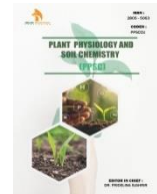




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RESEARCH ARTICLE

EFFECT OF SEED PRIMING ON GERMINATION AND SEEDLING GROWTH OF KIWI (*ACTINIDIA DELICIOSA* CV. BRUNO) IN ILAM, NEPAL

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ABSTRACT

Kiwifruit (*Actinidia deliciosa*) is an emerging fruit crop in Nepal. However, owing to its poor seed germination, growers lack the techniques for high-quality uniform rootstock production for grafting purposes. Ten treatments were tested, including control, tap water, cow urine (5% and 10%), vermiwash (10% and 20%), KNO₃ (1% and 3%), and GA₃ (4000 ppm and 6000 ppm), using a Completely Randomized Design with three replications. The results revealed that the highest germination percentage (47.69%) was recorded on GA₃ at 6000 ppm, which was statistically at par with KNO₃ 1%, GA₃ 4000 ppm, KNO₃ 3%, and vermiwash 20% and the lowest germination percentage (35.07%) was recorded on the control. The highest seedling height (9.74 cm) was recorded on KNO₃ at 3% which was statistically similar to KNO₃ 1%, vermiwash 20%, GA₃ 4000 ppm, and cow urine 10% and the shortest seedling height (6.69 cm) was found in the control. The highest fresh shoot weight (0.183 g), fresh root weight (0.093 g), dry shoot weight (0.019 g), dry root weight (0.005 g), and shoot length (3.86 cm) were observed in KNO₃ at 3% which was statistically at par with GA₃ 6000 ppm and vermiwash 20% and the lowest values recorded in the control. Similarly, KNO₃ 1% achieved the highest root length (6.06 cm) and seedling vigor index-I (445.77), while the lowest values were recorded in the control. The highest seedling vigor index-II (1.070) was found in GA₃ 6000 ppm, while the control showed the lowest (0.545). From the findings of this experiment, it is revealed that the seeds treated with GA₃ 6000 ppm, GA₃ 4000 ppm, KNO₃ 3%, KNO₃ 1%, vermiwash 20% and cow urine 10% could be the most effective and appropriate method to improve the germination and seedling growth of kiwifruit for rootstock purposes.

KEYWORDS

Germination, Kiwifruit, Seedling growth, Seed priming

1. INTRODUCTION

Kiwifruit (*Actinidia deliciosa*), belonging to the family Actinidiaceae and the genus *Actinidia*, is a dicotyledonous, perennial plant that includes a number of important commercial species (Maghdouri et al., 2021). The kiwifruit is a deciduous fruit native to the Yangtze River valley in southern and central China. This kiwi fruit is known as "China's miracle fruit" and "Horticulture wonder of New Zealand" (Raja et al., 2021).

Kiwifruit is rusty brown with a hairy surface and looks like a Sapota fruit. The flesh of kiwi fruit is light green in colour with a decorative pattern of lighter colored rays radiating from the center, and embedded in between are many small, soft, and dark seeds. Kiwi fruit has a refreshing and delicate flavor with a pleasing aroma (Pandey and Tripathi, 2014a). It is highly nutritious and of medicinal value. Kiwi is rich in vitamin C, and it contains more calcium, potassium, phosphorus, and iron, and is low in calories (Pandey and Tripathi, 2014a). There are more than 50 species of the genus *Actinidia*. Among them, *A. deliciosa* is widely cultivated and in large quantities. Most of the species of *Actinidia* haven't been cultivated, and their production potential hasn't been tested. Various species of *Actinidia* are naturally found in China. It has been said that the origin of the kiwifruit was from China (Ferguson, 1991).

Nepal offers suitable topography, climate, and soil for profitable production of kiwifruit. The main challenges include inadequate scientific study on kiwifruit, lack of adoption of improved technology, insufficient investment, poor quality planting material, unstable prices and profit margins, along with inappropriate market channels (Sharma et al., 2020). The increasing population of consumers towards the consumption of the fruit has shown ample space for the expansion of the area under the crop (Poudel et al., 2019). Kiwi has been reported to show best performance at an altitude of 1200 to 2500 masl (MoAD, 2017). The total area, productive area, production, and yield of Kiwifruit in Nepal are 2,599 ha; 1,014 ha; 7,698 mt, and 7.59 mt/ha, respectively. In Ilam District, the kiwi production area was 200 ha with production 1500 mt and yield 7.50 mt/ha (MOALD, 2021/22). Dolakha, Ilam, Kavre, Solukhumbhu, Ramechhap, Sindhuli, Panchthar, Dhankuta, Baglung, Parbat, Kaski, Salyan, Nuwakot, and Myagdi are potential districts in Nepal to grow kiwifruit (Gotame et al., 2016).

Priming is a simple procedure that partially hydrates the seed in a controlled environment, followed by seed drying, so that germination processes begin, without radicle emergence. This approach is useful for several crops where germination and emergence can be constrained by unfavorable soil conditions (Damalas et al., 2019). The importance of

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priming includes enhanced stress tolerance, faster and stronger responses, improved yield and growth, and efficient use of resources. Hence, seed treatment with GA₃ 6000 ppm, GA₃ 4000 ppm, KNO₃ 3%, KNO₃ 1%, vermiwash 20% as well as cow urine 10% can be the best alternative for proper germination and seedling growth. These results would be useful for nurserymen and kiwi growers for high-quality uniform rootstock production for grafting purposes.

2. MATERIALS AND METHODS

2.1. General Experimental Details

The experiment was conducted at Harit Shanti Expedition Multipurpose Cooperation Organization Ltd., Ilam Municipality. It started on March 28, 2024, and ended on May 30, 2024. The site is located at an elevation of 1200m above sea level. The geographical location of the experimental site was about latitude: 26.53° 59.99' N and longitude: 87.55° 59.99' E. The sample seeds were taken from a local farm of the variety "Bruno".

A field experiment was carried out with ten treatments and three replications. The treatments were: control, tap water, cow urine 5%, cow urine 10%, vermiwash 10%, vermiwash 20%, KNO₃ 1%, KNO₃ 3%, GA₃ 4000 ppm, and GA₃ 6000 ppm. The priming of the seed was done in a lab for 24 hours and dried in the shade until the moisture content was decreased.

2.1.1. Experimental design

The experiment was conducted on a Completely Randomized Design (CRD) with ten treatments and three replications. The treatments were 30 experimental setups for each germination test.

2.1.2. Details of the field operation

The tray was filled with respective media, i.e., peatmoss and vermicompost (3:1) on a volume basis. The media was filled properly into every cell of the tray. A total of 30 trays were used for the research. The Bruno seeds were dibbled at the centre of each hole at a depth of 1cm. and then the seeds were covered lightly with the respective media. Foliar application of micronutrients was given uniformly to the seedlings with the help of a hand sprayer.

2.2 Data Collection and Statistical Analysis

Germination parameters and seedling parameters measurements were taken in five randomly selected plants from each tray. Various data were obtained from measurements taken for several traits. The following data was collected.

2.2.1 Germination percentage (%)

The total number of germinated seeds out of the total seeds sown was recorded for each replication of each treatment. The total count was taken as a percentage.

$$\text{Germination \%} = \frac{\text{Number of germinated seeds}}{\text{Total number of seed sown}} \times 100\%$$

2.2.2 Seedling vigor index (SVI)

According to ISTA, Seed vigor is the sum of the activity and performance of seed lots with acceptable germination in a wide range of environments. Seedling vigor index was calculated by multiplying germination (%) and seedling length. Similarly, seedling vigor index-II was calculated by multiplying germination (%) and seedling dry weight. The seed vigor was calculated as:

- Seedling vigor index-I = % germination × seedling length (cm)
- Seedling vigor index-II = % germination × seedling dry weight (g)

2.2.3 Data analysis

Different parameters were recorded during the experimentation. The collected data were entered into Microsoft Excel. The significant difference between treatments, analysis of variance was carried out using R Studio version 4.4.1, and LSD was used for mean separation at 5% level of significance.

3. RESULTS

3.1 Effect of Seed Priming on Germination Percentage, Seed Vigor Index-I and Seed Vigor Index-II

Effect of different priming treatments on germination percentage, seed vigor index-I, and seed vigor index-II (Table 1).

3.1.1 Germination percentage (%)

Germination percentage was significantly affected by different methods of seed priming. The result showed that the germination percentage was significantly influenced by different seed priming techniques. The highest germination percentage was achieved with GA₃ 6000 ppm (47.69%) which was statistically at par with KNO₃ at 1% (46.63%), GA₃ 4000 ppm (45%) as well as KNO₃ 3% (43.61%) and vermiwash 20% (43.61%) while the lowest germination percentage was obtained from control (35.07%) which was statistically at par with tap water (35.65%) as well as vermiwash 10% (37.3%) and cow urine 5% (36.31%).

3.1.2 Seed vigor index-I and seed vigor index-II

Seedling vigor index-I was significantly affected by different methods of seed priming (Table 6). The result showed that the seedling vigor index-I was significantly influenced by different seed priming techniques. Significantly, the highest seedling vigor index-I was observed in KNO₃ at 1% (445.77), which was statistically at par with KNO₃ at 3% (425.43), vermiwash 20% (415.25), GA₃ 4000 ppm (411.95), and GA₃ 6000 ppm (408.55). The lowest seedling vigor index was observed in the control (234.89), which was statistically equivalent to tap water (263).

Similarly, the seedling vigor index-II was significantly influenced by different seed priming techniques. Significantly, the highest seedling vigor index-II was observed in GA₃ at 6000 ppm (1.070) which was statistically at par with KNO₃ 3% (1.028) and the lowest seedling vigor index-II was observed in control (0.545) which was statistically at par with tap water (0.555), cow urine 5% (0.610) as well as cow urine 10% (0.678) and vermiwash 10% (0.700).

Table 1: Effect of seed priming on germination percentage, seed vigor index-I and seed vigor index-II of Kiwi (*Actinidia deliciosa* cv. Bruno) seeds in Ilam, Nepal, 2024

Treatment	Germination %	Seed vigor index-I	Seed vigor index-II
Control	35.07 ^d	234.87 ^d	0.55 ^e
Tap water	35.65 ^{bc}	263.00 ^{cd}	0.55 ^e
Cow urine-5%	36.31 ^{cd}	308.48 ^{bc}	0.61 ^e
Cow urine-10%	40.37 ^b	346.01 ^b	0.68 ^{de}
Vermiwash-10%	37.5 ^{cd}	304.27 ^{bc}	0.70 ^{de}
Vermiwash-20%	43.61 ^{ab}	415.25 ^a	0.83 ^{cd}
KNO ₃ - 1%	46.63 ^a	445.77 ^a	0.88 ^{bc}
KNO ₃ - 3%	43.61 ^{ab}	425.43 ^a	1.03 ^{ab}
GA ₃ - 4000ppm	45 ^a	411.95 ^a	0.80 ^{cd}
GA ₃ - 6000ppm	47.69 ^a	408.55 ^a	1.07 ^a
CV(%)	6.13	9.76	12.03
LSD _{0.05}	4.3	59.23	0.16
SEm(±)	1.6	24.64	0.06
F-test	***	***	***
Grand mean	41.14	356.36	0.77

Means with the same letter in column are not significantly different at p = 0.05 by LSD. *Significant at 5% (P < 0.05). **Significant at 1% (P < 0.01), *** = significant at (P < 0.001), and NS: not significantly different at 5% (P > 0.05). LSD = Least significant difference, CV = Coefficient of variance

3.2 Effect of Seed Priming on Seedling Height, Shoot Length, and Root Length

Effect of different priming treatments on seedling height, shoot length, and root length (Table 2).

3.2.1 Seedling height, shoot length, and root length

The result showed that the seedling height was significantly influenced by different seed priming techniques. Significantly, the highest seedling height was observed in KNO₃ at 3% (9.74 cm) which was statistically at

par with KNO₃ 1% (9.55 cm), vermiwash 20% (9.52 cm), GA₃ 4000 ppm (9.17 cm) and cow urine 10% (8.62 cm) and lowest seedling height was found in control (6.69 cm) which was statistically at par with tap water (7.38 cm).

Similarly, the highest shoot length was observed in KNO₃ at 3% (3.86 cm) which was statistically at par with GA₃ at 4000 ppm (3.77 cm) as well as KNO₃ 1% (3.50 cm), vermiwash 20% (3.49 cm) and GA₃ and the lowest shoot length was observed in control (2.79 cm) which was statistically at par with tap water (2.81 cm) as well as cow urine 5% (3.05 cm), cow urine 10% (3.25 cm) and vermiwash 10% (3.03 cm).

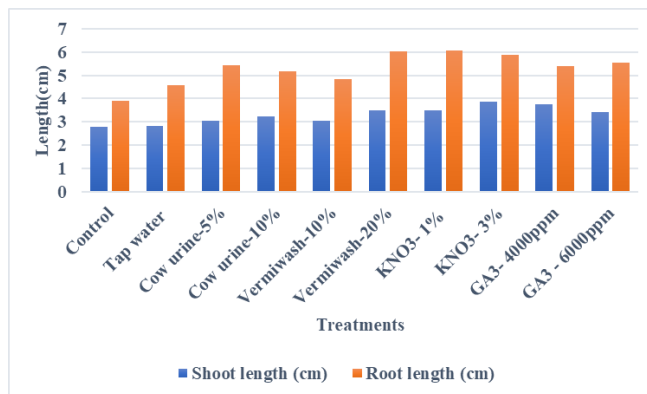


Figure 1: Comparison of effects of priming on shoot length and root length of Kiwi (*Actinidia deliciosa* cv. Bruno) seeds in Ilam, Nepal, 2024

The root length was significantly influenced by different seed priming techniques. Significantly, the highest root length was observed in KNO₃ at 1% (6.06 cm) which was statistically at par with vermiwash at 20% (6.03 cm) as well as KNO₃ 3% (5.88 cm), GA₃ 4000 ppm (5.40 cm), GA₃ 6000 ppm (5.53 cm), cow urine 5% (5.42 cm) and cow urine 10% (5.18 cm) and lowest root length was observed in control (3.90 cm) which was statistically at par with tap water (4.57 cm) and vermiwash 10% (4.85 cm).

Table 2: Effect of seed priming on seedling height, shoot length, and root length of Kiwi (<i>Actinidia deliciosa</i> cv. Bruno) seeds in Ilam, Nepal, 2024			
Treatment	Seedling height (cm)	Shoot length (cm)	Root length (cm)
Control	6.69 ^e	2.79 ^c	3.90 ^d
Tap water	7.38 ^{de}	2.81 ^c	4.57 ^{cd}
Cow urine-5%	8.47 ^{bcd}	3.05 ^{bc}	5.42 ^{abc}
Cow urine-10%	8.62 ^{abc}	3.25 ^{bc}	5.18 ^{abc}
Vermiwash-10%	8.10 ^{cd}	3.03 ^{bc}	4.85 ^{bcd}
Vermiwash-20%	9.52 ^{ab}	3.49 ^{ab}	6.03 ^a
KNO ₃ -1%	9.55 ^{ab}	3.50 ^{ab}	6.06 ^a
KNO ₃ -3%	9.74 ^a	3.86 ^a	5.88 ^{ab}
GA ₃ -4000ppm	9.17 ^{abc}	3.77 ^a	5.40 ^{abc}
GA ₃ -6000ppm	8.57 ^{bc}	3.43 ^{ab}	5.53 ^{abc}
CV(%)	7.85	8.39	11.56
LSD _{0.05}	1.15	0.47	1.04
SEm(±)	0.35	0.14	0.26
F-test	***	**	*
Grand mean	8.58	3.30	5.28

Means with the same letter in column are not significantly different at p = 0.05 by LSD. *Significant at 5% (P < 0.05). **Significant at 1% (P < 0.01), *** = significant at (P < 0.001), and NS: not significantly different at 5% (P > 0.05). LSD = Least significant difference, CV = Coefficient of variance

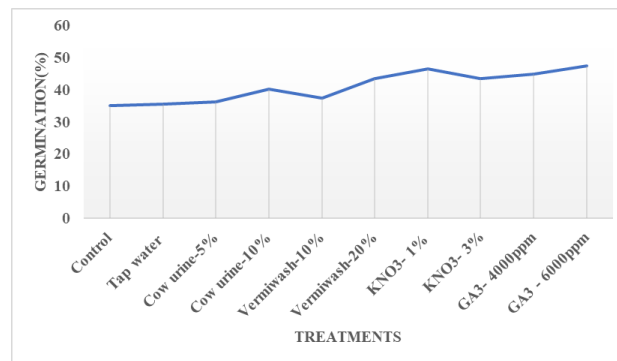


Figure 2: Line graph of Germination (%) over different treatments of Kiwi (*Actinidia deliciosa* cv. Bruno) seeds in Ilam, Nepal, 2024

3.3 Effect of Seed Priming on Fresh Shoot Weight, Fresh Root Weight, Dry Shoot Weight, and Dry Root Weight

Effect of different priming treatments on fresh shoot weight, fresh root weight, dry shoot weight, and dry root weight (Table 3).

3.3.1 Fresh shoot weight and fresh root weight

The result showed that the fresh shoot weight was significantly influenced by different seed priming techniques. Significantly, the highest fresh shoot weight was observed in KNO₃ at 3% (0.183 g) which was statistically at par with GA₃ at 4000 ppm (0.176 g), vermiwash at 20% (0.174 g), KNO₃ at 1% (0.172 g) and GA₃ at 6000 ppm (0.169 g) and the lowest fresh shoot weight was observed in control (0.110g) which was statistically at par with tap water (0.116 g).

Similarly, the fresh root weight was significantly influenced by different seed priming techniques. Significantly, the highest fresh root weight was observed in KNO₃ at 3% (0.093 g) which was statistically at par with GA₃ at 6000 ppm (0.092 g) and the lowest fresh root weight was observed in control (0.022 g) which was statistically at par with tap water (0.031 g), cow urine 5% (0.033 g) and vermiwash 10% (0.030 g).

3.3.2 Dry shoot weight and dry root weight

The result showed that the dry shoot weight was significantly influenced by different seed priming techniques. The highest dry shoot weight was observed in KNO₃ at 3% (0.019 g) which was statistically at par with GA₃ at 6000 ppm (0.018 g) and the lowest dry shoot weight was observed in control (0.012 g) which was statistically at par with tap water (0.012 g) as well as cow urine 5% (0.013g), cow urine 10% (0.013 g) and vermiwash 20% (0.015 g).

Similarly, the highest dry root weight was observed in KNO₃ at 3% (0.005 g) which was statistically at par with GA₃ 6000 ppm (0.005 g), vermiwash 20% (0.005 g) and KNO₃ 1% (0.004 g) and the lowest dry root weight was observed in control (0.004 g) which was statistically at par with tap water (0.004 g), cow urine 5% (0.004 g), cow urine 10% (0.004g) as well as vermiwash 10% (0.004 g).

Table 3: Effect of seed priming on fresh shoot weight, fresh root weight, dry shoot weight, and dry root weight of Kiwi (*Actinidia deliciosa* cv. Bruno) seeds in Ilam, Nepal, 2024

Treatment	Fresh shoot weight (g)	Fresh root weight (g)	Dry shoot weight (g)	Dry root weight (g)
Control	0.11 ^d	0.022 ^d	0.012 ^d	0.0035 ^d
Tap water	0.12 ^{cd}	0.031 ^d	0.012 ^{cd}	0.0036 ^d
Cow urine-5%	0.14 ^b	0.033 ^d	0.013 ^{bcd}	0.0038 ^d
Cow urine-10%	0.14 ^b	0.046 ^c	0.013 ^{bcd}	0.0036 ^d
Vermiwash-10%	0.13 ^{bc}	0.030 ^d	0.015 ^{bc}	0.0038 ^{cd}
Vermiwash-20%	0.17 ^a	0.049 ^{bc}	0.015 ^{bcd}	0.0046 ^{abc}
KNO ₃ - 1%	0.17 ^a	0.058 ^b	0.015 ^b	0.0040 ^{abcd}
KNO ₃ - 3%	0.18 ^a	0.093 ^a	0.019 ^a	0.0048 ^a
GA ₃ - 4000ppm	0.18 ^a	0.058 ^b	0.014 ^{bcd}	0.0039 ^{bcd}
GA ₃ - 6000ppm	0.17 ^a	0.092 ^a	0.018 ^a	0.0047 ^{ab}
CV(%)	8.26	13.89	11.47	12.0013
LSD _{0.05}	0.021	0.012	0.003	0.0008
SEm(±)	0.009	0.008	0.001	0.0002
F-test	***	***	**	*
Grand mean	0.15	0.051	0.014	0.004

Means with the same letter in column are not significantly different at $p = 0.05$ by LSD. *Significant at 5% ($P < 0.05$). **Significant at 1% ($P < 0.01$), *** = significant at ($P < 0.001$) and NS: not significantly different at 5% ($P > 0.05$). LSD = Least significant difference, CV = Coefficient of variance

4. DISCUSSION

Seed priming is a strategy that carefully manages water availability, permitting seeds to fully absorb moisture and initiate the necessary early metabolic activities of the first germination phase, yet holding the process precisely at that point, preventing further development in the second and third phases (Koirala et al., 2019). Kiwifruit seeds show difficulty in germinating. As the root systems of seedlings obtained from seeds are superior to the roots of cuttings, grafting the desired variety onto the seedling rootstocks is the most common method for propagating kiwifruit. Grafted kiwifruit vines adapt well to a variety of soil conditions. There are several reports in the literature which demonstrate that the use of seed priming with various growth regulators are suitable procedure for enhancing the kiwifruit seed germination (Lawes and Anderson, 1980; Ahn et al., 1984; Mattiuz et al., 1996; Verma et al., 1998; Ynoue et al., 1999; Ozcan, 2000; Ozcan and Erisgin, 2000).

Priming seeds with KNO₃ accelerated germination by enhancing imbibition and reactivating seed metabolism, which resulted in faster seedling establishment and greater shoot and root length (Umesh et al., 2023). Seed priming with GA₃ and KNO₃ significantly increased the plant height, fresh and dry weight, and strong seedling index (Anwar et al., 2020). Vermiwash exhibited growth-promoting effects on the ecomorphological characters such as plant height, length, and diameter of the internode, number of leaves, leaf surface area, root length, wet and dry weight of the shoot and root (Kaur et al., 2015).

Vermiwash has growth-promoting effects on plants (Javed et al., 2020). Okra seeds primed with vermiwash @ 20% showed improved seed germination, seedling length, and dry weight (Stephen et al., 2018). Seed priming of chili with vermiwash solution diluted 8 times for a duration of 30 hours is the best for improving the germination and establishment parameters (Jiang et al., 2016). Seed priming with cow urine 5% at 24 hrs soaking duration improved the seed vigor (Mehta et al., 2010).

We observed that the total germination rate of kiwifruit seeds primed with GA₃ 6000 ppm, KNO₃ at 1%, GA₃ 4000 ppm, as well as KNO₃ 3% and vermiwash 20% increased. It was observed that the germination percentage was higher the using 6000 ppm of GA₃ (Çelik et al., 2006). The use of GA₃ primed seed is believed to increase the seed germination and seedling vigor. Concentration of GA₃ (4000 ppm and 6000 ppm) treated kiwi seeds showed germination capacity of the Kiwi seed has a faster germination rate. Higher concentration of GA₃ gives higher germination, and untreated seeds give lower germination (KC, 2018).

5. CONCLUSION

Significant variations were observed among different concentrations of seed priming on various parameters. The highest seed germination (%) and seedling vigor index-II were found to be maximum in GA₃ 6000 ppm, which was statistically at par with KNO₃ 3%. Similarly, the highest dry shoot weight, dry root weight, fresh shoot weight, fresh root weight, seedling height, and shoot length were found to be maximum in KNO₃ 3%. Similarly, the highest seedling vigor index-I and root length were recorded in KNO₃ 1% which was statistically at par with vermiwash 20%. Seed treated with 6000 ppm of GA₃ could significantly help to improve the seed germination percentage and seedling growth of Kiwi fruit, which was statistically at par with KNO₃ 1%, KNO₃ 3%, GA₃ 4000 ppm, and vermiwash 20%. Similarly, KNO₃ 3% and Vermiwash 20% could be a better alternative growing media for higher germination percentage, faster germination, and quicker growth of seedlings with greater root biomass as compared to the control. Hence, seed treatment with GA₃ 6000 ppm, GA₃ 4000 ppm, KNO₃ 3%, KNO₃ 1%, vermiwash 20% as well as cow urine 10% can be the best alternative for proper germination and seedling growth. These results would be useful for nurserymen and kiwi growers for high-quality, uniform rootstock production for grafting purposes.

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COMPETING INTEREST

The authors hereby declare that they possess no competing interests in this paper.

AUTHORS' CONTRIBUTION

Ayasha Shahi: Writing – review & editing, Writing – original draft, Methodology, Data curation, Conceptualization, Formal analysis. Ganesh Lamsal: Writing – review & editing, Writing – original draft, Validation, Supervision, Conceptualization, Methodology. Sandeep Timalina: Writing – review & editing, Writing – original draft, Methodology. Jay Chaurasia: Writing – review & editing, Writing – original draft, Methodology.

DATA AVAILABILITY STATEMENT

The data will be available on request to the corresponding author.

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