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Influence of Growth Regulators and Different Chemical Treatments on Morpho-physiological Traits of Khirni (*Manilkara hexandra* L.)

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The present investigation was conducted at Research Farm, Horticulture Section, College of Agriculture, Dhule to identify the effect of different combinations of growth regulators and chemicals on morphological characteristics of khirni. Khirni seedlings were grown and effect on them was

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studied for chemical combinations such as GA_3 @ 50 ppm, GA_3 @ 75 ppm, GA_3 @ 100 ppm, GA_3 @ 200 ppm, NAA @ 100 ppm, KNO_3 @ 1 %, Cow urine @ 10 %, Cow urine @ 100 %, Cow dung slurry, and Control (Distilled water). Based on the findings, it is advised that khirni seedlings be treated with cow dung slurry for 36 hours in order to prepare them for grafting. This experiment should be carried out for a further two to three seasons in order to ensure compliance. With the highest average fresh root weight, maximum average fresh shoot weight, maximum root : shoot ratio (fresh weight basis), higher average root length, and maximum root density of khirni seedlings, the seed soaked in cow dung slurry (T_9) was deemed promising based on the overall results.

Keywords: Khirni; vegetative growth; rootstock; seedlings survival; NAA; cow dung slurry; growth regulator.

1. INTRODUCTION

Manilkara hexandra (Roxb.) Dubard is a significant native minor fruit species in India, belonging to the Sapotaceae family. The species is found in western and central India, particularly in the Madhya Pradesh, Gujarat, Rajasthan, and Vidarbha region of Maharashtra, where it grows naturally in wild populations or is occasionally grown in backyards and homestead gardens. The fruit of this tree species has a high economic value because it is a mature fresh fruit that is extremely sweet and can be eaten both raw and after drying.

The quality of seedlings obtained from a nursery affects their establishment in the main field and the ultimate productivity of an orchard. Various pre-sowing seed treatments to improve germination and to reduce germination time have been widely investigated in tree species (Prasad & Prasad 2009b, Prasad *et al*. 2011). Several efforts like treatment with chemicals, growth regulators hot water, cattle urine and cow dung slurry have been used to overcome hard seed coat dormancy.

Use of plant growth regulators in enhancing seedling growth of numerous plant species is well known (Marler & Mickelbart, 1992; Hazrat *et al*., 2006). Auxins and gibberellins have vital role in plant growth by promoting shoot and root growth due to physiological action on cell and Napthalic acetic acid (NAA), Gibberellic acid (GA_3) and Tricontanol are widely used for growth improvement in many crops. Addressing the vital root zone and so reducing the wetting area, it enables optimal water and nutrient utilization (Jain *et al*., 2023). In addition, synthetic chemicals and other naturally available bioproducts of organics are known to contain vital plant growth substances, which enhance the growth and development of plant.

Sapota is frequently multiplied by softwood grafting, also known as inarch grafting, which employs khirni (*Manilkara heaxandra*) as a rootstock. Khirni seeds have incredibly poor germination rates and grow very little thereafter. Khirni seedlings require a long time to grow to the right height and vigour for grafting. The germination and subsequent development of the Khirni seeds have already been improved. In many plant species, it is well-known that bio-regulators can enhance seed germination and seedling development (Malshe *et al*., 2014).

Furthermore, various naturally occurring bio-products of organics, such as cow dung and cow urine, as well as synthetic chemicals (Vachhani *et al*., 2014; Jadhav *et al*., 2015), are known to contain vital plant growth substances that support plant development and growth (Anonymous, 1993; Shirol *et al*., 2005; Shinde & Malshe, 2015).

2. MATERIALS AND METHODS

The nursery at Research Farm, Horticulture Section, College of Agriculture, Dhule is where the study was carried out in the Dhule district of Maharashtra state (India). Fresh khirni seeds were purchased from the Satpuda Hills rural area in the Dhadgaon tehsil, Nandurbar district, Maharashtra. All seeds were immersed in a 1:5 aqueous solution of the corresponding chemicals for 36 hours prior to planting. Following treatment, the seeds were allowed to dry in the shade for ten minutes.

Five plants were chosen at random and designated as observational plants from each treatment in order to record the vegetative observations. These observations were made on the 30^{th}, 60^{th}, 90^{th}, 120^{th}, 150^{th}, and 180^{th} day from the date of germination. From the period of germination to six months, observations were made on vegetative parameters such as stem diameter, seedling height, number of leaves per seedling, leaf area, and average number of internodes per seedling at monthly intervals.

Following characters were studied during this conduct:

1. **Stem diameter (mm):** The stem diameter of five selected seedlings from each replication treatment combination was measured with the help of digital vernier caliper from the base and after computing the mean it was recorded as average stem diameter of seedling in millimeter at monthly interval from germination up to six months.
2. **Seedling height (cm):** The height of five selected plants were measured from ground level to the growing tip with the help of measuring scale and after computing the mean, it was recorded on 30th, 60th, 90th, 120th, 150th and 180th day after germination as a height of plant in centimetre.
3. **Number of leaves per seedling:** Total number of leaves per plant was counted from five selected observational plants and after computing the mean, it was calculated as leaves per plant. These observations were recorded at 30th, 60th, 90th, 120th, 150thand 180th day after germination.
4. **Leaf area (cm^2):** Leaf area was measured by graph paper method for which five leaves were taken randomly from each selected plant and recorded after computing. These observations were recorded at 30th, 60th, 90th, 120th, 150th and 180th day after germination.
5. **Number of seedling survival:** The treatment wise seedling survive in polythene bags were observed on 30th, 60th, 90th, 120th, 150thand 180th day after germination for recording the observation of seedling survival.
6. **Survival percentage (%):** The survival percentage was calculated at 30th, 60th, 90th, 120th, 150thand 180th day after germination. It was calculated based on below mentioned formula:

   Survival percentage (%) =

   $$\frac{Number\ of\ seedlings\ survived}{Number\ of\ seed\ germinated} \times 100$$

7. **Average number of internode per seedling:** Total number of internodes per plant was counted from five selected observational plants and after computing the mean, it was calculated as average number of internodes per seedling. These observations were recorded at 30th, 60th, 90th, 120th, 150th and 180th day after germination.

The data was statistically analyzed as per the standard procedure given by Panse and Sukhatme (1954).

3. RESULTS AND DISCUSSION

Pre-sowing treatments have been reported to enhance the rate of seed germination, seedling vigour and growth (Singh *et al*., 2024). It was recommended that the maximum number of vigorous seedlings can be produced by treatment with GA3 at 100 ppm followed by GA3 at 200 ppm for 36 hours (Rai *et al*., 2018; Sejal *et al*., 2022). The stem diameter was non-significant at 30th days after germination, whereas significantly influenced by different treatment at 60th, 90th, 120th, 150th and 180th days after germination. The data regarding the various effects of seed treatments on stem diameter have presented in Table 2. The treatment T_4 (GA_3 @ 200 ppm) recorded significantly the highest stem diameter at 60th and 90th days after germination and exhibited linear increase in stem diameter. This treatment produced 1.25 mm and 1.50 mm stem diameter at 60th and 90th DAG which was at par with the treatment T_9 (Cow dung slurry) 1.20 mm, and T_8 (Cow urine @ 100 %). At 120th, 150th and 180th DAG the highest stem diameter 1.70 mm, 2.70 mm and 2.80 mm was recorded in treatment T_9 (Cow dung slurry) which was at par with the treatment T_4 (GA_3 @ 200 ppm) 1.62 mm, T_3 (GA_3 @ 100 ppm) 1.60 mm and T_8 (Cow urine @ 100 %) 1.58 mm 120th days after germination. Stem diameter may be increase due to greater cell division and elongation at the stem portion (Sargent, 1965). The results are in conformity with the findings of Patil *et al*. (2018) reported in jamun, Desai *et al*. (2017) in papaya and Rajput (2017) in custard apple.

For seedling height, the data was presented in Table 3. This treatment produced 4.25 cm, 6.12 cm, 6.83 cm and 9.17 cm seedling height at 30th, 60th, 90th and 120th DAG which was at par with the treatment T_9 (Cow dung slurry) 4.18 cm and T_3 (GA_3 @ 100 ppm) 4.09 cm, T_2 (GA_3 @ 75 ppm) 3.98 cm and T_5 (NAA @ 100 ppm) 3.98 cm after 30th days after germination and on 60th DAG which was at par with the treatment T_9 (Cow dung slurry) 6.70 cm, T_8 (Cow urine @ 100 %) 6.62 cm, T_3 (GA_3 @ 100 ppm) 6.55 cm, T_5 (NAA @ 100 ppm) 6.50 cm, T_6 (KNO_3 @ 1 %) 6.49 cm,

T_7 (Cow urine @ 10 %) 6.45 cm and T_2 (GA_3 @ 75 ppm) 6.36 cm. On 90th DAG which was at par with the treatment T_9 (Cow dung slurry) 6.70 cm, T_8 (Cow urine @ 100 %) 6.62 cm, T_3 (GA_3 @ 100 ppm) 6.55 cm, T_5 (NAA @ 100 ppm) 6.50 cm, T_6 (KNO_3 @ 1 %) 6.49 cm, T_7 (Cow urine @ 10 %) 6.45 cm and T_2 (GA_3 @ 75 ppm) 6.36 cm.

Table 1. Details of treatment combinations applied in the current study

Sr. No.		Treatments
1	T_1	GA_3 @ 50ppm
2	T_2	GA_3 @ 75ppm
3	T_3	GA_3 @ 100ppm
4	T_4	GA_3 @ 200ppm
5	T_5	NAA @ 100ppm
6	T_6	KNO_3 @ 1%
7	T_7	Cow urine @ 10%
8	T_8	Cow urine @ 100%
9	T_9	Cow dung slurry
10	T_{10}	Control (Distilled water)

Table 2. Effect of different growth regulators and cow urine on stem diameter of khirni

Treatment		Stem diameter (mm)					
		30th DAG	60th DAG	90th DAG	120th DAG	150th DAG	180th DAG
T_1	GA_3 @ 50 ppm	1.01	1.09	1.25	1.38	2.25	2.28
T_2	GA_3 @ 75 ppm	1.02	1.12	1.28	1.48	2.28	2.30
T_3	GA_3 @ 100 ppm	1.02	1.16	1.45	1.60	2.48	2.56
T_4	GA_3 @ 200 ppm	1.05	1.25	1.50	1.62	2.60	2.72
T_5	NAA @ 100 ppm	1.02	1.15	1.38	1.49	2.40	2.42
T_6	KNO_3 @ 1 %	1.02	1.13	1.35	1.39	2.26	2.36
T_7	Cow urine @ 10 %	1.02	1.12	1.29	1.43	2.35	2.60
T_8	Cow urine @ 100 %	1.02	1.19	1.48	1.58	2.50	2.78
T_9	Cow dung slurry	1.03	1.20	1.50	1.70	2.70	2.80
T_{10}	Control (Distilled water)	1.01	1.08	1.20	1.35	2.20	2.26
S.E(m)±		0.01	0.03	0.04	0.05	0.10	0.08
C.D. at 5 %		NS	0.10	0.12	0.16	0.29	0.25

Note: DAG: Days after germination

Table 3. Effect of different growth regulators and cow urine on seeding height of khirni

Treatment		Seedling height (cm)					
		30th DAG	60th DAG	90th DAG	120th DAG	150th DAG	180th DAG
T_1	GA_3 @ 50 ppm	3.63	5.33	6.25	7.30	9.15	9.88
T_2	GA_3 @ 75 ppm	3.98	5.58	6.36	7.50	9.50	10.86
T_3	GA_3 @ 100 ppm	4.09	5.77	6.55	8.75	10.76	12.38
T_4	GA_3 @ 200 ppm	4.25	6.12	6.83	9.17	12.87	14.23
T_5	NAA @ 100 ppm	3.98	5.71	6.50	7.56	10.50	11.65
T_6	KNO_3 @ 1 %	3.74	5.50	6.49	7.36	9.20	10.38
T_7	Cow urine @ 10 %	3.80	5.68	6.45	7.38	10.13	14.65
T_8	Cow urine @ 100 %	4.03	5.87	6.62	7.80	12.39	15.63
T_9	Cow dung slurry	4.18	6.10	6.70	9.08	13.80	16.85
T_{10}	Control (Distilled water)	3.53	5.25	5.90	7.25	8.32	8.96
S.E(m)±		0.12	0.17	0.17	0.24	0.34	0.45
C.D. at 5 %		0.34	0.49	0.49	0.72	1.00	1.32

Note: DAG: Days after germination

The data on 120th DAG which was at par with the treatment T_9 (Cow dung slurry) 9.08 cm and T_3 (GA_3 @ 100 ppm) 8.75 cm. At 150th and 180th DAG the highest seedling height 13.80 cm and 16.85 cm was recorded in treatment T_9 (Cow dung slurry) which was at par with the treatment T_9 (Cow dung slurry) 9.08 cm and T_3 (GA_3 @ 100 ppm) 8.75 cm, 180th days after germination and on 180th DAG which was at par with the treatment T_8 (Cow urine @ 100 %) 15.63 cm. The treatment T_{10} (Control-Distilled water) was found to be poor and recorded 3.53 cm, 5.25 cm, 5.90 cm,7.25 cm, 8.32 cm and 8.96 cm seedling height at 30th, 60th, 90th, 120th, 150th and 180th DAG. The results in accordance with the results of Harshawardhan and Rajshekhar (2012) Vasantha *et al*. (2014) in tamarind.

Number of leaves per seedling was non-significant at 30th days after germination, whereas significantly increased by different seed treatments at 60th, 90th, 120th, 150th and 180th days after germination. The treatment T_4 (GA_3 @ 200 ppm) recorded significantly the highest number of leaves per seedling at 60th days after germination. This treatment produced 3.10 number of leaves per seedling at 60th DAG which was at par with the treatment T_9 (Cow dung slurry) 3.00, T_8 (Cow urine @ 100 %) 2.98, T_3 (GA_3 @ 100 ppm) 2.95, T_5 (NAA @ 100 ppm) 2.93. T_6 (KNO_3 @ 1 %) 2.90 and T_7 (Cow urine @ 10 %) 2.90 after 60 days after germination. At 90th, 120th, 150th and 180th DAG the highest number of leaves per seedling 3.95, 6.15, 9.45 and 10.05 was recorded in treatment T_9 (Cow dung slurry) which was at par with the treatment T_4 (GA_3 @ 200 ppm) 3.90, T_8 (Cow urine @ 100 %) 3.88, T_3 (GA_3 @ 100 ppm) 3.76 and T_5 (NAA @ 100 ppm) 3.56. 90th days after germination. The data was presented in the Table 4.

The treatment T_{10} (Control-Distilled water) was found to be poor and recorded 2.73, 3.41, 4.43, 7.10 and 8.48 number of leaves per seedling at 60th, 90th, 120th, 150th and 180th DAG. The highest number of leaves in cow dung slurry may be the result of the nutrients in the cow dung and the auxin in the cow urine, both of which may have promoted or induced vigorous growth, resulting in more branches and a better ability for the plants to absorb sunlight, which in turn allows them to produce more leaves. Shinde and Malshe (2015) found similar results in Khirni.

Leaf area was non-significant at 30th days after germination, whereas significantly influenced by different seed treatments at 60th, 90th, 120th, 150th and 180th days after germination. Details are given in Table 5. The treatment T_4 (GA_3 @ 200 ppm) recorded significantly the maximum leaf area at 60th and 90th days after germination and exhibited linear increase in leaf area. This treatment produced 4.25 cm^2 and 11.95 cm^2 leaf area at 60th and 90th DAG which was followed by treatment T_9 (Cow dung slurry) 3.68 cm^2, T_8 (Cow urine @ 100 %) 3.50 cm^2 and on 90th DAG which was followed by treatment T_9 (Cow dung slurry) 11.28 cm^2. On 120 DAG which was at par with the treatment T_9 (Cow dung slurry) 15.05 cm^2. At 150th and 180th DAG the highest leaf area 17.25 cm^2 and 22.00 cm^2 was recorded in treatment T_9 (Cow dung slurry) which was followed by treatment T_4 (GA_3 @ 200 ppm) 15.25 cm^2,T_8 (Cow urine @ 100 %) 14.00 cm^2, T_3 (GA_3 @ 100 ppm) 10.50 cm^2. The treatment T_{10} (Control-Distilled water) was found to be poor and recorded 1.03 cm^2, 2.40 cm^2, 5.76 cm^2, 8.25 cm^2, 8.50 cm^2 and 10.50 cm^2 leaf area at 30th, 60th, 90th, 120th, 150th and 180th DAG. The increased of leaf area when the seed treated with GA_3 @ 200 ppm may be due to activity of GA_3 at the apical meristem resulting in more synthesis of nucleoprotein responsible for increasing leaf initiation and area (Sen and Gunthi, 1976). The results are similar with the findings of Shinde and Malshe (2015) reported in khirni and Desai *et al.* (2017) in papaya.

The data on 30th days after germination the highest number of seedling survived (43.33) was recorded in treatment T_9 (Cow dung slurry) which was at par with the treatment T_4 (GA_3 @ 200 ppm) 40.33, however lowest number of seedling survived (28.67) observed in treatment T_{10} (Control-Distilled water). On 60th days after germination the highest number of seedling survived (41.67) was recorded in treatment T_9 (Cow dung slurry). However, lowest number of seedling survived (26.67) was observed in treatment T_{10} (Control-Distilled water). The highest number of seedling survived (37.00) at 90th, 120th, 150th, 180th days after germination were recorded in treatment T_9 (Cow dung slurry) which was found statistically at par with the treatment, T_4 (GA_3 @ 200 ppm) 34.67. The lowest number of seedling survived (22.67) was recorded in control T_{10} (Control-Distilled water). Cow dung treated seeds were the most effective for increasing number of seedling survival. It might be observed due to the presence of N, P, K, S and other micronutrients could have been cause for increase number of seedling survival (Table 6).

Table 4. Effect of different growth regulators and cow urine on number of leaves per seedling of khirni

Treatment		Number of leaves per seedling					
		30th DAG	60th DAG	90th DAG	120th DAG	150th DAG	180th DAG
T_1	GA_3 @ 50 ppm	2.00	2.80	3.43	4.56	7.23	8.50
T_2	GA_3 @ 75 ppm	1.98	2.83	3.50	4.90	7.50	8.72
T_3	GA_3 @ 100 ppm	2.00	2.95	3.76	6.00	8.23	8.80
T_4	GA_3 @ 200 ppm	2.10	3.10	3.90	6.07	9.30	9.42
T_5	NAA @ 100 ppm	2.00	2.93	3.56	4.95	8.00	8.83
T_6	KNO_3 @ 1 %	1.96	2.90	3.52	4.62	7.25	8.60
T_7	Cow urine @ 10 %	2.00	2.90	3.50	4.98	7.76	9.50
T_8	Cow urine @ 100 %	2.00	2.98	3.88	5.60	9.00	10.00
T_9	Cow dung slurry	2.02	3.00	3.95	6.15	9.45	10.05
T_{10}	Control (Distilled water)	2.00	2.73	3.41	4.43	7.10	8.48
S.E(m)±		0.18	0.07	0.13	0.19	0.24	0.29
C.D. at 5 %		NS	0.20	0.37	0.56	0.71	0.84

Note: DAG: Days after germination

Table 5. Effect of different growth regulators and cow urine on leaf area of khirni

Treatment		Leaf area (cm^2)					
		30th DAG	60th DAG	90th DAG	120th DAG	150th DAG	180th DAG
T_1	GA_3 @ 50 ppm	1.08	2.45	5.88	8.50	9.08	11.55
T_2	GA_3 @ 75 ppm	1.15	2.48	5.89	8.96	9.12	13.68
T_3	GA_3 @ 100 ppm	1.45	2.92	7.21	12.50	10.50	14.35
T_4	GA_3 @ 200 ppm	1.68	4.25	11.95	15.08	15.25	18.50
T_5	NAA @ 100 ppm	1.40	2.56	6.80	9.00	10.50	14.21
T_6	KNO_3 @ 1 %	1.35	2.53	6.00	8.66	9.00	13.25
T_7	Cow urine @ 10 %	1.21	2.50	5.90	8.68	10.25	17.25
T_8	Cow urine @ 100 %	1.50	3.50	9.25	9.68	14.00	18.31
T_9	Cow dung slurry	1.59	3.68	11.28	15.05	17.25	22.00
T_{10}	Control (Distilled water)	1.03	2.40	5.76	8.25	8.50	10.50
S.E(m)±		0.15	0.15	0.22	0.31	0.38	0.45
C.D. at 5 %		NS	0.46	0.66	0.92	1.13	1.33

Note: DAG: Days after germination

Table 6. Effect of different growth regulators and cow urine on number of seedling survived of khirni

Treatment		Number of seedling survived					
		30th DAG	60th DAG	90th DAG	120th DAG	150th DAG	180th DAG
T_1	GA_3 @ 50 ppm	34.33	31.67	25.67	25.67	25.67	25.67
T_2	GA_3 @ 75 ppm	38.67	34.00	28.33	28.33	28.33	28.33
T_3	GA_3 @ 100 ppm	38.33	36.00	33.33	33.33	33.33	33.33
T_4	GA_3 @ 200 ppm	40.33	37.33	34.67	34.67	34.67	34.67
T_5	NAA @ 100 ppm	38.67	35.33	31.00	31.00	31.00	31.00
T_6	KNO_3 @ 1 %	27.00	25.33	23.33	23.33	23.33	23.33
T_7	Cow urine @ 10 %	34.00	31.67	28.00	28.00	28.00	28.00
T_8	Cow urine @ 100 %	39.00	37.00	34.33	34.33	34.33	34.33
T_9	Cow dung slurry	43.33	41.67	37.00	37.00	37.00	37.00
T_{10}	Control (Distilled water)	28.67	26.67	22.67	22.67	22.67	22.67
S.E(m)±		1.07	1.01	0.86	0.86	0.86	0.86
C.D. at 5 %		3.16	2.97	2.55	2.55	2.55	2.55

Note: DAG: Days after germination

Table 7. Effect of different growth regulators and cow urine on survival percentage of khirni

Treatment		Survival percentage					
		30th DAG	60th DAG	90th DAG	120th DAG	150th DAG	180th DAG
T_1	GA_3 @ 50 ppm	68.67 (55.96)*	63.33 (52.73)*	51.33 (45.76)*	51.33 (45.76)*	51.33 (45.76)*	51.33 (45.76)*
T_2	GA_3 @ 75 ppm	77.33 (61.57)	68.00 (55.55)	56.67 (48.83)	56.67 (48.83)	56.67 (48.83)	56.67 (48.83)
T_3	GA_3 @ 100 ppm	76.67 (61.12)	72.00 (58.05)	66.67 (54.74)	66.67 (54.74)	66.67 (54.74)	66.67 (54.74)
T_4	GA_3 @ 200 ppm	80.67 (63.92)	74.67 (59.78)	69.33 (56.37)	69.33 (56.37)	69.33 (56.37)	69.33 (56.37)
T_5	NAA @ 100 ppm	77.33 (61.57)	70.67 (57.21)	62.00 (51.94)	62.00 (51.94)	62.00 (51.94)	62.00 (51.94)
T_6	KNO_3 @ 1 %	54.00 (47.29)	50.67 (45.38)	46.67 (43.09)	46.67 (43.09)	46.67 (43.09)	46.67 (43.09)
T_7	Cow urine @ 10 %	68.00 (55.55)	63.33 (52.73)	56.00 (48.45)	56.00 (48.45)	56.00 (48.45)	56.00 (48.45)
T_8	Cow urine @ 100%	78.00 (62.03)	74.00 (59.34)	68.67 (55.96)	68.67 (55.96)	68.67 (55.96)	68.67 (55.96)
T_9	Cow dung slurry	86.67 (68.59)	83.33 (65.90)	74.00 (59.34)	74.00 (59.34)	74.00 (59.34)	74.00 (59.34)
T_{10}	Control (Distilled water)	57.33 (49.21)	53.33 (46.91)	45.33 (42.32)	45.33 (42.32)	45.33 (42.32)	45.33 (42.32)
S.E(m)±		2.14	2.01	1.73	1.73	1.73	1.73
C.D. at 5 %		6.31	5.93	5.09	5.09	5.09	5.09

Note: DAG: Days after germination

Table 8. Effect of different growth regulators and cow urine on average numbers of internode per seedling

Treatment		Average number of internode per seedling					
		30th DAG	60th DAG	90th DAG	120th DAG	150th DAG	180th DAG
T_1	GA_3 @ 50 ppm	1.18	2.18	3.15	3.20	3.25	4.25
T_2	GA_3 @ 75 ppm	1.39	2.28	3.25	3.56	3.55	4.42
T_3	GA_3 @ 100 ppm	1.82	2.52	3.56	4.50	4.56	4.90
T_4	GA_3 @ 200 ppm	2.90	3.80	4.40	5.00	5.12	5.22
T_5	NAA @ 100 ppm	1.59	2.50	3.52	4.16	4.22	4.58
T_6	KNO_3 @ 1 %	1.52	2.48	3.42	3.45	3.48	4.36
T_7	Cow urine @ 10 %	1.38	2.30	3.38	3.49	3.97	5.30
T_8	Cow urine @ 100 %	1.90	2.88	3.78	4.28	4.58	5.56
T_9	Cow dung slurry	2.50	2.90	3.80	4.75	4.80	5.90
T_{10}	Control (Distilled water)	1.00	2.12	3.07	3.12	3.15	3.19
S.E(m)±		0.05	0.08	0.10	0.12	0.12	0.18
C.D. at 5 %		0.16	0.23	0.30	0.36	0.35	0.54

Note: DAG: Days after germination

The data revealed that, the survival percentage at 30th, 60th, 90th, 120th, 150th and 180th days after germination were significantly increased by different seed treatments. They are described in Table 7. The data on 30th days after germination the highest survival percentage (86.67 %) was recorded in treatment T_9 (Cow dung slurry) which was at par with the treatment T_4 (GA_3 @ 200 ppm) 80.67 %, however lowest survival percentage (57.33 %) observed in treatment T_{10} (Control-Distilled water). On 60th days after germination the highest survival percentage (83.33 %) was recorded in treatment T_9 (Cow dung slurry). However, lowest survival percentage (53.33 %) was observed in treatment T_{10} (Control-Distilled water).

The highest survival percentage (74.00 %) at 90th, 120th, 150th, 180th days after germination were recorded in treatment T_9 (Cow dung slurry) which was found statistically at par with the treatment, T_4 (GA_3 @ 200 ppm) 69.33 %. The lowest survival percentage ((45.33 %) was recorded in control T_{10} (Control-Distilled water). There were significant differences observed in survival percentage. The seeds treated with cow dung were the most effective for maximum number of seedling survival it mean increasing survival percentage. It might be due to the presence of N, P, K, S nutrients and other micronutrients could have been cause for maximum survival percentage. Similar results were also reported by Naguri and Tank (2015) in mango seedlings.

For average number of internode per seedling, data revealed that, the average number of internode per seedling at 30th, 60th, 90th, 120th, 150th and 180th days after germination were significantly influenced by different seed treatments. The treatment T_4 (GA_3 @ 200 ppm) recorded significantly the maximum average number of internode per seedling at 30th, 60th, 90th, 120th and 150th days after germination and exhibited linear increase in average number of internode per seedling. This treatment produced 2.90, 3.80, 4.40, 5.00 and 5.12 average number of internode per seedling at 30th, 60th, 90th, 120th and 150th DAG which was followed by treatment T_9 (Cow dung slurry) 2.50, T_8 (Cow urine @ 100 %) 1.90, T_3 (GA_3 @ 100 ppm) 1.82, T_5 (NAA @ 100 ppm) 1.59, T_6 (KNO_3 @ 1 %) 1.52, T_2 (GA_3 @ 75 ppm) 1.39, T_7 (Cow urine @ 10 %) 1.38 and T_1 (GA_3 @ 50 ppm) 1.18 at 30th days after germination and on 60th DAG which was followed by treatment T_9 (Cow dung slurry) 2.90, T_8 (Cow urine @ 100 %) 2.88, T_3 (GA_3 @ 100 ppm) 2.52, T_5 (NAA @ 100 ppm) 2.50, T_6 (KNO_3 @ 1 %) 2.48, T_7 (Cow urine @ 10 %) 2.30, T_2 (GA_3 @ 75 ppm) 2.28, and T_1 (GA_3 @ 50 ppm) 2.18. On 90th DAG which was followed by treatment T_9 (Cow dung slurry) 3.80, T_8 (Cow urine @ 100 %) 3.78, T_3 (GA_3 @ 100 ppm) 3.56, T_5 (NAA @ 100 ppm) 3.52, T_6 (KNO_3 @ 1 %) 3.42, T_7 (Cow urine @ 10 %) 3.38, T_2 (GA_3 @ 75 ppm) 3.25, and T_1 (GA_3 @ 50 ppm) 3.15. On 120th DAG which was at par with the treatment T_9 (Cow dung slurry) 4.75 and 150th DAG which was at par with the treatment T_9 (Cow dung slurry) 4.80.

At 180th DAG the highest average number of internode per seedling 5.90 was recorded in treatment T_9 (Cow dung slurry) which was at par with the treatment T_8 (Cow urine @ 100 %) 5.56. 180th days after germination. The treatment T_{10} (Control-Distilled water) was found to be poor and recorded 1.00, 2.12, 3.07, 3.12, 3.15 and 3.19 average number of internode per seedling at 30th, 60th, 90th, 120th, 150th and 180th DAG.

4. CONCLUSION

From the present study following conclusions were obtained: The highest stem diameter (2.80 mm) at 180th days after germination were recorded in treatment T_9 (Cow dung slurry) which was at par with the treatment T_8 (Cow urine @ 100 %) 2.78 mm. The highest seedling height (16.85 cm) at 180th days after germination were recorded in treatment T_9 (Cow dung slurry) which was at par with the treatment T_8 (Cow urine @ 100%) 15.63 cm. The highest number of leaves per seedling (10.05) at 180th days after germination were recorded in treatment T_9 (Cow dung slurry) which was at par with the treatment, T_8 (Cow urine @ 100 %) 10.00. The highest leaf area (22.00cm^2) at 180th days after germination were recorded in treatment T_9 (Cow dung slurry) which was followed by treatment T_4 (GA_3 @ 200ppm) 18.50cm^2. The treatment, T_9 (Cow dung slurry) recorded the highest number of seedling survived (37.00), which was found statistically at par with the treatment, T_4 (GA_3 @ 200 ppm) 34.67. The treatment, T_9 (Cow dung slurry) registered the highest survival percentage (74.00 %) and showed at par with T_4 (GA_3 @ 200 ppm) 69.33 %. T_9 (Cow dung slurry) recorded the highest average number of internode per seedling (5.90), which was at par with the treatment, T_8 (Cow urine @ 100 %) 5.56.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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