**Abstract:**

The experiment was laid out in complete randomized block design (CRBD) and three replication with ten treatments *viz*., GA3 @ 50 ppm, GA3 @ 75 ppm, GA3 @ 100 ppm, GA3 @ 200 ppm, NAA @ 100 ppm, KNO3 @ 1 %, Cow urine @ 10 %, Cow urine @ 100 %, Cow dung slurry, and Control (Distilled water). The study was conducted at the Research Farm, Horticulture Section, College of Agriculture, Dhule, in the Maharashtra state (India) with the objective of enhancing rooting characteristics in khirni. Results suggested that the seed soaked in cow dung slurry (T9) was the most promising. It had maximum 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 seedling. Ad hoc, it is advised that khirni seedlings be treated with cow dung slurry for 36 hours to prepare them for grafting when they are being raised for sapota grafting. However, this experiment should be carried out over the course of two to three seasons in order to ensure consistency and to advise nursery men.

**Keywords:** *Khirni, root growth, rootstock, chemical treatment, root density, average root: shoot ratio, average fresh shoot weight, average fresh root weight.*

**Introduction:**

Khirni is commonly known as (*Manilkara hexandra* Roxb.) include "Rayan" and "Ranjana." Grey bark, glabrous branchlets, lustrous, alternating leaves that are occasionally grouped together at the tips of branchlets, and noticeable scars characterise this 15-18 m tall tree. Groups of flowers are created in the spring. Berries or fruits have one or two seeds (8-10 mm), are delicious and edible, oblong-oblong to ellipsoid, and are 1–1.5 cm in length.

The mature fruit is eaten fresh in rural regions, but it may also be preserved and stored for a long time (Singh *et al*., 2017). Khirni is mostly propagated via seeds. It is a drought-tolerant plant that grows slowly. For khirni, there are no updated versions. Rayan or khirni is a popular rootstock for sapota in India, and it is prized for its latex, wood, fruits, and leaves. As ripe, fresh fruits that are delicious and an excellent source of iron, minerals, sugars, proteins, carbohydrates, and vitamin A, Khirni fruits have a high economic value (Pareek *et al*., 1998 and Singh *et al*., 2006).

Sapota are frequently multiplied by softwood grafting or inarch grafting by employing khirni (*Manilkara heaxandra*) as a rootstock. Khirni seeds have very weak germination rates, and their following growth is also quite little. Khirni seedlings need a lot of time to grow to the right height and vigour for grafting. Addressing the vital root zone and so reducing the wetting area, it enables optimal water and nutrient utilization (Jain *et al*., 2023). Improvements have already been made to the khirni seeds germination and subsequent development. It is generally known that bioregulators can improve seed germination and seedling growth in a variety of plant species (Malshe *et al.,* 2014). In addition, it is known that synthetic chemicals (Vachhani *et al.,* 2014; Jadhav *et al.* 2015) and other naturally occurring bio-products of organics (cow-dung, cow urine) contain essential plant growth substances that promote plant growth and development (Anonymous, 1993; Shirol *et al.,* 2005; Shinde and Malshe, 2015).

The establishment of seedlings in the main field and the orchard's eventual yield are both impacted by the quality of the seedlings purchased from a nursery. Numerous pre-sowing seed treatments have been extensively studied in tree species to enhance germination and shorten germination time (Prasad and Prasad 2009b, Prasad *et al*. 2011). To overcome hard seed coat dormancy, a variety of methods have been employed, including chemical treatment, growth regulators, hot water, and slurry made from cow dung and urine.

It is commonly recognised that plant growth regulators may be used to increase the development of seedlings of many different plant species (Marler and Mickelbart, 1992 and Hazrat *et al*., 2006). Because of their physiological effects on cells, auxins and gibberellins play a crucial role in plant development by encouraging the growth of shoots and roots. Napthalic acetic acid (NAA), gibberellic acid (GA3), and triacontanol are commonly used to stimulate crop growth in a variety of crops. Furthermore, it is well recognised that essential plant growth components found in synthetic chemicals and other naturally occurring organic bioproducts promote the growth and development of plants. The study on the influence of various chemicals on root growth characteristics of khirni was carried out in order to investigate the effects of plant growth regulators, cow dung slurry, cow urine, and other chemicals on the germination, growth, and development of khirni seedlings.

**Materials and Methods:** The study was carried out in the Nursery at Research Farm, Horticulture Section, College of Agriculture, Dhule, in the Maharashtra state (India). In the remote Satpuda Hills area of Dhadgaon tehsil, dist. Nandurbar, Maharashtra, fresh khirni seeds were purchased. Prior to planting, every seed was immersed in a 1:5 aqueous solution of the corresponding compounds for 36 hours. The seeds were shade-dried for ten minutes following the application of treatments. The treatment details are mentioned in table 1.

To document the vegetative observations, five randomly selected plants from each treatment were assigned as observational plants. On the 30th, 60th, 90th, 120th, 150th, and 180th days following the day of germination, these observations were made. The average fresh root weight, average fresh shoot weight, root: shoot fresh weight ratio, average root length and root density were recorded and the average was worked out by using statistical method. During this activity, the following characteristics were examined:

1. **Average fresh root weight (g):** Selected five randomly plants were recorded 180th day after germination. Weight was taken on electronic balance. The average fresh weight of root was recorded after computing the mean in gram.
2. **Average fresh shoot weight (g):** Selected five randomly plants were recorded 180th days after germination. Weight was taken with the help of electronic balance. The average fresh weight of shoot was recorded after computing the mean in gram.
3. **Average root: shoot ratio (weight basis):** Selected five randomly plants were recorded 180th days after germination.The root : shoot ratio of each treatment was calculated by root weight dividing the shoot weight of respective treatments. Ratio was recorded after computing the mean.
4. **Average root length (cm):** The khirni is dicot plant and hence tap root is the main root. The average root length of five selected plants from each replication treatment combination was measured by scale. After computing the mean it recorded as length of primary root in centimeter.
5. **Root density (mg/inch3):** Root density was calculated at the 180th day after germination with the help of formula given below and recorded in mg per inch cube. (Zotarelli *et.al* 2009)

 Fresh weight of root (mg)

 Root density (mg/in3) = --------------------------------- x 1000

 Soil volume (inch3)

The data was statistically analyzed as per the standard procedure given by Panse and Sukhatme (1984).

**Results and Discussion:** The observations were recorded by selecting five seedlings from each treatment at monthly interval and up to the age of six months and the average was worked out. The present study shown the following results. The data pertaining the various effects of seed treatments on average fresh root weight have presented in table 2. The data revealed that, the average fresh root weight significantly influenced due to different chemical treatments at 180th days after germination. The maximum average fresh root weight (2.67 g) was observed under treatment T9 (Cow dung slurry), which was at par with the treatment, T8 (Cow urine @ 100 %) 2.50g. The minimum average fresh root weight (0.85 g) was recorded under the treatment T10 (Control-Distilled water). The average fresh root weight of seedlings in cow dung treatment might be due to the presence of growth promoting substances (auxins) and nutrients, it promote root growth. Similar results were also reported by Sankaranarayanan and Vijaykumar(1994) in tamarind.

For fresh shoot weight, the data revealed that the significantly higher average fresh shoot weight (9.45 g) was recorded under treatment T9 (Cow dung slurry), which was at par with the treatment, T8 (Cow urine @ 100 %) 9.31 g, T7 (Cow urine @ 10 %) 8.50 g and T4 (GA3 @ 200 ppm) 8.31 g. The lowest average fresh shoot weight (6.50 g) was recorded under the treatment T10 (Control-Distilled water) at 180th days after germination. The higher average fresh shoot weight in cow dung slurry treatment may be attributed to the presence of growth promoting substances (auxins) and NPK nutrients in cattle cow dung It helps to increased shoot growth .The higher amount of photosynthates utilized for shoot development might be effect on maximum shoot weight. The data regarding the various effects of seed treatments on average fresh shoot weight have presented in table 3.

For root: shoot ratio, the data revealed that, the root: shoot ratio significantly varies from 0.28 to 0.13 in different treatments at 180th days after germination. The maximum root: shoot ratio (0.28) was observed under treatment T9 (Cow dung slurry) and showed at par with the treatment, T7 (Cow urine @ 10 %) 0.27, T8 (Cow urine @ 100 %) 0.27 and T4 (GA3 @ 200 ppm) 0.24. The minimum root: shoot ratio (0.13) was recorded under treatment T10 (Control-Distilled water). The maximum root: shoot ratio on fresh weight basis observed in cow dung slurry seed treatment which may be attributed to the presence of growth promoting substances (auxins) and NPK nutrients in cattle cow dung. The root weight was less than shoot weight. This might be due to that, maximum amount of photosynthates utilized for shoot development and minimum for root development (table 4).

The data regarding the various effects of seed treatments on average root length have presented in table 5. The data revealed that, the significantly higher average root length (34.69 cm) was recorded under treatment T9 (Cow dung slurry), which was at par with the treatment, T8 (Cow urine @ 100 %) 32.28 cm. The lowest average root length (21.18 cm) was recorded under treatment T10 (Control- Distilled water) at 180th days after germination. This might be due to the presence of growth promoting substances and minerals like, N, P, K, Ca, Mg, S and other micronutrients which may be contributed in increased physiological activities of seedling, essential for cell division and root enlargement. These results are in accordance with Shinde and Malse (2015) in khirni.

The data presented that, the maximum root density (15.51 mg/in3) was observed under treatment T9 (Cow dung slurry) which was at par with the treatment, T8 (Cow urine @ 100 %) 14.52 mg/in3. The minimum root density (4.94 mg/in3) was recorded under treatment T10 (Control-Distilled water). There were significant differences due to different seed treatments at 180th days after germination. The data regarding the various effects of seed treatments on rooting density have presented in table 6. The rapid growth and maximum root density of seedlings in cow dung treatment observed might be due to the presence of nutrients like, N, P, K and growth promoting substances. Similar results were also reported by Sankaranarayanan *et al.* (1994) in tamarind.

**Conclusion:** The present study resulted in the findings that the treatment T9 (Cow dung slurry) registered the maximum average fresh root weight (2.67 g), which was at par with the treatment, T8 (Cow urine @ 100 %) 2.50 g. Treatment T9 (Cow dung slurry) recorded the highest average fresh shoot weight (9.45 g), which was at par with the treatment, T8 (Cow urine @ 100 %) 9.31 g. The maximum root: shoot ratio (0.28) was observed under treatment T9 (Cow dung slurry) and showed at par with the treatment, T7 (Cow urine @ 10 %) 0.27. Higher average root length (34.69 cm) was recorded under treatment T9 (Cow dung slurry), which was at par with the treatment, T8 (Cow urine @ 100 %) 32.28 cm. The maximum root density (15.51 mg/in3) was observed under treatment T9 (Cow dung slurry) which was at par with the treatment, T8 (Cow urine @ 100%) 14.52mg/in3.

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

|  |  |
| --- | --- |
| Sr. No. | Treatments |
| 1 | T1 | GA3 @ 50ppm |
| 2 | T2 | GA3 @ 75ppm |
| 3 | T3 | GA3 @ 100ppm |
| 4 | T4 | GA3 @ 200ppm |
| 5 | T5 | NAA @ 100ppm |
| 6 | T6 | KNO3 @ 1% |
| 7 | T7 | Cow urine @ 10% |
| 8 | T8 | Cow urine @ 100% |
| 9 | T9 | Cow dung slurry |
| 10 | T10 | Control (Distilled water) |

**Table 2: Effect of different growth regulators and cow urine on average fresh root weight at 180th day after germination.**

|  |  |
| --- | --- |
| Treatment | Average fresh root weight (g) 180th DAG |
| T1 | GA3 @ 50 ppm | 1.18 |
| T2  | GA3 @ 75 ppm | 1.40 |
| T3 | GA3 @ 100 ppm | 1.84 |
| T4 | GA3 @ 200 ppm | 1.96 |
| T5 | NAA @ 100 ppm | 1.56 |
| T6 | KNO3 @ 1 % | 1.30 |
| T7 | Cow urine @ 10 % | 2.31 |
| T8 | Cow urine @ 100 % | 2.50 |
| T9 | Cow dung slurry | 2.67 |
| T10 | Control (Distilled water) | 0.85 |
| S.E(m)± | 0.06 |
| C.D. at 5 % | 0.17 |

**Table 3: Effect of different growth regulators and cow urine on average fresh shoot weight at 180th day after germination.**

|  |  |
| --- | --- |
| Treatment | Average fresh shoot weight (g) at 180th DAG |
| T1 | GA3 @ 50 ppm | 7.25 |
| T2  | GA3 @ 75 ppm | 7.65 |
| T3 | GA3 @ 100 ppm | 8.00 |
| T4 | GA3 @ 200 ppm | 8.31 |
| T5 | NAA @ 100 ppm | 7.84 |
| T6 | KNO3 @ 1 % | 7.55 |
| T7 | Cow urine @ 10 % | 8.50 |
| T8 | Cow urine @ 100 % | 9.31 |
| T9 | Cow dung slurry | 9.45 |
| T10 | Control (Distilled water) | 6.50 |
| S.E(m)± | 0.38 |
| C.D. at 5 % | 1.11 |

**Table 4: Effect of different growth regulators and cow urine on root: shoot ratio (fresh weight basis) at 180th day after germination.**

|  |  |
| --- | --- |
| Treatment | Root : shoot fresh weight ratio at 180th DAG |
| T1 | GA3 @ 50 ppm | 0.17 |
| T2  | GA3 @ 75 ppm | 0.18 |
| T3 | GA3 @ 100 ppm | 0.23 |
| T4 | GA3 @ 200 ppm | 0.24 |
| T5 | NAA @ 100 ppm | 0.20 |
| T6 | KNO3 @ 1 % | 0.17 |
| T7 | Cow urine @ 10 % | 0.27 |
| T8 | Cow urine @ 100 % | 0.27 |
| T9 | Cow dung slurry | 0.28 |
| T10 | Control (Distilled water) | 0.13 |
| S.E(m)± | 0.01 |
| C.D. at 5 % | 0.04 |

**Table 5: Effect of different growth regulators and cow urine on average root length at 180th day after germination.**

|  |  |
| --- | --- |
| Treatment | Average root length (cm) at 180th DAG |
| T1 | GA3 @ 50 ppm | 22.80 |
| T2  | GA3 @ 75 ppm | 25.00 |
| T3 | GA3 @ 100 ppm | 27.40 |
| T4 | GA3 @ 200 ppm | 29.18 |
| T5 | NAA @ 100 ppm | 26.49 |
| T6 | KNO3 @ 1 % | 23.70 |
| T7 | Cow urine @ 10 % | 30.20 |
| T8 | Cow urine @ 100 % | 32.28 |
| T9 | Cow dung slurry | 34.69 |
| T10 | Control (Distilled water) | 21.18 |
| S.E(m)± | 0.85 |
| C.D. at 5 % | 2.51 |

**Table 6: Effect of different growth regulators and cow urine on root density at 180th day after germination.**

|  |  |
| --- | --- |
| Treatment | Root density (mg/in3) at 180th DAG |
| T1 | GA3 @ 50 ppm | 6.85 |
| T2  | GA3 @ 75 ppm | 8.11 |
| T3 | GA3 @ 100 ppm | 10.69 |
| T4 | GA3 @ 200 ppm | 11.39 |
| T5 | NAA @ 100 ppm | 9.04 |
| T6 | KNO3 @ 1 % | 7.55 |
| T7 | Cow urine @ 10 % | 13.40 |
| T8 | Cow urine @ 100 % | 14.52 |
| T9 | Cow dung slurry | 15.51 |
| T10 | Control (Distilled water) | 4.94 |
| S.E(m)± | 0.34 |
| C.D. at 5 % | 1.01 |