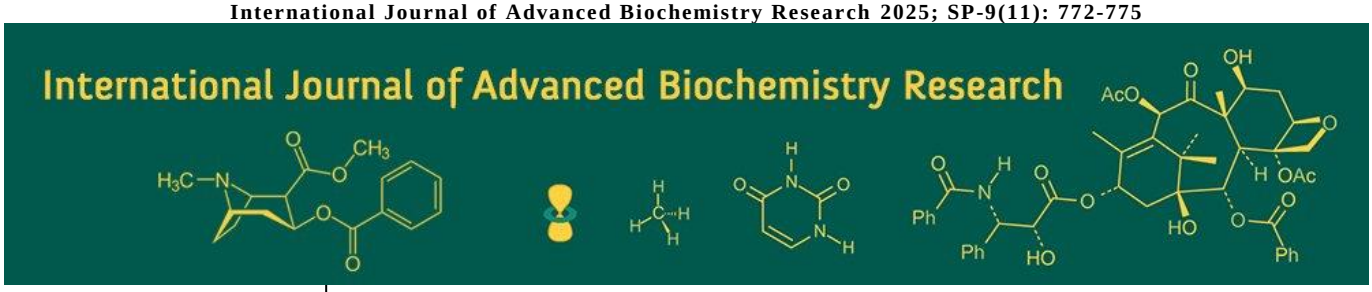

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Effect of method, time and application of biofertilizer on root development in vegetative propagation of jamun (*Syzygium cuminii* (L.) skeels)

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Abstract
The research was to study the effect of propagation method, timing, and biofertilizer application on root development in *Jamun* (*Syzygium cuminii* (L.) Skeels). Among all the propagation methods evaluated, vegetative methods of propagation were evaluated, softwood grafting with Vesicular Arbuscular Mycorrhiza (VAM) proved to be the most effective, particularly during November and February. This combination yielded the highest number of roots, the maximum fresh root weight, and the longest root length. The positive influence of VAM on rooting parameters highlights its potential for improving propagation efficiency and establishing sustainable, eco-friendly nursery practices.

Keywords: Vegetative propagation, softwood grafting, VAM, root growth, Jamun

Introduction
Java plum (*Syzygium cuminii* (L.) Skeels) is a hardy, underexploited fruit crop belonging to the family *Myrtaceae*. Commonly known as black plum or Indian blackberry, it is widely distributed throughout India, easily cultivated under tropical and sub-tropical climatic conditions, grow well under arid climatic conditions, needs just 400 to 600mm of rainfall for cultivation (Singh and Srivastava, 2000) [10].

The fruit is valued for its pleasant taste, nutritional richness, and therapeutic properties. It contains substantial quantities of dietry fiber, folic acid, antioxidants, vitamin C, and minerals such as iron, calcium, potassium, magnesium, and phosphorus. Traditionally, jamun is used to prepare beverages, squashes, jellies, jams, vinegar, and wine. Medicinally, fruits are used to treat diarrhoea, while seed powder exhibits the property of inhibiting conversion of starch into sugar due to compounds such as jamboline (glucoside) and jambosin (alkaloid) (Dastur, 1952; Thaper, 1958) [3, 13]. The leaves and bark also possess antibacterial and astringent qualities.

However, large-scale cultivation of jamun is constrained by its long juvenile phase, cross-pollinated nature, and lack of standard cultivars. Vegetative methods of propagation techniques such as grafting, cuttings, layering and budding are therefore essential for producing true-to-type plants and shortening the pre-bearing period.

In recent years, the focus on sustainable agriculture has encouraged the use of biofertilizers such as Vesicular Arbuscular Mycorrhiza (VAM - *Acaulospora laevis*). Mycorrhizal fungi enhance root growth, nutrient uptake, and overall plant vigor while reducing dependence on chemical inputs. Hence, this investigation aimed to study a suitable technique for propagation using different methods, time and application of VAM on root development in *Jamun* cv. AJG-85.

Materials and Methods
The investigation was conducted during 2016-2017 at the nusery unit of Department of Fruit Science, KRCCH, Arabhavi, Karnataka, India.

Experimental Details
- **Design:** Factorial Completely Randomized Design (CRD)
- **Factors:**

- **Factor I:** Methods of propagation (Patch budding, Softwood grafting, Hardwood cutting, Air layering,)
- **Factor II:** Months of propagation (November, December, January, February)
- **Replications:** 3
- **Treatments:** 16

Plant Material and Treatments

Hardwood Cuttings

The matured one year old shoots were prepared for cutting with 20-25 cm length and 6 nodes. Leaves were removed and basal ends were cut at a slant to increase the absorption surface. The blitox treatment was done for cuttings to prevent infection and planted in polybags containing soil:sand:FYM (2:1:1). Each bag received 5 g of VAM inoculum. Regular watering was maintained.

Air Layering

The one year old, uniform pencil size thickness shoots were ringed (2.5-3.0 cm), wrapped with moist sphagnum moss mixed with 5 g of VAM, and tied with transparent polyethylene film (200 gauge). Layers were detached after 90 days and planted in polybags containing the standard potting mixture.

Patch Budding

Seedling rootstocks raised in polybags were used for patch budding. Healthy scions were collected early in the morning and budded above 15 cm from ground level. Each polybag received 5 g of VAM. Budding success was assessed after one month.

Softwood Grafting

Seedling rootstocks (15-20 cm tall) were decapitated and wedge grafted with scion shoots of similar thickness. Grafts were tied with polythene strips and inoculated with **5 g of** VAM per polybag. The grafts were sprayed every 15 days once with 0.2% captan and maintained under shade net conditions and later exposed to sunlight after bud sprouting.

Results and Discussion

Number of Roots

The maximum number of roots was recorded in softwood grafting treated with VAM (36.23, 41.66, and 47.06 at 30, 60, and 90 DAP, respectively). February recorded the maximum root count among the months. The between method and time revealed that softwood grafting with VAM in November and February produced significantly higher root numbers.

Berta *et al*. (1994) [2] reported that VAM induces morphological and anatomical changes in roots, including increased cell division and soluble protein content, thereby enhancing root initiation and growth.

Root Fresh Weight

The maximum fresh root weight was also observed in softwood grafting with VAM (4.48, 5.90, and 7.26 g at 30, 60, and 90 DAP). Among months, February resulted in the heaviest roots. The combination of softwood grafting + VAM + February showed the best performance.

The synthesis of plant growth promotion hormones such as indole acetic acid (IAA) and gibberellins by AM fungi, which stimulate root biomass accumulation (Hooker and Arkinton, 1992; Gunze and Hennessy, 1980) [2, 5].

Root Length

The maximum root length was recorded in softwood grafting with VAM (32.73, 34.15, and 35.56 cm at 30, 60, and 90 DAP). November and February were the most favorable months. Enhanced elongation may result from VAM-induced improvement in nutrient uptake and auxin metabolism. Similar results were reported in mango (Santosh, 2004; Bassanagowda, 2005) [9, 1] and jamun (Devachandra, 2006) [4].

Percent Survivability

Softwood grafting with VAM recorded the highest survival percentage (84.55%), especially in November (87.13%). The favorable temperature and relative humidity during this period promoted cambial activity and callus formation, facilitating better graft union (Hartman and Kester, 1979; Srivastava, 1964) [6, 12].

Table 1: Impact of Propagation Practices, Temporal Factors, and VA Mycorrhizal Inoculation on Root Proliferation at Sequential Intervals

Propagation (P)	No. of roots/ plant								
	30 DAP			60 DAP			90 DAP		
	M_1	M_2	Mean of propagation	M_1	M_2	Mean of propagation	M_1	M_2	Mean of propagation
P_1	0 (0.70)*	0 (0.70)	0 (0.70)	0 (0.70)	0 (0.70)	0 (0.70)	0 (0.70)	0 (0.70)	0 (0.70)
P_2	0. (0.70)	0 (0.70)	0 (0.70)	0 (0.70)	0 (0.70)	0 (0.70)	0 (0.70)	0 (0.70)	0 (0.70)
P_3	0 (0.70)	0 (0.70)	0 (0.70)	0 (0.70)	1.73 (1.49)	0.86 (1.10)	2.53 (1.74)	2.06 (1.59)	2.30 (1.66)
P_4	0 (0.70)	1.06 (1.25)	0.53 (0.97)	0 (0.70)	4.00 (2.12)	2.00 (1.41)	3.53 (2.00)	5.20 (2.38)	4.36 (2.19)
P_5	20.93 (4.62)	27.72 (5.31)	24.33 (4.96)	28.85 (5.41)	34.60 (5.92)	31.72 (5.66)	33.46 (5.82)	40.36 (6.39)	36.91 (6.10)
P_6	23.33 (4.88)	36.00 (6.03)	29.66 (5.46)	36.06 (6.05)	41.33 (6.46)	38.70 (6.25)	40.86 (6.42)	46.13 (6.82)	43.50 (6.62)
P_7	26.93 (5.23)	29.13 (5.44)	28.03 (5.33)	32.86 (5.76)	36.06 (6.04)	34.46 (5.90)	43.39 (6.62)	42.20 (6.53)	42.79 (6.57)
P_8	36.47 (6.07)	36.00 (6.03)	36.23 (6.05)	41.06 (6.44)	42.26 (6.53)	41.66 (6.49)	47.93 (6.95)	46.20 (6.83)	47.06 (6.89)
Mean of month (M)	13.45 (2.95)	16.24 (3.27)	-	17.35 (3.31)	20 (3.74)	-	21.46 (3.87)	22.77 (3.99)	-
	S.Em±	CD@5%	-	S.Em±	CD@5%	-	S.Em±	CD@5%	-
Propagation (P)	0.62 (0.05)	1.80 (0.16)	-	0.81 (0.06)	2.34 (0.19)	-	0.79 (0.05)	2.29 (0.18)	-
Month (M)	0.31 (0.02)	0.90 (0.08)	-	0.40 (0.03)	1.17 (0.09)	-	0.39 (0.02)	1.14 (0.09)	-
(PxM)	0.88 (0.07)	2.55 (0.23)	-	1.15 (0.08)	3.32 (0.27)	-	1.12 (0.08)	3.25 (0.26)	-

Treatment details: DAP: Days After Propagation, ()* Values in the parentheses are square root transformed values

P_1: Hardwood cutting P_2: Hardwood cutting + VAM P_3: Air layering P_4: Air layering + VAM M_1:November P_5: Patch budding P_6: Patch budding + VAM P_7: Softwood grafting P_8: Softwood grafting + VAM M_2: February

Table 2: Impact of Propagation Practices, Temporal Factors, and VA Mycorrhizal Inoculation on fresh weight of roots at Sequential Intervals

Propagation (P)	Fresh weight of root/ plant (g)								
	30 DAP			60 DAP			90 DAP		
	M_1	M_2	Mean of propagation	M_1	M_2	Mean of propagation	M_1	M_2	Mean of propagation
P_1	0 (0.70)*	0 (0.70)	0 (0.70)	0 (0.70)	0 (0.70)	0 (0.70)	0 (0.70)	0 (0.70)	0 (0.70)
P_2	0 (0.70)	0 (0.70)	0 (0.70)	0 (0.70)	0 (0.70)	0 (0.70)	0 (0.70)	0 (0.70)	0 (0.70)
P_3	0 (0.70)	0 (0.70)	0 (0.70)	0 (0.70)	0.72 (1.10)	0.36 (0.90)	0.62 (1.05)	0.80 (1.13)	0.71 (1.09)
P_4	0 (0.70)	0.82 (1.14)	0.41 (0.92)	0 (0.70)	1.89 (1.54)	0.94 (1.12)	1.02 (1.23)	2.36 (1.69)	1.69 (1.46)
P_5	2.72 (1.79)	3.79 (2.07)	3.25 (1.93)	4.10 (2.14)	5.60 (2.46)	4.85 (2.30)	4.72 (2.28)	5.91 (2.52)	5.31 (2.40)
P_6	3.07 (1.88)	4.22 (2.17)	3.64 (2.03)	5.15 (2.37)	6.16 (2.58)	5.66 (2.47)	5.54 (2.45)	6.17 (2.56)	5.85 (2.50)
P_7	3.13 (1.90)	2.93 (1.84)	3.03 (1.87)	3.79 (2.07)	5.09 (2.36)	4.44 (2.21)	5.90 (2.52)	5.73 (2.48)	5.81 (2.50)
P_8	3.80 (2.07)	5.16 (2.37)	4.48 (2.22)	5.02 (2.34)	6.78 (2.69)	5.90 (2.52)	6.82 (2.70)	7.70 (2.86)	7.26 (2.78)
Mean of month (M)	1.59 (1.31)	2.11 (1.46)		2.26 (1.47)	3.28 (1.77)		3.08 (1.70)	3.58 (1.83)	
	S.Em±	CD@5%		S.Em±	CD@5%		S.Em±	CD@5%	
Propagation (P)	0.27 (0.03)	0.32 (0.08)		0.42 (0.02)	0.49 (0.10)		0.18 (0.02)	0.54 (0.11)	
Month (M)	0.05 (0.01)	0.16 (0.04)		0.08 (0.01)	0.24 (0.05)		0.08 (0.01)	0.27 (0.05)	
(PxM)	0.15 (0.05)	0.45 (0.11)		0.22 (0.03)	0.69 (0.14)		0.26 (0.03)	0.76 (0.16)	

Treatment details: DAP: Days After Propagation ()* Values in the parentheses are square root transformed values
P_1: Hardwood cutting P_2: Hardwood cutting + VAM P_3: Air layering, P_4: Air layering + VAM M_1: November P_5: Patch budding P_6: Patch budding + VAM P_7: Softwood grafting P_8: Softwood grafting + VAM M_2: February

Table 3: Impact of Propagation Practices, Temporal Factors, and VA Mycorrhizal Inoculation on the length of the longest root at Sequential Intervals

Method of propagation (P)	Length of longest root (cm)								
	30 DAP			60 DAP			90 DAP		
	M_1	M_2	Mean of propagation	M_1	M_2	Mean of propagation	M_1	M_2	Mean of propagation
P_1	0 (0.70)*	0 (0.70)	0 (0.70)	0 (0.70)	0 (0.70)	0 (0.70)	0 (0.70)	0 (0.70)	0 (0.70)
P_2	0 (0.70)	0 (0.70)	0 (0.70)	0 (0.70)	0 (0.70)	0 (0.70)	0 (0.70)	0 (0.70)	0 (0.70)
P_3	0 (0.70)	0 (0.70)	0 (0.70)	0 (0.70)	2.23 (1.65)	1.11 (1.17)	3.40 (1.97)	2.63 (1.76)	3.01 (1.86)
P_4	0 (0.70)	2.83 (1.82)	1.41 (1.26)	0 (0.70)	4.63 (2.26)	2.31 (1.48)	4.50 (2.23)	5.86 (2.52)	5.18 (2.37)
P_5	16.40 (3.85)	23.93 (4.94)	20.16 (4.39)	24.30 (4.97)	27.53 (5.29)	25.91 (5.13)	25.40 (5.08)	28.66 (5.39)	27.03 (5.24)
P_6	25.83 (5.12)	30.53 (5.57)	28.18 (5.34)	27.10 (5.25)	32.20 (5.71)	29.65 (5.48)	30.33 (5.54)	32.66 (5.75)	31.50 (5.65)
P_7	28.53 (5.38)	27.33 (5.27)	27.93 (5.32)	34.26 (5.89)	28.90 (5.41)	31.58 (5.65)	32.20 (5.71)	30.36 (5.55)	31.28 (5.63)
P_8	33.60 (5.83)	31.86 (5.68)	32.73 (5.76)	35.66 (6.01)	32.63 (5.75)	34.15 (5.88)	36.63 (6.09)	34.50 (5.91)	35.56 (6.00)
Mean of month (M)	13.04 (2.87)	14.56 (3.17)	-	15.16 (3.12)	16.01 (3.43)	-	16.55 (3.50)	16.83 (3.54)	-
	S.Em±	CD@5%	-	S.Em±	CD@5%	-	S.Em±	CD@5%	-
Propagation (P)	1.21 (0.17)	3.50 (0.51)	-	0.65 (0.06)	1.88 (0.17)	-	0.58 (0.04)	1.69 (0.16)	-
Month (M)	0.60 (0.08)	1.75 (0.25)	-	0.32 (0.03)	0.94 (0.08)	-	0.29 (0.02)	0.84 (0.08)	-
(PxM)	1.65 (0.24)	4.95 (0.70)	-	0.92 (0.09)	2.66 (0.24)	-	0.82 (0.06)	2.39 (0.23)	-

Treatment details: DAP: Days After Propagation ()* Values in the parentheses are square root transformed values
P_1: Hardwood cutting P_2: Hardwood cutting + VAM, P_3: Air layering, P_4: Air layering + VAM, M_1:November P_5: Patch budding, P_6: Patch budding + VAM, P_7: Softwood grafting, P_8: Softwood grafting + VAM M_2: February

Table 4: Impact of Propagation Practices, Temporal Factors, and VA Mycorrhizal Inoculation percent survivability of propagated plants at 90 days after propagation

Method of propagation (P)	Survivability of propagated plants (%)		
	M_1	M_2	Mean of propagation
P_1	0 (0.28)*	0 (0.28)	0 (0.28)
P_2	0 (0.28)	0 (0.28)	0 (0.28)
P_3	13.33 (21.36)	15.63 (23.04)	14.48 (22.20)
P_4	20.23 (26.59)	22.70 (28.40)	21.46 (27.50)
P_5	23.80 (29.18)	31.40 (34.07)	27.60 (31.62)
P_6	28.76 (32.41)	42.86 (40.87)	35.81 (36.64)
P_7	72.50 (58.38)	72.93 (58.66)	72.72 (58.52)
P_8	87.13 (69.03)	81.97 (64.90)	84.55 (66.97)
Mean of month (M)	30.72 (29.69)	33.43 (31.31)	-
	S.Em ±	CD@5%	-
Propagation (P)	1.22 (0.90)	3.68 (2.60)	-
Month (M)	0.61 (0.45)	1.84 (1.30)	-
(PxM)	1.73 (1.27)	5.21 (3.68)	-

Treatment details: DAP: Days After Propagation ()* Values in the parentheses are square root transformed values
P_1: Hardwood cutting P_2: Hardwood cutting + VAM P_3: Air layering P_4: Air layering + VAM M_1:November P_5: Patch budding P_6: Patch budding + VAM P_7: Softwood grafting P_8: Softwood grafting + VAM M_2:February

Conclusion

Among the various vegetative propagation techniques tested, softwood grafting with VAM performed best for *Jamun* cv. AJG-85. Conducting grafting operations during November and February significantly improved root number, root length, root weight, and survival rate. The results clearly demonstrate that VAM inoculation enhances rooting efficiency, offering a sustainable and environmentally friendly approach to large-scale propagation of Jamun.

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