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Effect of different media and time of soft wood grafting in Nagpur mandarin

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Abstract
An experiment entitled "Effect of different media and time of soft wood grafting in Nagpur Mandarin" was carried out at the Fruit Nursery Unit, Dr. PDKV, Akola. The experiment was laid out in FRBD considering different media (T) as first factor with four levels T_1 i.e., Soil: Sand: FYM (2:1:1), T_2 i.e., Soil: Cocopeat: Vermicompost (1:1:1), T_3 i.e., Cocopeat: FYM (1:1), T_4 i.e., Cocopeat: Vermicompost (1:1) and second factor of growth month (M) with five levels M_1 (August), M_2 (September), M_3 (October), M_4 (November), M_5 (December) with twenty treatment combination replicated three times and observations recorded at 60 DAG, 120 DAG and in June. As regards growth characters, plant height (cm), Number of leaves per plant, and final success percentage (%), proven to be superior in softwood grafting done in T_2M_1, i.e., Soil: Cocopeat: Vermicompost in a ratio of 1:1:1 in the last week of August.

Keywords: Nagpur Mandarin, media, plant height, soft wood grafting

Introduction
Citrus is one of the largest genera of flowering trees and shrubs, classified under the order *Sapindales*, subfamily *Aurantioideae*, within the *Rutaceae* family, commonly referred to as the rue family. Mandarin (*Citrus reticulata* Blanco) from the Rutaceae family is considered to be one of the most important cultivated species among citrus and is being commercially grown in certain specific regions of the country, like Nagpur mandarin in central India. In India, total citrus cultivation is done on an area of about 1.05 million ha with an annual production of about 13.97 million MT, and productivity is about 13.26 t/ha. The area under mandarin is about 4.77 lakh ha with an annual production of 62.19 lakh tonnes, and the average productivity is around 13.04 t/ha. Over the last 20 years, the area under citrus in is increased by 5.95% and production is increasing by 6.2% annually (National Horticultural Board). Vermicompost boosts plant growth in soils and media. Cocopeat, a coconut husk by-product, has a suitable pH and EC for horticulture (Abad *et al*., 2002) [1]. FYM, made from cow dung, urine, and crop waste, enriches soil with nutrients (0.5% N, 0.2% P, 0.5% K) and improves soil health (Meena *et al*., 2018) [8]. The success of a fruit nursery largely relies on producing healthy rootstock suitable for grafting. An essential factor in seedling development is the preparation of an appropriate potting mixture. The propagation medium significantly influences seed germination, serving not only as a supportive environment for growth but also as a source of vital nutrients for the plants (Ramteke *et al*., 2015) [12]. The survival of seedlings is especially affected by different seasonal times of grafting. So, the trial was framed to find out the proper time and media for softwood grafting under Akola conditions.

Materials and Methods
The present experiment entitled, "Effect of different media and time of soft wood grafting in Nagpur mandarin", was carried out at Fruit Nursery, Department of Fruit Science, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola (M.S.) during the year 2024-25 with objective to find a suitable time and potting media for soft wood grafting in Nagpur mandarin. The experiment was laid out in Factorial Randomised Block Design (FRBD) considering different media (T) as first factor with four levels T_1 i.e., Soil: Sand: FYM (2:1:1), T_2 i.e., Soil: Cocopeat: Vermicompost (1:1:1), T_3 i.e., Cocopeat: FYM (1:1), T_4 i.e.,

Cocopeat: Vermicompost (1:1) and second factor months of grafting(M) with five levels M_1 (August), M_2 (September), M_3 (October), M_4 (November), M_5 (December) with twenty treatment combination replicated three times. The six-month-old rootstocks were transplanted in polybags having a size 8''x12'' in the last week of July, and grafting was done in the last week of the month as required by the research. The observations were recorded at 60 DAG,120 DAG, and in June. The final survival percentage was recorded in June.

Results and Discussions

Days to sprouting

The days to sprouting were significantly influenced by the different media, time, and their interaction in the Nagpur mandarin Table 1.

Minimum days to sprouting were observed in T_1M_1 i.e., Soil: Sand: FYM in the ratio of 2:1:1 in August (19.30 days), which was at par with T_1M_2 i.e., Soil: Sand: FYM in September (20.60 days), and maximum days to sprouting were observed in T_3M_5 i.e., Cocopeat: FYM in the ratio of 1:1 in December (28.00 days). Bhavna, G. (2013) investigated how different growing media and rootstock ages influence the success rate of epicotyl grafting in mango cultivar Kesar and concluded that the M_6 [soil + FYM + sand (1:1:1)] media has the minimum time to completion sprouting (9.06 days) of the graft. It may be due to higher meristematic activity and also because of the optimal weather conditions prevailing during that period, due to which early sprouting occurs. This fact followed the findings of Sharma and Tiwari (1995) [13] and Prasanth *et al*. (2007) [11] in mango.

Table 1: Effect of different potting media and time of softwood grafting on days to sprouting

Treatments	Days to sprouting (After grafting)					
	Months of softwood grafting					
Potting media	**M_1 (August)**	**M_2 (September)**	**M_4 (October)**	**M_4 (November)**	**M_5 (December)**	**Mean**
T_1 Soil: sand: FYM (2:1:1)	19.30	20.60	21.57	23.97	25.80	22.24
T_2 Soil: Cocopeat: Vermicompost (1:1:1)	20.70	21.33	21.37	23.50	26.50	22.68
T_3 Cocopeat: FYM (1:1)	22.70	22.33	22.77	25.40	28.00	24.24
T_4 Cocopeat: Vermicompost (1:1)	21.33	21.50	23.00	26.67	24.33	23.36
Mean	21.00	21.44	22.17	24.88	26.15	
Interaction (T X M)						
	T	M				T X M
'F' Test	Sig.	Sig.				Sig.
SE (m±)	0.46	0.51				1.03

Sprouting percentage (%)

The days to sprouting were significantly influenced by the different media, time, and their interaction in the Nagpur mandarin Table (2). Maximum sprouting percentage were observed in T_1M_1 i.e., Soil: Sand: FYM in the ratio of 2:1:1 in August (97.67%) which was at par with T_2M_1 i.e., Soil: Cocopeat: Vermicompost in ratio of 1:1:1 in August (97.40%) and minimum sprouting percentage was observed in T_3M_3 i.e., Cocopeat: FYM in ratio of 1:1 in October (59.75%). Bhavna, G. (2013) examined how growing media and rootstock age affect the success of epicotyl grafting in mango cv. Kesar, focusing on their impact on graft sprouting percentage observed in the M_6 [soil + FYM + sand (1:1:1)] media. Tayade *et al.* (1988) [16] reported that mango grafts achieved a 100% sprouting rate from July to September under Akola conditions.

Treatments	Sprouting percentage (%) (After grafting)					
	Months of softwood grafting					
Potting media	**M_1 (August)**	**M_2 (September)**	**M_3 (October)**	**M_4 (November)**	**M_5 (December)**	**Mean**
T_1 Soil: sand: FYM (2:1:1)	97.67	95.30	81.00	84.57	89.29	89.57
T_2 Soil: Cocopeat: Vermicompost (1:1:1)	97.40	93.83	80.00	84.43	89.47	89.03
T_3 Cocopeat: FYM (1:1)	92.30	94.30	59.75	81.13	85.23	81.12
T_4 Cocopeat: Vermicompost (1:1)	94.17	93.13	79.13	87.6	85.67	87.94
Mean	95.38	94.14	73.8	84.43	87.42	
Interaction (T X M)						
	T		**M**			**T X M**
'F' Test	Sig.		Sig.			Sig.
SE (m±)	0.36		0.41			0.82
CD at 5%	1.04		1.17			2.33

Plant height (cm)

The height of the plant in Nagpur mandarin was significantly influenced by the time and media Table 1(a).

Among the various potting media evaluated, the highest plant height was observed in T_2 (Soil: Cocopeat: Vermicompost in 1:1:1 ratio), recording 28.43 cm, 35.35 cm, and 54.51 cm at 60 DAG, 120 DAG, and in June, respectively. This was closely followed by T_1 (Soil: Sand: FYM in 2:1:1 ratio), which recorded 26.74 cm, 34.74 cm, and 53.73 cm at the same stages. The lowest plant height was recorded in T_3 (Cocopeat: FYM in 1:1 ratio) with 24.91 cm, 29.97 cm, and 48.84 cm, respectively. According to Dash *et al*. (2019) [4], this can be attributed to the growing media's favourable influence on soil porosity, improved water retention capacity, and enhanced availability of essential nutrients, especially nitrogen and micronutrients, which collectively support superior root and shoot development compared to conventional soil.

Among the different grafting months, the highest plant height was recorded in M_1 (August), measuring 32.57 cm, 36.79 cm, and 62.12 cm at 60 DAG, 120 DAG, and in June, respectively. This was followed by M_2 (September), which

recorded 26.79 cm, 35.10 cm, and 59.89 cm. The lowest plant height was observed in M_3 (October), with values of 22.31 cm, 29.06 cm, and 37.93 cm at the corresponding stages. The observed results could be attributed to favourable climatic conditions during the monsoon season, which supported rapid growth and positively influenced both the rootstock and scion shoot. This may have been due to the extended period available for meristematic cell activity, along with improved physiological processes such as enhanced photosynthesis and reduced respiration. These findings are in line with those reported by Mandal *et al.* (2011) [7].

Table 1(a): Effect of different potting media and time of softwood grafting on plant height

Treatment	Plant height (cm)		
	After grafting		
	60 DAG	120 DAG	In June
A. (Different potting media)			
T_1 Soil: sand: FYM (2:1:1)	26.74	34.74	53.73
T_2 Soil: Cocopeat: Vermicompost (1:1:1)	28.43	35.35	54.51
T_3 Cocopeat: FYM (1:1)	24.91	29.97	39.43
T_4 Cocopeat: Vermicompost (1:1)	25.95	31.68	44.07
'F' test	Sig.	Sig.	Sig.
SE (m) ±	0.25	0.43	0.33
CD at 5%	0.70	1.23	0.94
B. (Time of soft wood grafting)			
M_1 (August)	32.57	36.79	57.10
M_2 (September)	26.79	35.10	54.33
M_3 (October)	22.31	29.06	35.86
M_4 (November)	24.59	29.41	42.16
M_5 (December)	26.29	34.31	50.22
'F' test	Sig.	Sig.	Sig.
SE (m) ±	0.27	0.48	0.37
CD at 5%	0.79	1.38	1.05

Plant height in Nagpur mandarin was significantly affected by the interaction between grafting time and potting media, as shown in Table 1(b). The highest plant height was recorded in T_2M_1 (Soil: Cocopeat: Vermicompost in a 1:1:1 ratio during August), with values of 33.54 cm, 42.31 cm, and 65.13 cm at 60 DAG, 120 DAG, and in June, respectively. This was closely followed by T_1M_1 (Soil: Sand: FYM in a 2:1:1 ratio during August), which showed plant heights of 33.39 cm, 39.06 cm, and 63.10 cm at the same intervals. The lowest plant height was observed in T_3M_3 (Cocopeat: FYM in a 1:1 ratio during October), with respective values of 20.33 cm, 23.00 cm, and 30.00 cm.

Table 1(b): Interaction effect of different potting media and time of soft wood grafting on plant height

Treatment	Plant height (cm)		
	After grafting		
	60 DAG	120 DAG	In June
T_1M_1	33.39	39.06	63.10
T_1M_2	26.90	36.40	62.83
T_1M_3	21.32	29.52	39.23
T_1M_4	25.91	31.62	47.10
T_1M_5	26.18	37.08	56.37
T_2M_1	33.54	42.31	65.13
T_2M_2	28.80	34.36	61.50
T_2M_3	26.67	30.33	40.20
T_2M_4	26.69	33.36	48.20
T_2M_5	26.54	36.37	57.50
T_3M_1	30.40	36.36	47.17
T_3M_2	25.30	32.43	43.33
T_3M_3	20.33	23.00	30.00
T_3M_4	21.66	26.67	36.33
T_3M_5	26.87	31.41	40.33
T_4M_1	32.96	29.41	53.00
T_4M_2	26.16	37.22	49.67
T_4M_3	21.00	33.22	34.00
T_4M_4	24.08	33.41	37.00
T_4M_5	25.57	26.00	46.67
'F' test	Sig	Sig	Sig
SE (m) ±	0.55	0.96	0.74
CD at 5%	1.57	2.76	2.11

Number of leaves per plant

The number of leaves per plant in Nagpur mandarin was significantly influenced by the time and media Table 2 (a). Among the various potting media, the highest number of leaves was recorded in T_2 (Soil: Cocopeat: Vermicompost in a 1:1:1 ratio) with 16.75, 25.85, and 60.21 leaves at 60 DAG, 120 DAG, and in June, respectively. These results were statistically at par with T_1 (Soil: Sand: FYM in a 2:1:1 ratio), which recorded 16.65, 25.77, and 59.61 leaves at the same stages. The lowest number of leaves was observed in

T_3 (Cocopeat: FYM in a 1:1 ratio), with values of 13.83, 22.08, and 47.47, respectively. These findings are in close agreement with the results reported by Parasana *et al.* (2012) [9].

Among the different grafting months, the highest number of leaves was observed in M_1 (August), with 17.73, 26.52, and 59.32 leaves at 60 DAG, 120 DAG, and in June, respectively. These values were statistically comparable to M_2 (September), which recorded 17.51, 26.18, and 58.86 leaves at the same intervals. In contrast, the lowest leaf count was noted in M_3 (October), with 12.18, 21.06, and 47.52 leaves, respectively. This improvement in August and September may be due to faster and more efficient graft union formation, along with better nutrient uptake, which likely contributed to enhanced plant growth and increased leaf production. These observations align with the findings of Patel and Amin (1981) [10] in mango and Chovatia and Singh (2000) [5] in Jamun.

Table 2 (a): Effect of different potting media and time of soft wood grafting on the number of leaves per plant

Leaves per plant			
Treatment	**After grafting**		
	60 DAG	**120 DAG**	**In June**
A. (Different potting media)			
T_1 Soil: sand: FYM (2:1:1)	16.65	25.77	59.61
T_2 Soil: Cocopeat: Vermicompost (1:1:1)	16.75	25.85	60.21
T_3 Cocopeat: FYM (1:1)	13.83	22.08	47.47
T_4 Cocopeat: Vermicompost (1:1)	16.14	24.71	51.57
'F' test	Sig.	Sig.	Sig.
SE (m) ±	0.08	0.16	0.17
CD at 5%	0.22	0.47	0.48
B. (Time of soft wood grafting)			
M_1 (August)	17.73	26.52	59.32
M_2 (September)	17.51	26.18	58.86
M_3 (October)	12.18	21.06	47.52
M_4 (November)	15.45	24.09	51.78
M_5 (December)	16.33	25.16	56.09
'F' test	Sig.	Sig.	Sig.
SE (m) ±	0.09	0.18	0.19
CD at 5%	0.25	0.53	0.53

The number of leaves per plant in *Nagpur mandarin* was significantly affected by the interaction between grafting time and potting media, as presented in Table 2(b). The highest leaf count was recorded in T_2M_1 (Soil: Cocopeat: Vermicompost in a 1:1:1 ratio during August), with 18.80, 27.83, and 65.17 leaves at 60 DAG, 120 DAG, and in June, respectively. This was closely followed by T_1M_1 (Soil: Sand: FYM in a 2:1:1 ratio during August), which had 18.60, 27.67, and 65.13 leaves at the same stages. The lowest number of leaves was observed in T_3M_3 (Cocopeat: FYM in a 1:1 ratio during October), with values of 10.10, 18.53, and 41.23, respectively. This may be attributed to favourable climatic conditions, particularly optimal temperature and humidity, which enhanced cellular activity, early sprouting, and photosynthate accumulation in newly grafted plants. These factors likely contributed to an increased number of nodes and improved nutrient uptake by leaf primordia, ultimately resulting in a higher number of leaves per graft. Similar findings were reported by Kurre *et al.* (2024) [6] in mango.

Table 2 (b): Interaction effect of different potting media and time of soft wood grafting on leaves per plant

Leaves per plant			
Treatment	**After grafting**		
	60 DAG	**120 DAG**	**In June**
T_1M_1	18.60	27.67	65.13
T_1M_2	17.75	27.26	64.09
T_1M_3	13.30	22.20	49.00
T_1M_4	16.50	25.53	57.87
T_1M_5	17.10	26.17	61.47
T_2M_1	18.80	27.83	65.17
T_2M_2	18.27	26.97	64.50
T_2M_3	12.83	22.37	52.33
T_2M_4	16.70	25.73	57.00
T_2M_5	17.13	26.37	62.07
T_3M_1	15.70	24.07	51.80
T_3M_2	15.83	23.57	51.47
T_3M_3	10.10	18.53	41.23
T_3M_4	13.20	21.63	44.40
T_3M_5	14.30	22.60	48.43
T_4M_1	17.80	26.50	55.17
T_4M_2	18.20	26.93	54.90
T_4M_3	12.50	21.13	47.50
T_4M_4	15.40	23.47	47.87
T_4M_5	16.80	25.50	52.40
'F' test	Sig	Sig	Sig
SE (m) ±	0.17	0.37	0.37
CD at 5%	0.50	1.05	1.07

Final survival of seedlings (%)

The final survival of seedlings was significantly influenced by the different media, time, and their interaction in the Nagpur mandarin Table 3.

Maximum final survival of grafts was observed in T_2M_1 i.e. Soil: Cocopeat: Vermicompost in the ratio of 1:1:1 in August (86.83%) which is followed by in T_1M_1 i.e. Soil: Sand: FYM in ratio of 2:1:1 in August (86.10%) and minimum final survival of grafts was observed in T_3M_3 i.e. Cocopeat: FYM in ratio of 1:1 in October (37.17%).

Vermicompost is a nutrient-rich blend of worm castings, decomposed organic matter, humus, earthworms, cocoons, and beneficial soil organisms. Earthworms enhance soil quality by lowering the C: N ratio and increasing humic acid, action exchange capacity, and water-soluble carbohydrates (Talashilkar *et al.*, 1999) [15]. Cocopeat, a by-product of coconut husks (Abad *et al.*, 2002) [1], is an effective growing medium widely used for tropical crops (Yahaya & Mohklas, 1999) [17]. The higher success rate might be attributed to the sufficient presence of carbohydrates and other nutrients in both the scion and rootstock. These stored food reserves are likely redirected to support new growth, thereby enhancing meristematic activity in the scion. Additionally, the high atmospheric humidity between August 15 and September 15 likely promoted better callus formation at the graft union, compared to October 30 (T6), when humidity levels are significantly lower. These findings are consistent with the observations reported by Mandal *et al.* (2011) [7].

Table 3: Effect of different potting media and time of softwood grafting on the final survival of the graft

Treatments	Final survival of grafts (%)					
	Months of softwood grafting					
Potting media	**M_1 (August)**	**M_2 (September)**	**M_3 (October)**	**M_4 (November)**	**M_5 (December)**	**Mean**
T_1 Soil: sand: FYM (2:1:1)	86.10	83.73	44.00	60.00	84.00	71.57
T_2 Soil: Cocopeat: Vermicompost (1:1:1)	86.83	85.43	45.10	61.20	85.07	72.73
T_3 Cocopeat: FYM (1:1)	79.53	78.73	37.00	54.30	72.27	64.37
T_4 Cocopeat: Vermicompost (1:1)	79.93	79.83	39.17	58.00	76.30	66.65
Mean	83.10	81.93	41.32	58.38	79.41	
Interaction (T X M)						
	T		**M**			**T X M**
'F' Test	Sig.		Sig.			Sig.
SE (m±)	0.24		0.27			0.54
CD at 5%	0.69		0.78			1.55

Conclusion

As regards growth characters final success percentage (%), plant height (cm), Number of leaves per plant, proven to be superior in softwood grafting done in T_2M_1 i.e., Soil: Cocopeat: Vermicompost in ratio of 1:1:1 in August.

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