Standardization of protocols for plant growth~~ing~~ media and seasons for cuttings of Kusum [*Schleichera oleosa* (Lour.) Oken]~~: A major challenge~~

ABSTRACT

Growing cuttings of Kusum (*Schleichera oleosa*), is a major hurdle for the Lac growers in India. This species is primarily known as the lac host tree for lac production besides other multiple uses. Due to high population pressure and market demand, the natural population and genetic diversity of this species is declining day-by-day. Maintaining the selected best germplasm through clonal propagation is the need of the hour. Mass multiplication through cuttings could only be the right choice of the grower if found successful. But, no successful cuttings of Kusum have been reported till date. Therefore, an experiment was carried out during 2018-21 following Completely Randomized Design (CRD) to standardize the plant growth~~ing~~ media and the seasons for growing cuttings at the very initial stages of the experiment. The result revealed that the root, shoot and leaf growths in cuttings of Kusum are significantly influenced by the different plant growth~~ing~~ media. The maximum rooting initiation (43.33±0.96%) was observed in the cuttings grown in media of Coco peat : FYM : Vermicompost (2:2:1). The maximum rooting (44.50±1.85 %) in the cuttings prepared from seedlings of less than 5 years old and 33.75 ± 1.49 % rooting in the cuttings prepared from 10-20 years old plantation, were recorded in the month of May. Based on the present investigation, it is concluded that the plant growing media having the composition of Coco peat : FYM : Vermicompost (2:2:1) is more appropriate and recommended for growing cuttings of Kusum. Moreover, the month of May is highly recommended for growing cuttings of Kusum for maximum success. Regarding selection of mother plant, it is advised to select the Kusum plant from the plantation aged less than five years old.

Key words: Kusum; *Schleichera oleosa*; clonal propagation; vegetative propagation; cuttings; plant growing media; season

INTRODUCTION

In India, the species *Schleichera oleosa* (Lour.) Oken (syn., *Pistacia oleosa* Lour., *S. trijuga* Willd., *Cussambium oleosum* Kuntze), belongs to the family Sapindaceae, locally known as Kusum, is primarily known as the lac host tree for lac production, which is also known to be exploited for multiple uses including ethnobotanical purpose (Guleria and Vaidya, 2015; Goswami and Singh, 2017; Sarkar *et al.*, 2017a). Growing cuttings of Kusum, is a major hurdle for the Lac growers in India. The natural population and genetic diversity of this species is declining day-by-day due to high population pressure, industrialization, modernization and market demand (Sarkar *et al.*, 2017b). Conservation of such demanding species and also for maintaining the selected best germplasm through clonal propagation is the need of the hour.

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Mass production of seedlings of this species is a major challenge as it is a cross pollinated species that leads to heterozygosity in the plants (Radhamani *et al.,* 2003). Genetic improvement through this auto-generated heterozygous plants may call for long term experiments and may require high monetary investments.

Mass multiplication through the most common method like cuttings could only be the most alternative, reliable and quicker approaches for the lac growers if found successful. Bhatt and Todaria (1990a & b), Chauhan *et al.* (1993) and Chauhan *et al.* (1997) reported that, different concentration of auxins and seasonal variation play a crucial role in root initiation in branch cuttings of different woody species. Moreover, the level of organic matter content, water holding capacity (Sabir *et al.,* 2004) and the level of nitrogen and potassium in rooting media (Sengel *et al.,* 2012) effect the growth of cuttings. Palanisamy and Kumar (1997) reported that exogenously applied auxins are sensitive to activate the cambium probably in the active period of cambium resulting significant root formation. Smith and Wareing (1972) stated that the endogeneous IAA, photoperiod and temperature apparent to control the vascular tissue more particularly the cambial activity.

The growing media is generally considered to be one of the vital inputs for rooting initiation (Dolor *et al.,* 2009). Rooting media should be selected on the basis of criteria, *i.e.*, availability and cost of rooting media components (Hartmann *et al.,* 2007). Peat moss is now a commonly used media, due to its properties of homogeneity and quality added to media, but an expensive media too (Abdel-Mohsen, 2015). Many literatures revealed that, growing media has an important role on success of cuttings and thereby influences the survival, shooting, rooting and other growth characteristics of any plant (Aamir *et al.,* 2019). Shah *et al.* (2013) suggested sawdust as an important growing media for quicker sprouting in the cuttings of *Ficus binnendijkii*. Experiment on effect of different media of cuttings on rooting of guava (*Psidium guajava* L.) revealed that soil loam and sawdust, except for shoot number and root diameter, had the lowest positive effect on guava rooting (Sardoei, 2014). In another experiment, carried out by Mabizela *et al.* (2017) revealed that the maximum rooting and survival percentage, root number and root length in the cuttings of honeybush (*Cyclopia subternata*) was due to the treatments of bark mix and 3mix as rooting media and Seradix B2 and Seradix B3 as plant growth regulators.

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Though there are ample successful methods of growing cuttings in other woody species available, but no successful cuttings have been reported so far in this Kusum tree. The problem

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of rooting in cuttings might be due to various internal and external factors like type of rooting substrate or plant growing media, growth regulator treatments, age of the source plant, pre-treatments and the season during which the cuttings are collected (Hartmann *et al.*, 2002; Soundy *et al.*, 2008). Considering the above all facts, an experiment was conducted to standardize the plant growing media and the seasons for growing cuttings of Kusum at the very initial stages of the experimental investigation.

2. Methodology

The experiment was conducted 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 study area comes under dry and humid tropical climate, received a maximum average rainfall of 401.95 mm during the month of August with a mean monthly highest temperature ranged from 24.0 °C in January to 37.5 °C in May and the average monthly lowest temperature ranged from 7.4 °C in January to 27.6 °C in May. The relative humidity of the experimental area increased with the South-west monsoon's onset and it became more than 80% in July. The relative humidity was lowest during summer (*i.e.*, < 50%).

2.1. Vegetative propagation through cuttings

The cuttings were collected throughout the year (during each month) from the available trees and from selected candidate plus trees (CPTs) of Institute of IFP, Ranchi and ICAR Indian Institute of Natural Resins and Gums (IINRG), Namkum, Ranchi during March, 2018 to August, 2021. The defoliation of shoots was carried out at least seven days before the collection of cuttings. The cuttings about 6-12 cm length and 0.5 – 2.5 cm in diameter having 2-3 buds were collected by using sharp Secateurs. The cuttings were then washed in 0.2% bavistin solution prior to hormonal treatment [dipped in 0.1 % Ascorbic Acid for 1 hour followed by IBA (2000 ppm) + 5 % Sucrose for 1 hour] to prevent attack of pathogens.

The cuttings were planted either in the hycopots or root trainers filled with rooting medium (sand) or in sand bed immediately after treatment with different plant growth hormones. 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

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(CRD). The planted cuttings were irrigated and weeded as and 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:

2.1.1. Standardization of plant growing media

The plant growing media was standardized using the comparative test of plant growth performance based on the:

(i) effect of different plant growing media on shoots and leaf growth in cuttings of Kusum, and

(ii) effect of different plant growing media on root growth and survival of cuttings of Kusum

The treatments details are given in Table 1. A total of 8 treatments with three replications consisting of 100 cuttings per replication per treatment following Completely Randomized Design (CRD) were considered. 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 length-width ratio, rooting initiation (%), number of secondary roots per cutting, root spread (cm), total root length (cm) and plant survival period (in days) were recorded.

Table 1: Different proportion of plant growing media

Treatment details	Treatment code
Soil : Sand : FYM (1:1:1)	T_1
Soil : Sand : Vermicompost (2:2:1)	T_2
Soil : Sand : FYM : Vermicompost (4:4:2:1)	T_3
Coco peat : Vermicompost (8:1)	T_4
Coco peat : FYM : Vermicompost (2:2:1)	T_5
Sand	T_6
Coco peat	T_7
Sand : Soilrite (2:1)	T_8

2.1.2 Seasons of growing cuttings

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The cuttings of young shoots of Kusum were collected during each month from seedlings of less than 5 years old as well as plantations of 10-20 years old and 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 rooting initiation (%), rooting success (%) and survival (%) were recorded. A total of 12 treatments with three replications consisting of 30 cuttings per replication per treatment following Completely Randomized Design (CRD) were considered.

2.2. Data analysis

The data were subjected to analysis of variance (ANOVA) to quantify the differences among applied treatments by using OPSTAT software (Sheoran *et al.,* 1998). Data transformation was also carried out as and when required to satisfy the ANOVA requirements. The data that have been transformed were expressed in original units for presentation in the Tables. Treatment means were compared from the estimated values of least significant difference (L.S.D) at 5 per cent level of significance for the error degree of freedom and coefficient of variation between different treatments was also calculated. Moreover, the Duncan's Multiple Range (DMR) Test was also done to compare larger pairs of means.

3. Results and Discussion

The results have been explained under the following sub-heads:

3.1. Effect of different plant growing media on shoots and leaf growth in cuttings of Kusum

Data in Table 2 evinced that the shoots and leaf growth in cuttings of Kusum are significantly ($P \leq 0.05$) influenced by the different plant growing media (Fig. 1 & 2). The maximum day required for first bud initiation (7.33 ± 0.34) was observed in the cuttings grown in Coco peat : Vermicompost (8:1) media, whereas the minimum as 3.33 ± 0.28 and 3.33 ± 0.29 were observed under the plant growing media of Coco peat and Sand : Soilrite (2:1), respectively. The number of shoots per cutting ranged from 1.13 ± 0.13 to 1.86 ± 0.11. The maximum number of shoots (1.86 ± 0.11) was observed in the plant growing media of Soil : Sand : Vermicompost (2:2:1), whereas the minimum (1.13 ± 0.13) was recorded in case of the cuttings grown in Coco peat media. Similarly, the number of leaves per cutting was recorded maximum as 5.08 ± 0.11 in case of cuttings grown in Coco peat : FYM : Vermicompost (2:2:1) media and the minimum as 2.45 ± 0.24 was recorded in the cuttings grown in Soil : Sand :

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FYM (1:1:1). The maximum average shoot length (12.35 ± 0.88 cm) value was observed in the cuttings grown in Coco peat : FYM : Vermicompost (2:2:1) media, whereas the minimum average shoot length (3.42 ± 0.30 cm) value was recorded in the cuttings grown in Soil : Sand : FYM (1:1:1) media. Similarly, the maximum average leaf length (11.33 ± 0.18 cm) was recorded in the cuttings grown in Coco peat : FYM : Vermicompost (2:2:1) media, whereas the minimum average leaf length (3.67 ± 0.19 cm) was observed in the cuttings grown in Soil : Sand : FYM (1:1:1). In case of average leaf width, the maximum (5.63 ± 0.16 cm) was recorded in the cuttings grown in Coco peat : FYM : Vermicompost (2:2:1) media, but the minimum (1.96 ± 0.03 cm) was recorded in the cuttings grown in Soil : Sand : FYM (1:1:1) media. Data further revealed that, the leaf width ratio was found to be maximum as 2.21 ± 0.01 in the cuttings grown in Coco peat media, whereas the minimum as 1.55 ± 0.10 in case of the cuttings grown in Soil : Sand : Vermicompost (2:2:1). Similar findings in regards to the effect and influence of plant growing media on shoot and leaf growth of other woody plants were also being reported by Aamir *et al.* (2019). The influence of different plant growing media on growth of cuttings might be due to the level of organic matter content, water holding capacity (Sabir *et al.,* 2004) and the level of nitrogen and potassium in rooting media (Sengel *et al.,* 2012). Earliness in sprouting and increase in number of sprouts may be due to better utilization of stored carbohydrates, nitrogen and other factors with the help of growth regulators (Wright, 1975; Chandramouli, 2001; Sahoo *et. al*., 2014). While propagating *Cordia africana* species through cuttings, Ambebe *et al.* (2018) suggested the plant growing media as sand and sawdust: sand (1:1) as the best suitable alternative for getting maximum spouting and growth of cuttings.

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Table 2: Effect of different plant growing media on shoots and leaf growth in cuttings of Kusum

Plant growing media	Days at first bud initiation	No. of shoots per cutting	No. of leaves per cutting	Average shoot length (cm)	Average leaf length (cm)	Average leaf width (cm)	Leaf length width ratio
Soil : Sand : FYM (1:1:1)	6.00 ± 0.58^{b}	1.17 ± 0.11^{b}	2.45 ± 0.24^{c}	3.42 ± 0.30^{c}	3.67 ± 0.19^{g}	1.96 ± 0.03^{f}	1.87 ± 0.07^{b}
Soil : Sand : Vermicompost (2:2:1)	6.00 ± 0.01^{b}	1.86 ± 0.11^{a}	4.64 ± 0.32^{a}	5.52 ± 0.29^{b}	4.73 ± 0.43^{f}	3.04 ± 0.10^{d}	1.55 ± 0.10^{c}
Soil : Sand : FYM : Vermicompost (4:4:2:1)	5.33 ± 0.33^{bc}	1.29 ± 0.13^{b}	2.76 ± 0.14^{bc}	5.60 ± 0.30^{b}	6.06 ± 0.17^{d}	3.64 ± 0.17^{c}	1.67 ± 0.04^{c}
Coco peat : Vermicompost (8:1)	7.33 ± 0.34^{a}	1.33 ± 0.08^{b}	2.67 ± 0.20^{c}	4.22 ± 0.42^{c}	5.44 ± 0.30^{e}	2.85 ± 0.11^{e}	1.91 ± 0.04^{b}
Coco peat : FYM : Vermicompost (2:2:1)	3.67 ± 0.33^{d}	1.85 ± 0.10^{a}	5.08 ± 0.11^{a}	12.35 ± 0.88^{a}	11.33 ± 0.18^{a}	5.63 ± 0.16^{a}	2.01 ± 0.02^{b}
Sand	4.33 ± 0.32^{cd}	1.67 ± 0.07^{a}	3.33 ± 0.17^{b}	5.98 ± 0.19^{b}	8.35 ± 0.32^{b}	4.28 ± 0.12^{b}	1.95 ± 0.03^{b}
Coco peat	3.33 ± 0.28^{d}	1.13 ± 0.13^{b}	2.50 ± 0.10^{c}	5.67 ± 0.17^{b}	6.89 ± 0.06^{c}	3.12 ± 0.03^{d}	2.21 ± 0.01^{a}
Sand : Soilrite (2:1)	3.33 ± 0.29^{d}	1.22 ± 0.07^{b}	2.82 ± 0.09^{bc}	6.65 ± 0.19^{b}	6.91 ± 0.07^{c}	3.56 ± 0.06^{c}	1.94 ± 0.02^{b}
F- ratio	***18.64***	***7.57***	***29.33***	***40.20***	***276.41***	***396.11***	***21.43***
d.f.	***14***	***14***	***14***	***14***	***14***	***14***	***14***
S.E. (± d)	***0.48***	***0.16***	***0.27***	***0.60***	***0.20***	***0.08***	***0.06***
L.S.D. ($P \leq 0.05$)	***1.05***	***0.34***	***0.58***	***1.30***	***0.44***	***0.17***	***0.13***
C.V. (%)	***12.05***	***13.25***	***9.92***	***11.92***	***3.70***	***2.71***	***4.01***

Data is shown as mean values of variables ± SE. The Means in a column followed by different superscript letters are significantly ($P \leq 0.05$) different using Duncan's multiple range test (DMRT).

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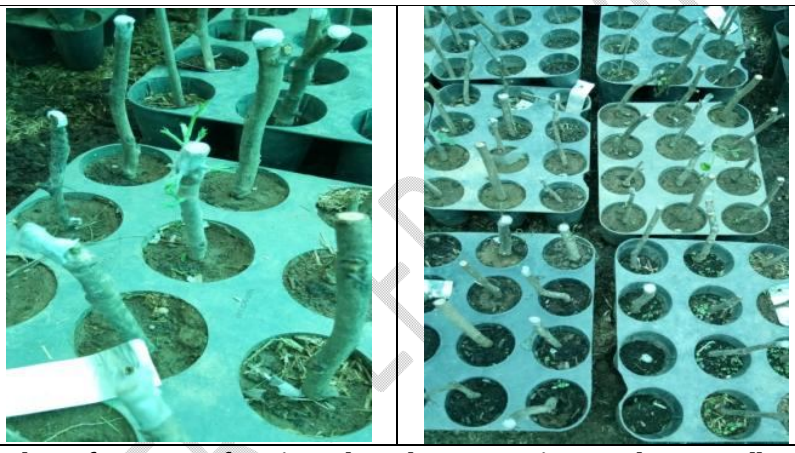
a. **Performances of cuttings planted on sand bed under shade-net**



b. Performances of cuttings planted on root trainers under manually operated mist chamber

c. Performances of cuttings planted on sand bed under closed poly-tunnel

Fig. 1: Growth performances of cuttings (a – c)

a. Shoot initiation on cuttings under different plant growing media

b. Rooting in cuttings of Kusum

Fig. 2: Shoot and root growth performances of cuttings (a & b)

3.2. Effect of different plant growing media on root growth in cuttings of Kusum

The root growth in cuttings of Kusum was influenced significantly by different plant growing media (Table 3, Fig. 2). The maximum rooting initiation (43.33 ± 0.96 %) was observed in the cuttings grown in media of Coco peat : FYM : Vermicompost (2:2:1), whereas no root initiation was observed in the cuttings grown in Soil : Sand : FYM (1:1:1) media. The number of secondary roots per plant ranged from 0 to 4.67 ± 0.31. The maximum number of secondary roots (4.67 ± 0.31) was observed in the plant growing media of Coco peat : FYM : Vermicompost (2:2:1), whereas no secondary roots were observed in case of the cuttings grown in Soil : Sand : FYM (1:1:1) media. In case of root spread, the maximum as 2.82 ± 0.07 cm was recorded in the cuttings grown in Coco peat : FYM : Vermicompost (2:2:1) media, followed by 2.22 ± 0.07 cm in case of cuttings grown in sand media. The total root length was found to be maximum as 10.45 ± 0.46 cm in the cuttings grown in Coco peat : FYM : Vermicompost (2:2:1) media, followed by 10.21 ± 0.25 cm in Sand media and 6.14 ± 0.46 cm in the Coco peat media. The plant survival period was also recorded and found to be varied significantly in all the plant growing media. The maximum plant survival period (90.00 ± 6.08 days) was recorded in the cuttings grown in Coco peat : FYM : Vermicompost (2:2:1) media, whereas the minimum plant survival period (42.33 ± 1.45 days) was recorded in the cuttings grown in Soil : Sand : FYM (1:1:1) media. Similar findings in regards to the effect and influence of plant growing media on root growth and survival of any plant were also being reported by Ambebe *et al*. (2018) and Aamir *et al.* (2019). Sardoei (2014) also had reported the highest rooting success in Guava when grown in sand. Similarly, the combination of plant growing media like garden soil, sand, FYM and peat moss, was reported as the best in terms of survival and rooting of cuttings in Olive trees (Aamir *et al*., 2019).

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Table 3: Effect of different plant growing media on root growth in cuttings of Kusum

Plant growing media	Rooting initiation* (%)	No. of secondary roots per cutting	Root spread (cm)	Total root length (cm)	Plant survival period (in day)
Soil : Sand : FYM (1:1:1)	0.00 ± 0.00 (0.00 ± 0.00)^{f}	0.00 ± 0.00^{e}	0.00 ± 0.00^{f}	0.00 ± 0.00^{e}	42.33 ± 1.45^{e}
Soil : Sand : Vermicompost (2:2:1)	3.33 ± 0.38 (10.48 ± 0.62)^{e}	1.67 ± 0.33^{d}	1.33 ± 0.06^{e}	2.39 ± 0.54^{d}	47.33 ± 3.18^{de}
Soil : Sand : FYM : Vermicompost (4:4:2:1)	10.00 ± 0.77 (18.40 ± 0.74)^{d}	2.67 ± 0.32^{bc}	1.61 ± 0.03^{d}	4.53 ± 0.5^{c}	55.33 ± 2.03^{cd}
Coco peat : Vermicompost (8:1)	3.33 ± 0.19 (10.51 ± 0.31)^{e}	2.33 ± 0.33^{cd}	1.81 ± 0.06^{c}	4.48 ± 0.13^{c}	63.00 ± 4.04^{bc}
Coco peat : FYM : Vermicompost (2:2:1)	43.33 ± 0.96 (41.15 ± 0.56)^{a}	4.67 ± 0.31^{a}	2.82 ± 0.07^{a}	10.45 ± 0.46^{a}	90.00 ± 6.08^{a}
Sand	16.67 ± 1.02 (24.07 ± 0.78)^{c}	4.33 ± 0.30^{a}	2.22 ± 0.07^{b}	10.21 ± 0.25^{a}	71.33 ± 2.03^{b}
Coco peat	20.00 ± 1.02 (26.54 ± 0.74)^{b}	3.33 ± 0.29^{b}	1.75 ± 0.07^{cd}	6.14 ± 0.46^{b}	58.00 ± 3.22^{cd}
Sand : Soilrite (2:1)	20.00 ± 1.73 (26.51 ± 1.24)^{b}	2.33 ± 0.33^{cd}	1.67 ± 0.05^{cd}	4.10 ± 0.46^{c}	50.67 ± 1.45^{de}
F- ratio	***328.31***	***26.05***	***197.36***	***99.59***	***19.74***
d.f.	***14***	***14***	***14***	***14***	***14***
S.E. (± d)	***0.99***	***0.41***	***0.08***	***0.51***	***4.85***
L.S.D. ($P \leq 0.05$)	***2.15***	***0.90***	***0.18***	***1.10***	***10.49***
C.V. (%)	***6.17***	***18.97***	***6.02***	***11.81***	***9.93***

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. ($P \leq 0.05$)* and *C.V. (%)* as mentioned in its corresponding column. Means in a column followed by different superscript letters are significantly ($P \leq 0.05$) different using DMR test.

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3.3. Seasonal effect on rooting success and per cent survival in cuttings

A perusal of data presented in Table 4 revealed that there were significant ($P \leq 0.05$) effects of different seasons or months on rooting success in the cuttings prepared from less than 5 years old trees. Season in which cuttings are taken, can also effect the rooting of stem cuttings (Mabizela *et al.*, 2017). In the present investigation, there was significant effect of different seasons on per cent rooting success in the cuttings in Kusum. The maximum rooting initiation (48.50 ± 2.10 %) and rooting success (44.50 ± 1.85 %) in the cuttings prepared from seedlings of less than 5 years old and 10 - 20 years old Kusum plantation were recorded in the month of May. Similar effect was also reported by Bhatt and Todaria (1990a & b), Chauhan *et al.* (1993), Chauhan *et al*. (1997), Agbo and Obi (2008) and Khosla and Pant (2009) who stated that, different concentration of auxins and seasonal variation play a crucial role in root initiation in branch cuttings of different woody species. Naveen (2002) also reported a better sprouting and rooting success in *Hippophae rhamnoides* when planted in August than in March. Shamet and Naveen (2005) suggested rainy season (July - August) as the best time for maximum cutting success in *Celtis australis*. But, spring season (March – April) was the best time for the cuttings of *Acer acuminatum* to obtain maximum rooting success (Kumar *et al.*, 2018).

Table 4: Effect of different seasons on rooting success and survival in cuttings of Kusum

Months	Cuttings from seedlings of less than 5 years old		Cuttings from 10-20 years old plantation	
	Rooting initiation (%)	Survival (%)	Rooting initiation (%)	Survival (%)
January	2.00 ± 0.71 (7.02 ± 2.38)^{g}	1.00 ± 0.41 (4.90 ± 1.73)^{gh}	0.50 ± 0.29 (2.87 ± 1.66)^{f}	Nil
February	5.50 ± 0.65 (13.49 ± 0.82)^{f}	4.00 ± 0.41 (11.49 ± 0.60)^{f}	3.50 ± 0.29 (10.75 ± 0.45)^{e}	
March	22.75 ± 1.38 (28.45 ± 0.94)^{d}	20.00 ± 0.71 (26.54 ± 0.51)^{d}	14.75 ± 0.48 (22.57 ± 0.39)^{d}	
April	30.00 ± 1.47 (33.18 ± 0.92)^{c}	27.50 ± 1.44 (31.59 ± 0.93)^{c}	28.25 ± 1.25 (32.08 ± 0.80)^{b}	
May	48.50 ± 2.10 (44.12 ± 1.21)^{a}	44.50 ± 1.85 (41.82 ± 1.07)^{a}	33.75 ± 1.49 (35.49 ± 0.91)^{a}	
June	40.25 ± 1.70 (39.35 ± 0.99)^{b}	32.75 ± 1.93 (34.87 ± 1.18)^{b}	31.50 ± 1.32 (34.12 ± 0.81)^{ab}	
July	37.50 ± 2.10	30.75 ± 1.65	23.00 ± 0.91	

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	(37.73 ± 1.25)^{b}	(33.64 ± 1.03)^{bc}	(28.63 ± 0.62)^{c}	
August	18.75 ± 1.38 (25.61 ± 1.01)^{d}	13.00 ± 0.71 (21.11 ± 0.59)^{e}	13.25 ± 0.85 (21.31 ± 0.73)^{d}	
September	9.75 ± 0.85 (18.14 ± 0.82)^{e}	6.25 ± 0.48 (14.44 ± 0.58)^{f}	4.50 ± 0.29 (12.22 ± 0.40)^{e}	
October	3.50 ± 0.65 (10.64 ± 1.03)^{f}	1.50 ± 0.65 (5.96 ± 2.17)^{g}	0.50 ± 0.29 (2.87 ± 1.66)^{f}	
November	0.50 ± 0.29 (2.87 ± 1.66)^{h}	0.25 ± 0.24 (1.43 ± 1.42)^{h}	0.00 ± 0.00 (0.00 ± 0.00)^{f}	
December	1.50 ± 0.65 (5.96 ± 2.17)^{gh}	0.50 ± 0.29 (2.87 ± 1.66)^{gh}	0.00 ± 0.00 (0.00 ± 0.00)^{f}	
F- ratio	***144.12***	***182.59***	***241.49***	**-**
d.f.	***33***	***33***	***33***	**-**
S.E. (± d)	***1.70***	***1.49***	***1.25***	**-**
L.S.D. (P ≤ 0.05)	***3.47***	***3.04***	***2.56***	**-**
C.V. (%)	***10.80***	***10.94***	***10.48***	**-**

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 ($P \leq 0.05$) different using DMR test.

4. Conclusion

The plant growing media and the season of growing cuttings significantly affected the rooting success in cuttings of Kusum. Based on the present investigation, it is concluded that the plant growing media having the composition of Coco peat : FYM : Vermicompost (2:2:1) is more appropriate and recommended for growing cuttings of Kusum. Season also play a key role for successful cuttings. The month of May is highly recommended for growing cuttings of Kusum for maximum success in India, though it may vary from place to place. Regarding selection of mother plant, it is suggested to select the Kusum plant from the plantation aged less than five years old.

6. References

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