 decreased the mean germination time and the coefficient of variation of germination time in cactus (*Pilosocereus gounellei* subsp *gounellei*) seeds, according to a previous research by Lima et al. (2020). The seedlings treated with BA 15 ppm demonstrated early germination (11.60 days) in comparison to the control (22.20 days), which was a positive outcome. This may be due to BA's role in the metabolic processes that improve dragon fruit seed germination and seedling vigor (Dissanayaka et al. 2015).

Vishnupriya et al. (2019), who carried out an in vitro seed germination investigation in dragon fruit and found that BA at 2 ppm stimulated early germination (6.99 days) in comparison to control, corroborated this conclusion. Seed germination percentage (%): GA3 was shown to be extremely significant across different concentrations of GA3 and BA, and seeds treated with GA3 at a concentration of 100 ppm (87.00%) had the highest germination percentage (Table 1). Furthermore, it was discovered that the germination percentage increased as the concentration did. Gibberellins, which have also been utilized to promote germination and stimulate early seedling emergence and development, may be responsible for both the activation of reserve food and the stimulation of first enzyme (Nabil et al. 2007). Our findings were consistent with those of Gurung et al. (2014), who discovered that the control group had the lowest germination percentage (30.00%) and the passion fruit with GA3 100 ppm had the highest germination percentage (74.00%). Seeds treated with BA showed increased germination, with the maximum percentage (84.20%) occurring at 15 ppm in a polyhouse with cocopeat and sand (1:1) because BA helps break seed dormancy. The results of Vishnupriya et al. (2019), who found improved germination of dragon fruit seeds with 2 ppm BA under in vitro conditions, provided support for our investigation.

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Table 1 Effect of different concentrations of GA₃ and BA on days taken for germination, germination percentage, shoot length and seedling length of dragon fruit seedlings

Treatment	Days taken for germination	Germination percentage (%)	Shoot length (cm)			Seedling length (cm)
			30 days	60 days	90 days	
T ₁ , 0 ppm GA ₃	22.20 ^a	68.00 ^g	0.45 ^e	1.91 ⁱ	3.18 ^g	8.85 ^g
T ₂ , 10 ppm GA ₃	19.80 ^b	70.80 ^{fg}	0.95 ^e	3.60 ^{gh}	5.23 ^f	8.92 ^g
T ₃ , 25 ppm GA ₃	14.00 ^d	74.00 ^{cde}	2.24 ^{cd}	4.67 ^d	8.11 ^d	13.08 ^e
T ₄ , 50 ppm GA ₃	11.80 ^e	76.20 ^{bcd}	2.76 ^{bc}	5.09 ^c	8.85 ^c	14.45 ^d
T ₅ , 75 ppm GA ₃	10.80 ^f	78.20 ^b	2.81 ^{ab}	5.56 ^b	9.90 ^b	17.57 ^b
T ₆ , 100 ppm GA ₃	10.60 ^f	87.00 ^a	3.55 ^a	6.20 ^a	10.27 ^a	18.33 ^a
T ₇ , 1 ppm BA	17.60 ^c	71.60 ^{ef}	1.65 ^{bcd}	3.45 ^h	6.87 ^e	11.00 ^f
T ₈ , 5 ppm BA	13.60 ^d	73.40 ^{def}	1.74 ^d	3.65 ^{fg}	7.04 ^e	9.26 ^g
T ₉ , 10 ppm BA	13.60 ^d	76.40 ^{bc}	1.84 ^{cd}	3.81 ^f	7.13 ^e	11.39 ^f
T ₁₀ , 15 ppm BA	11.60 ^e	84.20 ^a	2.54 ^{bcd}	4.45 ^e	8.32 ^d	16.10 ^c
SEm±	0.57	1.71	0.15	0.22	0.29	0.33
CD (<i>P</i> =0.05)	1.63	4.89	0.43	0.62	0.85	0.94

*Common letters are non-significant according to Duncan's multiple range test where *P*<0.05.

Shoot length: The minimum shoot length was in control (0.45, 1.91, and 3.18 cm) at 30, 60, and 90 DAS, whereas the maximum shoot length was measured with GA3 100 ppm at 30, 60, and 90 DAS with 3.55, 6.20, and 10.27 cm, respectively (Table 1 and Fig. 1). The dragon fruit seedling's longer shoots may have resulted from this hormone's improved osmotic absorption of nutrients, which caused cell elongation and ultimately fixed the seedling's height (Sen et al. 1990). The current study's results are consistent with those of Bishwas et al. (2018), who used GA3 to discover improved root shoot ratio and seedling vigor index in kiwifruit. The maximum shoot length (2.54, 4.45, and 8.32 cm at 30, 60, and 90 DAS, respectively) was observed at 15 ppm in comparison to the control. This was due to the increased metabolic activities in the BA-treated seeds, which led to the increased vigor of the seedlings (Dissanayaka et al. 2015). **Seedling length:** In this research, GA3 at 100 ppm concentration had the longest seedlings (18.33 cm), which was comparable to 75 ppm GA3. At 90 DAS, the control group had the shortest seedlings (8.85 cm) (Table 2 and Fig. 1). The rise in

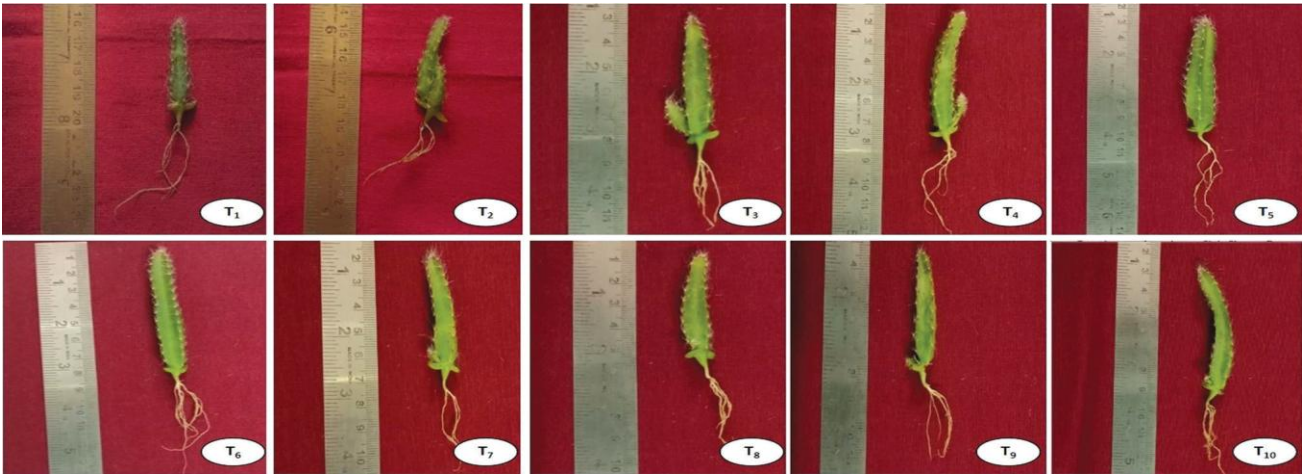


Fig. 1 Effect of different concentration of PGRs on seedling growth of dragon fruit.
Treatment details are given under Materials and Methods.

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Table 2 Effect of different concentration of GA₃ and BA on root parameters, fresh weight, ofling dry weight (g) and survival percentage of dragon fruit seedlings

Treatment	Root length (cm)	Number of roots per seedling	Fresh weight seedling (g)	ofling dry weight (g)	ival percentage (%)
T ₁ , 0 ppm GA ₃	4.20 ^g	3.10 ^h	1.28 ^h	0.30 ^h	35.00 ^{gh}
T ₂ , 10 ppm GA ₃	4.22 ^g	3.50 ^f	1.54 ^g	0.44 ^g	36.00 ^{fgh}
T ₃ , 25 ppm GA ₃	5.60 ^d	4.10 ^e	2.33 ^d	0.69 ^e	38.00 ^{ef}
T ₄ , 50 ppm GA ₃	5.78 ^d	4.30 ^d	2.68 ^c	0.82 ^c	39.00 ^{de}
T ₅ , 75 ppm GA ₃	7.54 ^c	5.40 ^b	2.72 ^c	0.78 ^d	43.00 ^{bc}
T ₆ , 100 ppm GA ₃	8.06 ^a	6.20 ^a	3.26 ^a	1.22 ^a	48.00 ^a
T ₇ , 1 ppm BA	4.34 ^{fg}	3.40 ^{fg}	1.65 ^f	0.42 ^g	34.00 ^h
T ₈ , 5 ppm BA	4.52 ^f	3.30 ^g	1.76 ^e	0.58 ^f	37.00 ^{efg}
T ₉ , 10 ppm BA	5.28 ^e	4.40 ^d	2.26 ^d	0.70 ^e	41.00 ^{cd}
T ₁₀ , 15ppm BA	7.78 ^b	4.70 ^c	3.00 ^b	1.02 ^b	44.00 ^b
SEm±	0.23	0.28	0.10	0.06	0.87
CD (P=0.05)	0.65	0.81	0.31	0.18	2.5

*Common letters are non-significant according to Duncan’s multiple range test where P<0.05.

enhanced shoot and root length due to enhanced cell division and internode elongation may be the cause of seedling length. According to Ratan and Reddy (2004), GA₃ seems to activate metabolic pathways or counteract the impact of an inhibitor on seedling development. In the case of BA treatment, seeds treated with 15 ppm had the longest seedlings (16.10 cm), which may be related to early germination and increased seedling vigor (Nawaz et al. 2013). Root length: The seedlings treated with treatment 100 ppm GA₃ had the longest roots (8.06 cm) at 90 DAS, whereas the control group had the shortest roots (4.20 cm) (Table 2). The exogenous treatment of GA₃ may have contributed to the increase in root length by inducing the development of gluconeogenic enzymes during the early stages of seed germination. This could account for the improved germination and vigor characteristics that are reflected in the increase in root length (Hota et al. 2018). Ramteke et al. (2015) observed that papaya variety Coorge Honeydew seeds treated with GA₃ at 200 ppm concentration displayed maximum tap root length, while Gurung et al. (2014) similarly discovered maximum root length with GA₃ at 500 ppm in papaya, supporting our results. with comparison to the control, the greatest root length (7.78 cm) with the BA treatment occurred at a concentration of 15 ppm. The increased root length may have been caused by the seedling's improved development rate and quick germination (Nawaz et al.

2013).

Each seedling's root count: In this investigation, GA3 had the largest root number (6.20) at 100 ppm, whereas the control group had the lowest root number (3.10) at 90 DAS (Table 2). The GA3 treatment, which may have aided in the synthesis of additional photosynthate and its active transfer to the root zone via the phloem, is responsible for the seedling's rapid root development. In a similar vein, Hota et al. (2018) found that the largest number of roots was counted in jamun seedlings at GA3 450 ppm, whereas Wagh et al. (1998) found that 400 ppm GA3 produced the highest germination percentage and maximum number of roots in aonla seedlings. Additionally, compared to the control, the seeds treated with BA 15 ppm showed a higher number of roots, which may have been caused by early germination and seedling vigor (Nawaz et al. 2013).

Fresh weight of seedlings: GA3 at 100 ppm concentration showed the highest fresh weight (3.26 g), whereas the control showed the lowest fresh weight (1.28 g) (Table 2). The influence of GA3 on the development of several plant sections, including cell division, cell elongation, auxin metabolism, cell wall flexibility, and cell membrane permeability, may be the cause of the greater fresh weight. The results of Hota et al. (2018) in jamun seedlings, which demonstrated maximum fresh weight at 450 ppm GA3, were consistent with this rationale for the improved fresh weight at higher concentrations of GA3. According to Dilip et al. (2017), it might also be because of the effect of mobilizing water and nutrients transported at a higher rate, which could have increased the production of photosynthetic products and translocated them to different parts of the plant. This could have improved seedling growth and recorded maximum fresh weight. The maximum seedling weight (3.00 g) among the various BA concentrations was noted at 15 ppm. The early germination and higher seedling development rate might be the cause (Nawaz et al. 2013).

Seedling dry weight: The treatment GA3 100 ppm had the greatest dry weight (1.22 g), followed by 15 ppm BA (1.02 g), and the control (0.30 g) had the lowest dry weight (Table 2). The rationale for the maximum dry weight of a seedling is connected to its fresh weight, and the seedlings with the highest fresh weight may also have the highest dry weight. Dilip et al. provided assistance for our work.

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(2017), who treated seeds with GA3 in Kagzi lime and found that the maximum dry weight occurred at 80 ppm GA3 for 12 hours.

Survival percentage: The seeds treated with GA3 100 ppm had the greatest survival rate (48.00%), whereas the control group had the lowest (35.00%) (Table 1). The results of Manekar et al. (2011) in Aonla, which demonstrated the maximum survival percentage at 200 ppm GA3, may have contributed to the maximum survivability of seedlings from seeds treated with gibberellic acid at higher concentrations (100 ppm) due to early germination and favorable growing conditions under GA3 treatment. In the current investigation, seeds with BA had the best survival rate (44.00%) at 15 ppm. It may be because of the early germination, a healthy amount and length of roots, and a strong seedling, all of which contributed to the seedling's increased survival.

In conclusion, GA3 at 100 ppm pre-treatment of dragon fruit seeds prior to sowing enhances early germination with maximum germination percentage and to enhance various shoot and root parameters and to get maximum survived seedlings. Additionally, BA (benzyl adenine) can be used as a plant growth hormone to promote seed germination because it can perform seedling growth at a lower concentration than GA3, but the performance is poor, and maximum seed germination was found at a concentration of BA.

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