Online ISSN 2456-6489 **Research Article**

Indian Journal of Agroforestry
Vol. 28, No. 2, April–June 2026

Enhancing Stem Cutting Success in Kusum (*Schleichera Oleosa*) Through Girdling, Defoliation, and Donor Age Selection: A Propagation Breakthrough

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https://doi.org/10.48165/ija.2026.28.02.11

ARTICLE INFO
Received: 09.01.2026
Accepted: 07.06.2026

Keywords:
Schleichera oleosa
Kusum
clonal propagation
girdling
defoliation
rooting success
donor age

ABSTRACT

Schleichera oleosa (Kusum) is a multipurpose tree species of immense ecological and socio-economic importance, particularly as a primary host for lac production. However, its large-scale plantation is constrained by poor seed propagation and low rooting success in stem cuttings. The present study evaluated the combined influence of girdling, defoliation, and mother plant age on rooting success in Kusum cuttings under controlled nursery conditions. Results revealed that both girdling and defoliation significantly enhanced rooting initiation, rooting success, and survival, with the highest rooting performance (45.56% initiation, 13.67% success, 14.32% survival) recorded from 5 – 10 years old donor plants subjected to girdling three months prior and defoliation seven days before cutting collection. Furthermore, juvenile donor material (<3 years old) exhibited superior rooting potential (53% initiation, 50.25% success, 48.50% survival) compared to older plantations, where rooting success declined with age. Post-transplanting assessment indicated excellent field establishment with zero mortality over two years. These findings highlight the critical role of pre-conditioning techniques and donor age in enhancing clonal propagation success, offering a viable pathway for mass multiplication and conservation of Kusum.

INTRODUCTION

Vegetative propagation serves as a reliable and cost-effective method for mass multiplication of woody perennials, particularly in species where conventional seed-based propagation is hindered by low viability, genetic heterogeneity, or long gestation periods (Ooyama and Toyoshima, 1965; Hartmann et al., 2002). Among the diverse vegetative techniques, stem cutting remains a widely accepted approach for producing true-to-type planting material. However, successful rooting of stem cuttings is highly species-specific and often influenced by a complex interplay of physiological, anatomical, biochemical, and environmental factors (Hareesh et al., 2001; Nautiyal et al., 2007).

The tree species Schleichera oleosa (Lour.) Oken, commonly known as Kusum, is a multipurpose species of high ecological and socio-economic significance. It serves as the primary host for lac production, contributing substantially to rural livelihoods in central and eastern India (Jaiswal and Singh, 2010; Sarkar et al., 2017a; Sarkar et al., 2022). Despite its immense potential for economic upliftment and ecological restoration, large-scale plantation efforts of Kusum are severely constrained by difficulties in seed propagation due to poor seed availability, fruit predation, seed dormancy, and genetic heterogeneity (Radhamani et al., 2003; Sinha, 2012; Siahaan, 2017; Sarkar et al., 2023).

Clonal propagation techniques such as stem cutting, grafting, and air-layering present promising alternatives for the multiplication of Kusum. Yet, previous attempts have recorded limited success, largely due to poor rooting responses in stem cuttings and the species' physiological recalcitrance (Sinha and Akhtar, 2008; Sarkar et al., 2019; Sarkar et al., 2022). Notably, studies in other woody species have established that girdling—the removal of a bark strip to interrupt downward translocation of carbohydrates—and defoliation can significantly enhance rooting by increasing the accumulation of carbohydrates, hormones, and rooting cofactors in cuttings (Stoltz and Hess, 1966; Basu et al., 1972; Hare, 1978; Ferriani and Krinski, 2019).

Moreover, the age of the mother plant is considered a crucial determinant of rooting success, with juvenile donor material exhibiting superior rooting capacity compared to mature plants (Hackett, 1988; Browne et al., 1996; Ky-Dembele et al., 2011). In Kusum, however, the effects of such pre-conditioning techniques and mother plant age on stem cutting propagation remain unexplored, representing a significant research gap.

Given these constraints and opportunities, the present investigation was conceptualized to address the challenges associated with vegetative propagation of Kusum through scientifically tested, practical methods. We hypothesize that girdling and defoliation of source branches, combined with the strategic selection of donor plant age, will synergistically enhance the rooting success in Kusum stem cuttings, thereby offering a viable mass multiplication pathway for this important species. Considering the above all facts, an experiment was conducted to evaluate the influence of girdling, defoliation, and mother plant age on rooting success in stem cuttings of Kusum (S. oleosa).

METHODOLOGY

Experimental sites

The experiment was conducted during 2018 to 2024 at research fields of ICAR Research Complex for Eastern Region, Farming System Research Centre for Hill and Plateau Region, Plandu, Ranchi (located at 23° 17' 17.1" North latitude and 85° 24' 34.79" East longitude) and Genetics and Tree Improvement Division, Institute of Forest Productivity (IFP), Lalgutwa, Ranchi (located at 23° 21' 28.37" North latitude and 85° 14' 41.43" East longitude). The experimental sites fall under a dry and humid tropical climate, receiving average maximum rainfall of 401.95 mm in August. The mean monthly temperature ranges from 7.4°C (January, minimum) to 37.5°C (May, maximum). Relative humidity peaks during the monsoon (> 80% in July) and remains below 50% during the summer.

Planting Material and Selection of Donor Trees

Healthy, disease-free candidate plus trees (CPTs) of *Schleichera oleosa* (Lour.) Oken were selected from plantations of IFP, Ranchi and ICAR-IINRG, Ranchi. Two age classes of mother plants viz., 5 to 10 years old trees, and 10 to 20 years old trees, were considered to evaluate the influence of donor age on rooting performance (Hackett, 1988; Browne et al., 1996).

Preparation of Cuttings and Hormonal Treatment

The cuttings were collected throughout the year, with intensive collections from March to September, coinciding with the active growth phase. To enhance rooting potential, defoliation of source branches was performed 7 days prior to cutting collection, as recommended by Dhakar and Das (2017). Semi-hardwood cuttings of 6-12 cm length and 0.5-2.5 cm diameter, bearing 2-3 healthy buds, were harvested using sterilized secateurs. Collected cuttings were surface-sterilized in 0.2% Bavistin (Carbendazim 50% WP) solution to prevent pathogen infestation, followed by immersion in 0.1% Ascorbic Acid for one hour to minimize oxidative browning (Johkan et al., 2008). Subsequently, cuttings were treated with a solution of Indole-3-butyric acid (IBA) at 2000 ppm + 5% Sucrose for one hour to promote root induction (Palanisamy and Kumar, 1997; Mani et al., 2018). A minimum of 100 cuttings each of the treatments per replication were selected. Two-third length of the cuttings were inserted in the rooting medium and arranged in the mist chamber or shade-net or poly-tunnel according to Completely Randomized Design (CRD). The planted cuttings were irrigated and weeded when required, until the termination of the experiment. The procedure for cuttings in Kusum followed in this experiment has been described under the following sub-heads:

Standardization of girdling and defoliation treatments

The cuttings of young shoots of Kusum were collected from girdled branches of different girdling- ring thickness before or after defoliations as treatments (Table 1) from 5-10 years old as well as 10-20 years old Kusum plantations during March to September every year. The parameters like rooting initiation (%), rooting success (%) and survival at six months (%) were recorded.

Table 1

Treatments	Girdling ring thickness (mm)	Time interval for preparation of cuttings after girdling (month)	Treatment symbol
Control (Non-girdling with no defoliation)	0	–	CG1
Girdling	2	1	CG2
Girdling	4	1	CG3
Girdling	6	1	CG4
Girdling	8	1	CG5
Girdling	10	1	CG6
Girdling	2	3	CG7
Girdling	4	3	CG8
Girdling	6	3	CG9
Girdling	8	3	CG10
Girdling	10	3	CG11
Girdling	2	6	CG12
Girdling	4	6	CG13
Girdling	6	6	CG14
Girdling	8	6	CG15
Girdling	10	6	CG16
Girdling + Defoliation	2	1	CG17
Girdling + Defoliation	4	1	CG18
Girdling + Defoliation	6	1	CG19
Girdling + Defoliation	8	1	CG20
Girdling + Defoliation	10	1	CG21
Girdling + Defoliation	2	3	CG22
Girdling + Defoliation	4	3	CG23
Girdling + Defoliation	6	3	CG24
Girdling + Defoliation	8	3	CG25
Girdling + Defoliation	10	3	CG26
Girdling + Defoliation	2	6	CG27
Girdling + Defoliation	4	6	CG28
Girdling + Defoliation	6	6	CG29
Girdling + Defoliation	8	6	CG30
Girdling + Defoliation	10	6	CG31
Defoliation	–	–	CG32

Table 3: *Effect of girdling and defoliation treatments on rooting success and survival in cuttings of Kusum*

Treatments	Girdling ring thickness (mm)	Time interval for preparation of Cuttings after girdling (month)	Treatment's symbol	Cuttings from 5-10 years old plantation			Cuttings from 10-20 years old plantation		
				Rooting initiation (%)	Rooting success (%)	Survival at six months (%)	Rooting initiation (%)	Rooting success (%)	Survival at six months (%)
Control (Non-girdling with no defoliation)	0		CG_1	0.00 ± 0.00 (0.00 ± 0.00)^{i}	0.00 ± 0.00^{g}	0.00 ± 0.00 (0.00 ± 0.00)^{k}	0.00 ± 0.00 (0.00 ± 0.00)^{i}	0.00 ± 0.00^{i}	0.00 ± 0.00 (0.00 ± 0.00)^{f}
Girdling	2	1	CG_2	0.00 ± 0.00 (0.00 ± 0.00)^{i}	0.00 ± 0.00^{g}	0.00 ± 0.00 (0.00 ± 0.00)^{k}	0.00 ± 0.00 (0.00 ± 0.00)^{i}	0.00 ± 0.00^{i}	0.00 ± 0.00 (0.00 ± 0.00)^{f}
Girdling	4	1	CG_3	0.00 ± 0.00 (0.00 ± 0.00)^{i}	0.00 ± 0.00^{g}	0.00 ± 0.00 (0.00 ± 0.00)^{k}	0.00 ± 0.00 (0.00 ± 0.00)^{i}	0.00 ± 0.00^{i}	0.00 ± 0.00 (0.00 ± 0.00)^{f}
Girdling	6	1	CG_4	0.00 ± 0.00 (0.00 ± 0.00)^{i}	0.33 ± 0.08^{g}	0.00 ± 0.00 (0.00 ± 0.00)^{k}	0.00 ± 0.00 (0.00 ± 0.00)^{i}	0.00 ± 0.00^{i}	0.00 ± 0.00 (0.00 ± 0.00)^{f}
Girdling	8	1	CG_5	1.11 ± 0.28 (5.96 ± 0.73)^{g}	0.00 ± 0.00^{g}	0.00 ± 0.00 (0.00 ± 0.00)^{k}	0.00 ± 0.00 (0.00 ± 0.00)^{i}	0.00 ± 0.00^{i}	0.00 ± 0.00 (0.00 ± 0.00)^{f}
Girdling	10	1	CG_6	0.00 ± 0.00 (0.00 ± 0.00)^{i}	0.00 ± 0.00^{g}	0.00 ± 0.00 (0.00 ± 0.00)^{k}	0.00 ± 0.00 (0.00 ± 0.00)^{i}	0.00 ± 0.00^{i}	0.00 ± 0.00 (0.00 ± 0.00)^{f}
Girdling	2	3	CG_7	0.00 ± 0.00 (0.00 ± 0.00)^{i}	0.33 ± 0.17^{g}	0.00 ± 0.00 (0.00 ± 0.00)^{k}	0.00 ± 0.00 (0.00 ± 0.00)^{i}	0.00 ± 0.00^{i}	0.00 ± 0.00 (0.00 ± 0.00)^{f}
Girdling	4	3	CG_8	1.11 ± 0.56 (4.95 ± 2.47)^{gh}	1.33 ± 0.17^{f}	0.00 ± 0.00 (0.00 ± 0.00)^{k}	0.00 ± 0.00 (0.00 ± 0.00)^{i}	0.37 ± 0.03^{h}	0.00 ± 0.00 (0.00 ± 0.00)^{f}
Girdling	6	3	CG_9	4.44 ± 0.56 (12.11 ± 0.80)^{f}	8.67 ± 0.33^{b}	2.17 ± 0.30 (8.42 ± 0.58)^{g}	1.22 ± 0.11 (6.33 ± 0.29)^{h}	1.67 ± 0.08^{e}	0.00 ± 0.00 (0.00 ± 0.00)^{f}
Girdling	8	3	CG_{10}	28.89 ± 1.11 (32.49 ± 0.71)^{b}	2.00 ± 0.29^{e}	8.93 ± 0.35 (17.38 ± 0..35)^{b}	5.55 ± 0.28 (13.62 ± 0.35)^{e}	0.32 ± 0.04^{h}	0.33 ± 0.03 (3.30 ± 0.16)^{d}
Girdling	10	3	CG_{11}	6.67 ± 0.96 (14.88 ± 1.11)^{e}	0.00 ± 0.00^{g}	2.41 ± 0.30 (8.89 ± 0.56)^{g}	1.05 ± 0.15 (5.86 ± 0.41)^{h}	0.00 ± 0.00^{i}	0.00 ± 0.00 (0.00 ± 0.00)^{f}

Table 3: *Effect of girdling and defoliation treatments on rooting success and survival in cuttings of Kusum* (continued)

Treatments	Girdling ring thickness (mm)	Time interval for preparation of Cuttings after girdling (month)	Treatment's symbol	Cuttings from 5-10 years old plantation			Cuttings from 10-20 years old plantation		
Girdling	2	6	CG_{12}	0.00 ± 0.00 $(0.00 \pm 0.00)^{i}$	0.00 ± 0.00^{g}	0.00 ± 0.00 $(0.00 \pm 0.00)^{k}$	0.00 ± 0.00 $(0.00 \pm 0.00)^{i}$	0.00 ± 0.00^{i}	0.00 ± 0.00 $(0.00 \pm 0.00)^{f}$
Girdling	4	6	CG_{13}	0.00 ± 0.00 $(0.00 \pm 0.00)^{i}$	0.00 ± 0.00^{g}	0.00 ± 0.00 $(0.00 \pm 0.00)^{k}$	0.00 ± 0.00 $(0.00 \pm 0.00)^{i}$	0.00 ± 0.00^{i}	0.00 ± 0.00 $(0.00 \pm 0.00)^{f}$
Girdling	6	6	CG_{14}	0.00 ± 0.00 $(0.00 \pm 0.00)^{i}$	1.00 ± 0.00^{f}	0.00 ± 0.00 $(0.00 \pm 0.00)^{k}$	0.00 ± 0.00 $(0.00 \pm 0.00)^{i}$	0.00 ± 0.00^{i}	0.00 ± 0.00 $(0.00 \pm 0.00)^{f}$
Girdling	8	6	CG_{15}	3.33 ± 0.00 $(10.51 \pm 0.00)^{f}$	0.00 ± 0.00^{g}	0.33 ± 0.17 $(2.70 \pm 0.1.35)^{j}$	0.00 ± 0.00 $(0.00 \pm 0.00)^{i}$	0.00 ± 0.00^{i}	0.00 ± 0.00 $(0.00 \pm 0.00)^{f}$
Girdling	10	6	CG_{16}	0.00 ± 0.00 $(0.00 \pm 0.00)^{i}$	0.00 ± 0.00^{g}	0.00 ± 0.00 $(0.00 \pm 0.00)^{k}$	0.00 ± 0.00 $(0.00 \pm 0.00)^{i}$	0.00 ± 0.00^{i}	0.00 ± 0.00 $(0.00 \pm 0.00)^{f}$
Girdling + Defoliation	2	1	CG_{17}	0.00 ± 0.00 $(0.00 \pm 0.00)^{i}$	0.00 ± 0.00^{g}	0.00 ± 0.00 $(0.00 \pm 0.00)^{k}$	0.00 ± 0.00 $(0.00 \pm 0.00)^{i}$	0.00 ± 0.00^{i}	0.00 ± 0.00 $(0.00 \pm 0.00)^{f}$
Girdling + Defoliation	4	1	CG_{18}	0.00 ± 0.00 $(0.00 \pm 0.00)^{i}$	0.33 ± 0.08^{g}	0.00 ± 0.00 $(0.00 \pm 0.00)^{k}$	0.00 ± 0.00 $(0.00 \pm 0.00)^{i}$	0.00 ± 0.00^{i}	0.00 ± 0.00 $(0.00 \pm 0.00)^{f}$
Girdling + Defoliation	6	1	CG_{19}	1.11 ± 0.28 $(5.96 \pm 0.73)^{g}$	1.33 ± 0.17^{f}	0.00 ± 0.00 $(0.00 \pm 0.00)^{k}$	0.00 ± 0.00 $(0.00 \pm 0.00)^{i}$	0.33 ± 0.08^{h}	0.00 ± 0.00 $(0.00 \pm 0.00)^{f}$
Girdling + Defoliation	8	1	CG_{20}	4.44 ± 0.56 $(12.11 \pm 0.80)^{f}$	0.00 ± 0.00^{g}	1.50 ± 0.14 $(7.02 \pm 0.34)^{h}$	1.11 ± 0.28 $(5.96 \pm 0.73)^{h}$	0.00 ± 0.00^{i}	0.00 ± 0.00 $(0.00 \pm 0.00)^{f}$
Girdling + Defoliation	10	1	CG_{21}	0.00 ± 0.00 $(0.00 \pm 0.00)^{i}$	0.00 ± 0.00^{f}	0.00 ± 0.00 $(0.00 \pm 0.00)^{k}$	0.00 ± 0.00 $(0.00 \pm 0.00)^{i}$	0.00 ± 0.00^{i}	0.00 ± 0.00 $(0.00 \pm 0.00)^{f}$
Girdling + Defoliation	2	3	CG_{22}	0.00 ± 0.00 $(0.00 \pm 0.00)^{i}$	3.67 ± 0.17^{d}	0.00 ± 0.00 $(0.00 \pm 0.00)^{k}$	0.00 ± 0.00 $(0.00 \pm 0.00)^{i}$	0.67 ± 0.04^{g}	0.00 ± 0.00 $(0.00 \pm 0.00)^{f}$
Girdling + Defoliation	4	3	CG_{23}	12.22 ± 0.55 $(20.45 \pm 0.48)^{d}$	8.33 ± 0.17^{b}	3.67 ± 0.18 $(11.03 \pm 0.27)^{f}$	2.22 ± 0.15 $(8.56 \pm 0.28)^{g}$	3.00 ± 0.14^{b}	0.00 ± 0.00 $(0.00 \pm 0.00)^{f}$

Table 3: *Effect of girdling and defoliation treatments on rooting success and survival in cuttings of Kusum* (continued)

Treatments	Girdling ring thickness (mm)	Time interval for preparation of Cuttings after girdling (month)	Treatment's symbol	Cuttings from 5-10 years old plantation			Cuttings from 10-20 years old plantation		
Girdling + Defoliation	6	3	CG_{24}	27.78 ± 0.55 (31.79 ± 0.36)^{b}	13.67 ± 0.33^{a}	9.00 ± 0.29 (17.45 ± 0.29)^{b}	10.00 ± 0.48 (18.42 ± 0.42)^{b}	6.00 ± 0.14^{a}	1.33 ± 0.08 (6.22 ± 0.21)^{b}
Girdling + Defoliation	8	3	CG_{25}	45.56 ± 1.11 (42.43 ± 0.64)^{a}	4.00 ± 0.29^{d}	14.32 ± 0.34 (22.22 ± 0.28)^{a}	20.00 ± 0.48 (26.55 ± 0.34)^{a}	2.67 ± 0.08^{c}	6.08 ± 0.07 (14.27 ± 0.10)^{a}
Girdling + Defoliation	10	3	CG_{26}	13.33 ± 0.96 (21.38 ± 0.81)^{d}	0.33 ± 0.08^{g}	4.61 ± 0.20 (12.39 ± 0.27)^{e}	8.89 ± 0.28 (17.34 ± 0.28)^{c}	0.00 ± 0.00^{i}	1.00 ± 0.13 (5.72 ± 0.35)^{c}
Girdling + Defoliation	2	6	CG_{27}	1.11 ± 0.28 (5.96 ± 0.73)^{g}	1.33 ± 0.17^{f}	0.83 ± 0.08 (5.22 ± 0.26)^{i}	0.00 ± 0.00 (0.00 ± 0.00)^{i}	0.67 ± 0.04^{g}	0.00 ± 0.00 (0.00 ± 0.00)^{f}
Girdling + Defoliation	4	6	CG_{28}	4.44 ± 0.56 (12.11 ± 0.80)^{f}	4.00 ± 0.14^{d}	1.33 ± 0.33 (6.53 ± 0.80)^{h}	2.22 ± 0.04 (8.57 ± 0.08)^{g}	1.33 ± 0.08^{f}	0.00 ± 0.00 (0.00 ± 0.00)^{f}
Girdling + Defoliation	6	6	CG_{29}	13.33 ± 0.48 (21.40 ± 0.41)^{d}	5.00 ± 0.14^{c}	6.42 ± 0.30 (14.66 ± 0.35)^{d}	4.45 ± 0.15 (12.17 ± 0.21)^{f}	2.33 ± 0.17^{d}	0.17 ± 0.09 (1.91 ± 1.00)^{e}
Girdling + Defoliation	8	6	CG_{30}	16.67 ± 0.48 (24.08 ± 0.37)^{c}	1.33 ± 0.17^{f}	7.55 ± 0.33 (15.94 ± 0.36)^{c}	7.78 ± 0.29 (16.18 ± 0.31)^{d}	0.00 ± 0.00^{i}	1.00 ± 0.06 (5.73 ± 0.17)^{c}
Girdling + Defoliation	10	6	CG_{31}	4.44 ± 0.56 (12.11 ± 0.80)^{f}	0.00 ± 0.00^{g}	2.40 ± 0.31 (8.87 ± 0.56)^{g}	0.00 ± 0.00 (0.00 ± 0.00)^{i}	0.00 ± 0.00^{i}	0.00 ± 0.00 (0.00 ± 0.00)^{f}
Defoliation	-	-	CG_{32}	0.50 ± 0.29 (3.26 ± 1.70)^{h}	0.00 ± 0.00^{g}	0.00 ± 0.00 (0.00 ± 0.00)^{k}	0.00 ± 0.00 (0.00 ± 0.00)^{i}	0.00 ± 0.00^{i}	0.00 ± 0.00 (0.00 ± 0.00)^{f}
F- ratio				*266.76*	*498.41*	*330.55*	*1040.72*	*505.01*	*262.15*
d.f.				*62*	*62*	*62*	*62*	*62*	*62*
S.E. (± d)				*1.00*	*0.20*	*0.53*	*0.31*	*0.08*	*0.26*
L.S.D. (P ≤ 0.05)				*2.01*	*0.40*	*1.05*	*0.63*	*0.16*	*0.53*
C.V. (%)				*13.34*	*13.84*	*12.96*	*8.81*	*16.45*	*19.26*

Table 2: *Age of mother plant*

Age of plant (Years)	Plant source
<3	Seedling
3 to 5	Seedling
3 to 5	Plantation
5 to 10	Plantation
10 to 15	Plantation
15 to 20	Plantation
20 to 40	Plantation
> 40	Plantation

Influence of Mother Plant Age on Rooting Performance

The cuttings of young shoots of Kusum were collected from different age groups of plants as treatments (Table 2) during March to September every year. The cuttings were planted in the sand bed under poly-tunnel maintaining the temperature as 28 - 30 °C and humidity as 70 – 80 % by manual spraying. The parameters like days at first bud initiation, number of shoots per cutting, number of leaves per cutting, average shoot length (cm), average leaf length (cm), average leaf width (cm), leaf-width ratio, rooting initiation (%), rooting success (%) and survival on Day 90 (%) were recorded.

Post-Transplanting Assessment under Field Conditions

Successfully rooted plants were hardened and transplanted to field conditions. Plant mortality data were recorded at six-month intervals over two consecutive years to assess field establishment success.

Experimental Design and Statistical Analysis

The stem cutting experiments were conducted annually from 2018 to 2021 (upto pre-transplanting/hardening stage) following a uniform experimental protocol, while the field performance of successfully transplanted rooted cuttings was evaluated annually from 2020 to 2024 after transplanting immediately after passing through the hardening/pre-transplanting stage. Prior to statistical analysis, data collected over multiple years were tested for homogeneity of variance. As no significant year × treatment interaction was detected, observations from all years were pooled and analyzed collectively. The pooled mean values are presented in the Results section. The experiments were laid out in a Completely Randomized Design (CRD), with each treatment comprising a minimum of 100 stem cuttings per replication. All quantitative data were subjected to Analysis of Variance (ANOVA) using OPSTAT software (Sheoran et al., 1998) to assess the significance of treatment effects.

Data transformations (arcsine or square root) were performed wherever necessary to meet ANOVA assumptions. However, results are presented in their original scale for ease of interpretation.

RESULTS

Effect of Girdling and Defoliation Treatments on Rooting Success and Survival of Kusum Cuttings

The results of the present investigation clearly demonstrated that both girdling and defoliation treatments had a significant influence on the rooting behaviour and survival of stem cuttings in S. oleosa (Kusum) (Table 3). Among the different treatment combinations tested, the highest rooting performance was observed in cuttings collected from 5–10-year-old mother plants, where branches were girdled three months prior to cutting preparation. In this treatment, a rooting initiation percentage of 45.56 ± 1.11%, rooting success of 13.67 ± 0.33%, and six-month survival rate of 14.32 ± 0.34% were recorded, indicating the superior response of relatively younger mother plants to the applied preconditioning techniques. Similarly, in cuttings collected from 10–20-year-old mother plants, the maximum rooting initiation (20.00 ± 0.48%), rooting success (6.00 ± 0.14%), and survival percentage at six months (6.08 ± 0.07%) were achieved when the branches were subjected to a combination of 8 mm thick girdling ring and defoliation performed seven days prior to cutting collection, followed by a three-month interval before harvesting the cuttings (Fig. 1).

Figure 1: Root growth in cuttings (A & B) of girdled branches and seedlings of less than five years old

Overall, the results revealed a clear synergistic effect of girdling and defoliation on rooting success, which was statistically significant (P ≤ 0.05) compared to the control treatment, where no girdling or defoliation was applied. Furthermore, the findings highlighted the crucial role of the age of the mother plant, with younger trees (5–10 years old) consistently exhibiting better rooting

Table 4: *Effect of age of mother on root growth in cuttings of Kusum*

Age of plant (Years)	Cutting source	Rooting initiation (%)	Rooting success (%)	Survival on Day 90 (%)
<3	Seedling	53.00 ± 1.41 (46.70 ± 0.81)[a]	50.25 ± 1.11 (45.13 ± 0.64)[a]	48.50 ± 2.40 (44.12 ± 1.38)[a]
3 to 5	Seedling	41.25 ± 1.65 (39.94 ± 0.96)[b]	38.50 ± 1.44 (38.33 ± 0.85)[b]	39.75 ± 1.80 (39.06 ± 1.06)[b]
3 to 5	Plantation	33.50 ± 1.85 (35.33 ± 1.13)[c]	9.00 ± 0.41 (17.44 ± 0.41)[c]	9.75 ± 0.85 (18.14 ± 0.82)[c]
5 to 10	Plantation	24.25 ± 1.55 (29.45 ± 1.05)[d]	0.50 ± 0.20 (3.46 ± 1.22)[d]	0.50 ± 0.29 (2.87 ± 1.66)[d]
10 to 15	Plantation	13.00 ± 0.91 (21.09 ± 0.78)[e]	0.00 ± 0.00 (0.00 ± 0.00)[e]	0.00 ± 0.00 (0.00 ± 0.00)[e]
15 to 20	Plantation	4.00 ± 0.41 (11.49 ± 0.60)[f]	0.00 ± 0.00 (0.00 ± 0.00)[e]	0.00 ± 0.00 (0.00 ± 0.00)[e]
20 to 40	Plantation	0.25 ± 0.24 (1.43 ± 1.40)[g]	0.00 ± 0.00 (0.00 ± 0.00)[e]	0.00 ± 0.00 (0.00 ± 0.00)[e]
> 40	Plantation	0.00 ± 0.00 (0.00 ± 0.00)[g]	0.00 ± 0.00[e] (0.00 ± 0.00)[e]	0.00 ± 0.00 (0.00 ± 0.00)[e]
F- ratio		*345.84*	*1149.35*	*492.76*
d.f.		*21*	*21*	*21*
S.E. (± d)		*1.34*	*0.78*	*1.19*
L.S.D. (P ≤ 0.05)		*2.81*	*1.64*	*2.50*
C.V. (%)		*8.17*	*8.48*	*12.95*

performance than older trees (10–20 years old) under similar treatment conditions. These results provide empirical evidence supporting the hypothesis that pre-conditioning techniques such as girdling and defoliation enhance rooting potential in Kusum cuttings, and their effect is strongly influenced by the physiological maturity of the donor plant

Effect of age of mother plant on root growth in cuttings of Kusum

The results of root growth *i.e.,* rooting initiation (%), rooting success (%) and survival on day 90 (%) in cuttings (Table 4;) revealed that there were significant (*P ≤ 0.05*) effect of age of mother plant on root growth in cuttings of Kusum. As the age of the mother plant increased, there was gradual decrease in the per cent rooting initiation (depicting specific correlation co-efficient, R^2 = 0.956), rooting success (depicting R^2 = 0.866) (Fig 4) and thereby decrease in survival of the cuttings on day 90 (depicting R^2 = 0.860) (Fig.5). The maximum rooting initiation (53.00 ± 1.41 %), rooting success (50.25 ± 1.11 %) and survival on day 90 (48.50 ± 2.40 %) were observed in the cuttings which were prepared from seedlings of 40 years old.

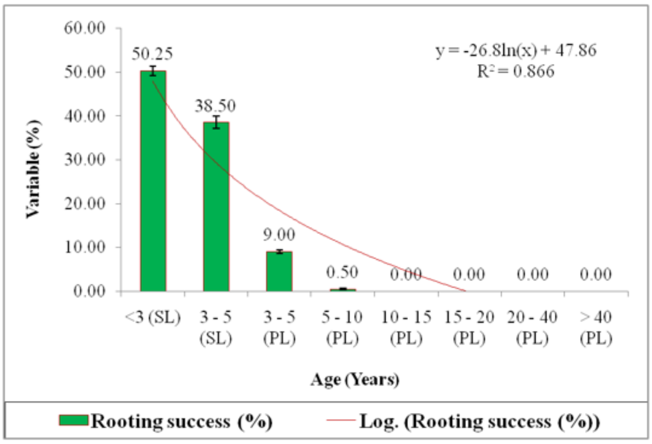

Figure 4: Correlation between age of mother plant and rooting success

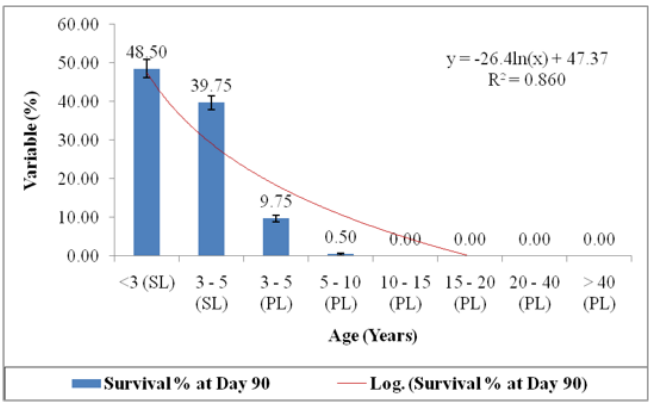

Figure 5: Correlation between age of mother plant and per cent survival on Day 90

Subsection Post-Transplanting Assessment under Field Conditions

The post-transplanting evaluation of successfully rooted Schleichera oleosa (Kusum) cuttings indicated excellent field establishment across all treatment groups. The hardened plants, which were raised under controlled nursery conditions, were transplanted to field sites following standard hardening protocols. Plant survival was monitored at six-month intervals over a period of two consecutive years to assess the field performance and mortality, if any. Remarkably, the results revealed zero plant mortality in all treated groups during the entire observation period under field conditions. This indicates that the plants developed through the standardized cutting techniques, including girdling and defoliation treatments, not only exhibited successful rooting but also demonstrated strong establishment potential and high survivability after transplantation to open field conditions.

DISCUSSION

Effect of girdling and defoliation treatments on rooting in cuttings of Kusum

Girdling has been effective in increasing the rooting of cuttings (Stoltz and Hess, 1966). Hartmann and Kester (1975) reported that, the rooting initiation in cuttings can be increased by girdling the stems that blocks the downward movement of carbohydrates and many root promoting factors. Total starch, total sugar, and rooting cofactor of Hibiscus tissue get increased above the girdle part (Stoltz and Hess, 1966). Moreover, girdling stimulates cell division, helps in production of root primordia and facilitates greater absorption of water and the applied growth hormones (Hartmann and Kester, 1975).

The result of the present investigation revealed that there was a synergistic effect of both girdling and defoliation treatments on rooting success in cuttings of Kusum when compared with control (*i.e.,* non-girdling treatment with no defoliation). The maximum rooting initiation (45.56 ± 1.11 %), rooting success (13.67 ± 0.33 %) and per cent survival at six months (14.32 ± 0.34 %) were observed in the cuttings prepared from 5 - 10 years old plantations after three months of Girdling (ring thickness of 8 mm) + Defoliation (7 days prior to preparation of cuttings) treatment when compared with the cuttings prepared from 10-20 years old. Similar results in regards to girdling effect were also reported by Basu *et al.* (1972) in Mango, Hare (1978) in 12 to 14 years old *Pinus elliottii* var. *elliollii* Engelm., Biswas (1986) in Jackfruit, Mani *et al.* (2018) in Litchi and Kumar *et al.* (2018) in *Acer acuminatum.* The effects of defoliation on growth of cuttings were reported by Brundell (1975) while propagating Chinese gooseberry (*Actinidia chinensis*) and by Ferriani and Krinski (2019) while propagating monkey-pepper (*Piper aduncum*). Moreover, the pre-conditioning treatments *viz.,* girdling, blanching and etiolation of branches or stems help to induce roots in some difficult to root plants including fruit species (Singh, 2018).

Data is shown as mean values of variables ± SE. The figures in parentheses are arcsine transformed values which were compared based on its derived *F- ratio, d.f., S.E. (± d), L.S.D. (P ≤ 0.05)* and *C.V. (%)* as mentioned in its corresponding column. Means in a column followed by different superscript letters are significantly (*P ≤ 0.05*) different using DMR test.Fig 2 (Fig 3)

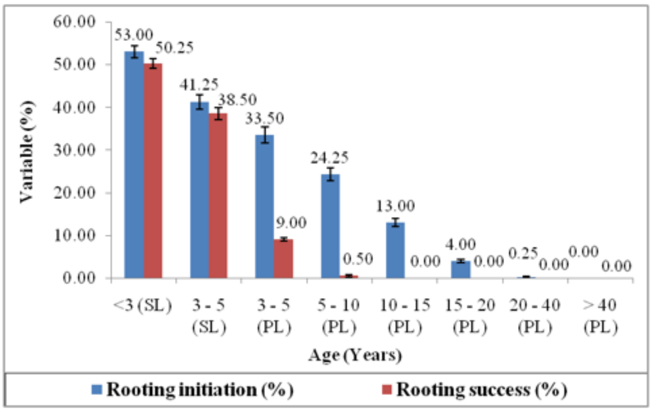

Figure 2: Effect of age of mother plant on rooting initiation and rooting success in cuttings of Kusum

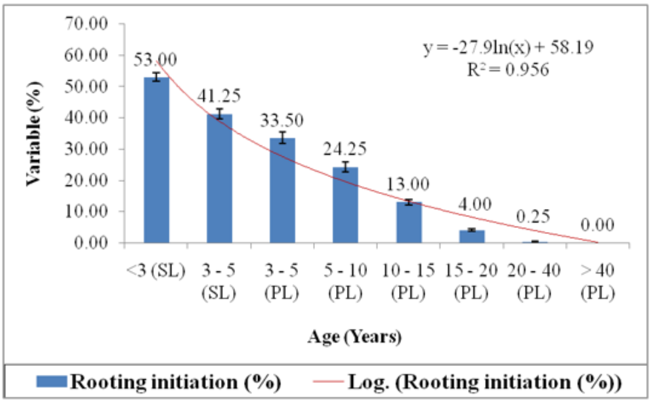

Figure 3: Correlation between age of mother plant and rooting initiation

Effect of age of mother plant on root growth in cuttings

The most critical factor affecting shoot and root growth in cuttings of Kusum was found to be the age of the plant or trees from where cuttings were prepared. The

DOI: https://doi.org/10.48165/ija.2026.28.02.11

perusal of present study evinced that there was a significant effect of age of source plant on root growth in cuttings of Kusum. The maximum rooting initiation (53.00 ± 1.41 %), rooting success (50.25 ± 1.11 %) and survival on day 90 (48.50 ± 2.40 %) were observed in the cuttings which were prepared from seedlings of 20 years old. These results are in consistent with many previous studies showing that cuttings derived from juvenile stock-plants are easier to root than those derived from mature stock-plants (Browne *et al.,* 1997; Berhe and Negash, 1998; Bhardwaj and Mishra, 2005; Amri *et al.,* 2010). The superior rooting ability of cuttings from seedlings over that of trees has been attributed to the effect of changes in the woody plant developmental process that occur with increasing age (Ky-Dembele *et al.,* 2011). The rooting potential of juvenile cuttings might be due to the availability of optimum levels of total carbohydrate and total sugar content, but low nitrogen level (Bhardwaj and Mishra, 2005); whereas, the reduction in rooting ability in cuttings from the stem of mature donors might be due to a decrease in the endogenous auxins content or an accumulation of inhibitory substances (Hartmann *et al.,* 2002). According to Luna (2008) in the coastal redwood (*Sequoia sempervirens)*, rooting percentages improves when young seedlings are the source of donor wood. Similar results were also reported by Bhatt and Todaria (1993) where young branch sections of *Bauhinia retusa* showed better rooting response than older branch sections. In Jack pine trees, Browne *et al.* (1996) had reported rooting frequency range of 45 to 75 % in 4 to 10 years old Jack as compared to 28 % in 30 year old trees. The investigations on Jack Pine have shown that there was a transitional period of decline in rooting capacity of central axis cuttings at 4 to 6 years of age (Browne *et al.,* 1997)

Data is shown as mean values of variables ± SE. The figures in parentheses are arcsine transformed values which were compared based on its derived *F- ratio, d.f., S.E. (± d), L.S.D. (P ≤ 0.05)* and *C.V. (%)* as mentioned in its corresponding column. Means in a column followed by different superscript letters are significantly (*P ≤ 0.05*) different using DMR test.

CONCLUSION

The present investigation conclusively demonstrated that the rooting success of *Schleichera oleosa* stem cuttings can be significantly enhanced through the application of girdling and defoliation techniques, particularly when combined with strategic selection of juvenile donor plants. Girdling effectively increased carbohydrate and rooting cofactor accumulation, while defoliation reduced water loss and improved cutting performance. The results established that cuttings from 5-10 years old trees subjected to girdling and defoliation yielded higher rooting success than those from older plantations. Notably, the best rooting performance was recorded in cuttings obtained from seedlings less than three years old, reaffirming the superior rooting potential of juvenile donor material. Furthermore, post-transplanting assessments confirmed excellent field establishment and zero mortality of rooted cuttings, underscoring the practical viability of the optimized propagation protocol. These findings offer a reliable, low-cost strategy for large-scale multiplication of Kusum, supporting both ecological restoration and livelihood enhancement in lac-growing regions

Acknowledgements

The authors express their heartfelt gratitude to the Director, Institute of Forest Productivity, Ranchi, for the consistent support, technical guidance, and research facilities that greatly contributed to the successful completion of this study. We are equally grateful to the Director, ICAR Research Complex for Eastern Region, Patna, for their kind cooperation and encouragement, which played a vital role in facilitating various aspects of the research. The assistance and efforts of the technical staff at both institutes are gratefully acknowledged

DECLARATION OF COMPETING INTEREST

The authors report no competing interest

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How to Cite this Article: Kumar Sarkar P., Sinha A., Sarkar A., Banerjee S., Kumar Dhakar M., Das B., Bhatt B.P.. (2026). Enhancing Stem Cutting Success in Kusum (*Schleichera Oleosa*) Through Girdling, Defoliation, and Donor Age Selection: A Propagation Breakthrough. *Indian Journal of Agroforestry*, ***28***(2), 89-101. https://doi.org/10.48165/ija.2026.28.02.11