STUDIES ON THE ROOTSTOCKS FOR MANDARINS IN THE WET SUB-TROPICS. II. (VARIETY SRINAGAR)

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SELECTION of suitable rootstocks for the commercial varieties of sweet oranges and mandarins for wet sub-tropical zones with high temperatures is a major problem, on which no systematic work has been done. The author initiated a series of such trials on sweet oranges and mandarins, and the results of three sweet orange scion varieties and Hill mandarin have already been reported (5, 6, 7, 8). The present paper deals with the performance of Srinagar variety of mandarins on Florida Rough, Jambheri, Italian 76, Seville orange, Sweet lime, Lime Sylhet and Karna Khatta rootstocks. The review of literature, materials and methods, and pomological descriptions of the rootstocks have already been detailed in the first paper of the series (5).

EXPERIMENTAL FINDINGS

THE growth records for the years 1957 to 1961 are presented below variate-wise.

1. Circumference of stock

THE stock girth measurements were recorded at a fixed point just below the bud-union, and the data is presented in Table I.

It is apparent from Table I that Florida Rough stock was significantly superior to Jambheri, Seville orange, Sweet lime and Lime Sylhet stocks throughout the period at 5 per cent level of probability. Although no significant differences were found over Italian 76 and Karna Khatta stocks, Florida Rough gave better stock girth throughout except during 1958, when Italian 76 proved to be slightly superior to it. Seville orange consistently possessed the minimum stock girth throughout and was preceded by Sweet lime stock.

Italian 76, except during 1958, was next to Florida Rough and was followed by Karna Khatta. During 1958, 1960 and 1961, Jambheri was superior to Lime Sylhet, which gave higher girth than Jambheri during 1957 and 1959.

2. Circumference of scion

THE data for scion-girth in centimeters is presented in Table II. It is evident from Table II that Srinagar trees on Seville orange stock possessed the minimum scion girth and were closely preceded by those on Sweet lime stock. During 1959, trees on Florida Rough gave the maximum scion girth, whereas those on Italian 76 excelled all others during 1957, 1958, 1960 and 1961, and the results were significant over Jambheri, Seville orange, Sweet lime and Lime Sylhet stocks at 5 per cent level of probability. Karna Khatta was consistently the third in order of merit and Lime Sylhet was ranked fourth during 1957, 1960 and 1961 but Jambheri proved to be superior during 1958 and 1959.

3. Volume of the tree

THE volume of the trees was computed in cubic meters according to the method detailed in the first paper of the series (5) and the values are given in Table III. A perusal of Table III shows that for this variate, Italian 76 excelled all other rootstocks, whereas Srinagar scion on Seville orange consistently possessed the minimum volume. Florida Rough was second in order of merit and was followed by Karna Khatta. Lime Sylhet except during 1958 and 1959 was better than Jambheri, which was followed by Sweet lime. During 1958 and 1959, Jambheri proved to be superior to Lime Sylhet stock. The results with Italian 76 stock were significantly superior to Jambheri, Seville orange, Sweet lime and Lime Sylhet during 1957 and 1958 and to all other rootstocks excepting Florida Rough, during 1959, 1960 and 1961.

4. Scion-stock ratio

THE scion-stock girth ratios as calculated from Tables I and II are compiled in Table IV. From a close study of Table IV it would appear that during 1959, 1960 and 1961 all the rootstocks under study, viz., Jambheri, Florida Rough, Sweet lime, Seville orange, Lime Sylhet, Karna Khatta and Italian 76 gave compatible unions as judged from the suggested interpretations of physical index of compatibility

by the author (5). Jambheri, Florida Rough, Seville orange and Lime Sylhet during 1957, and Jambheri, Seville orange and Lime Sylhet during 1958, however, gave only good combinations, while the rest were interpreted to be excellent ones. It was interesting to note that Italian 76 gave the best values throughout except during 1957 and Seville orange consistently the least. Sweet lime showed highest value of the ratio during 1957 only.

TABLE I.—Average girth of rootstocks per tree in cms.

Rootstocks	*Girth per tree in cms. recorded during*				
	1957	*1958*	*1959*	*1960*	*1961*
Jambheri	23·0	27·6	28·3	35·6	38·9
Florida Rough	30·8	35·3	40·3	46·3	49·7
Seville orange	13·5	16·8	21·0	25·0	29·3
Sweet lime	17·5	21·7	24·7	28·4	31·6
Italian 76	29·3	35·5	39·3	44·7	48·9
Lime Sylhet	23·1	26·1	29·7	35·4	38·2
Karna Khatta	27·3	31·6	35·7	40·5	43·8
S. E.	3·09	3·05	3·74	4·23	5·12
C. D. at 5%	6·2	6·1	7·5	8·5	10·3

TABLE II.—Average girth of Srinagar scions per tree in cms. on different rootstocks

Rootstocks	*Girth of Srinagar scion in cms. recorded during*				
	1957	*1958*	*1959*	*1960*	*1961*
Jambheri	18·4	23·3	27·7	31·7	34·9
Florida Rough	26·0	31·6	37·0	41·9	45·4
Seville orange	10·2	13·7	18·3	22·0	25·8
Sweet lime	16·1	19·1	22·3	26·2	29·3
Italian 76	26·4	31·9	36·7	42·0	46·2
Lime Sylhet	19·2	22·1	27·0	32·5	35·6
Karna Khatta	24·7	28·2	32·3	37·2	40·4
S. E.	2·81	2·93	3·08	3·04	3·75
C. D. at 5 %	5·7	5·9	6·2	6·1	7·5

TABLE III.—Average volume per Srinagar tree on different rootstocks in cubic meters

Rootstocks	*Volume per tree in cubic meters recorded during*				
	1957	*1958*	*1959*	*1960*	*1961*
Jambheri	9·38	20·58	24·95	47·63	57·86
Florida Rough	20·38	39·57	49·18	76·14	105·75
Seville orange	1·99	7·43	10·42	20·31	37·34
Sweet lime	6·54	12·53	15·33	29·77	38·09
Italian 76	22·01	41·99	56·21	95·10	124·31
Lime Sylhet	11·63	19·58	24·81	55·59	65·49
Karna Khatta	16·96	33·71	42·53	71·22	94·09
S. E.	3·20	5·23	6·40	11·44	12·96
C. D. at 5 %	6·49	10·62	12·99	23·12	26·19

TABLE IV.—Scion/ Stock girth ratio of Srinagar on different rootstocks

Rootstocks	*Scion stock ratio of girths recorded during*				
	1957	*1958*	*1959*	*1960*	*1961*
Jambheri	0·80	0·84	0·89	0·89	0·90
Florida Rough	0·84	0·90	0·92	0·90	0·91
Seville orange	0·76	0·82	0·87	0·87	0·88
Sweet lime	0·92	0·88	0·90	0·92	0·93
Italian 76	0·90	0·90	0·93	0·94	0·94
Lime Sylhet	0·83	0·85	0·91	0·91	0·93
Karna Khatta	0·90	0·89	0·90	0·91	0·92

5. Fruit yield

THE average number of fruits borne on a tree for each treatment was recorded year-wise from 1957 and the data are summarised in Table V. Table V presents some very interesting trends in the fruit yield of Srinagar on different rootstocks under study. During 1957, Karna Khatta gave the highest yields which were significantly superior to the yields on Jambheri and Seville orange. Italian 76, Florida Rough, Lime Sylhet, Sweet lime, Jambheri and Seville orange followed these yields in the descending order. Italian 76 stock proved to be superior over all others during 1958 and was followed by Florida Rough, Lime Sylhet, Karna Khatta, Jambheri, Seville orange and Sweet lime in order. Trees on Karna Khatta again gave the highest yields during 1959. The average yields during 1958 and 1959 were on the whole exceptionally low probably due to heavy wind storms in the month of April and similar trend was recorded with the other varieties reported earlier (5, 6, 7, 8). During 1960, Italian 76 again surpassed all other stocks and was followed by Karna Khatta, Lime Sylhet, Florida Rough, Jambheri, Seville orange and Sweet lime. The yields on this stock were significantly superior to those on Jambheri, Seville orange and Sweet lime stocks.

The entire trend of cropping was reversed during 1961, which was considered to be the commercial cropping year. Lime Sylhet, so far a moderate bearing stock, recorded the highest yields over all other stocks and the results were significant at 5 per cent level of probability over Jambheri, Seville orange and Sweet lime stocks. Florida Rough, Italian 76, Karna Khatta, Jambheri, Seville orange and Sweet lime were ranked in the descending order. During this year, besides counting the number of fruits the total weight of the fruits in kilograms was also recorded. Trees on Lime Sylhet stock gave the maximum yields in weight followed by Florida Rough, Karna Khatta, Jambheri, Italian 76, Seville orange and Sweet lime. The average individual fruit size was found to be the largest on Florida Rough and was followed by Jambheri, Lime Sylhet, Seville orange, Karna Khatta, Sweet lime and Italian 76.

6. Fruit quality

UNDER the physico-chemical analysis, the percentage of juice and of rag and peel, vitamin C content and T. S. S./Acid ratio were determined as detailed in the earlier paper (5). The data for different constituents are presented in Table VI.

(*a*) *Percentage of juice*: The highest juice percentage was found in Srinagar fruits on Lime Sylhet stock and was followed by those on Karna Khatta, Jambheri, Florida Rough, Italian 76, Sweet lime and Seville orange stocks.

(*b*) *Percentage of peel and rag*: Fruits on Seville orange gave the maximum percentage of peel and rag, whereas those on Lime Sylhet, the least. These values were, however, supplementary to those for the percentage of juice.

(*c*) *Vitamin C content.* Determinations of vitamin C content was done by direct titration of juice against 2, 6 dichloroindo-phenol and expressed as mgm. per 100 gms. of juice. 24.0 mgm. of vitamin C were estimated in Srinagar fruits on Lime Sylhet stocks while Karna Khatta, Sweet lime and Florida Rough gave 23.0, 22.0 and 20.0 mgs./100 gms. of juice. The values for Italian 76, Seville orange and Jambheri were 18.0, 17.0 and 15.0 mgm. per 100 gms. of juice, respectively.

(*d*) *T. S. S./Acid ratio.* The acidity was the highest in the fruits of Srinagar on Lime Sylhet stock followed by those on Florida Rough. Italian 76 and Karna Khatta had the same values and followed Florida Rough. Lowest acidity was found in fruits on Seville orange stock and was preceded by Jambheri and Sweet lime stocks, which had identical values.

The total soluble solids as determined by a hand refractometer were found to be 10 per cent in Florida Rough, Sweet lime, Italian 76, Lime Sylhet and Karna Khatta. The values for Jambheri and Seville orange stocks were recorded to be 9 per cent. The maximum T. S. S./Acid ratio was found in fruits on Seville orange stock followed by Sweet lime, Italian 76 and Karna Khatta, Florida Rough, Jambheri and Lime Sylhet stocks.

TABLE V.—Average yield of Srinagar fruits per tree on different rootstocks

Rootstocks	*Average yield in number of fruits during*					*Average yield of fruits during 1961*	
	1957	*1958*	*1959*	*1960*	*1961*	*Wt. in kg. per tree*	*Wt. in gm. per fruit*
Jambheri	57·0	44·0	29·7	138·2	94·3	12·25	129·9
Florida Rough	102·0	59·0	33·7	205·5	133·7	19·07	142·6
Seville orange	23·0	19·0	5·2	120·3	86·2	10·52	122·0
Sweet lime	80·0	14·3	13·3	106·2	70·6	7·35	104·1
Italian 76	108·3	71·3	31·6	229·3	119·7	12·21	102·0
Lime Sylhet	94·3	54·3	21·9	206·3	156·3	19·68	125·9
Karna Khatta	125·0	45·3	36·4	223·3	114·8	13·91	121·2
S. E.	26·0	17·5	10·3	35·2	28·5		
C. D. at 5 %	52·5	35·4	20·8	71·1	57·6		

TABLE VI—Analysis of Srinagar fruits obtained from different rootstocks during 1961

Characters	*% of juice*	*% of Rag and Peel*	*% of acidity*	*Total soluble solids*	*T. S.S./ Acid ratio*	*Vitamin C mgm. 100 gms. of juice*
Rootstocks						
Jambheri	42·3	56·8	·8750	9	10·3	15·0
Florida Rough	42·1	56·9	·9450	10	10·6	20·0
Seville orange	36·9	62·0	·7350	9	12·2	17·0
Sweet lime	38·4	60·7	·8750	10	11·4	22·0
Italian 76	40·2	58·5	·9100	10	11·0	18·0
Lime Sylhet	46·1	52·8	·9975	10	10·0	24·0
Karna Khatta	45·4	53·7	·9100	10	11·0	23·0

7. Incidence of diseases and deficiency symptoms

THE visual assessment of collar rot, zinc deficiency and winter chlorosis symptoms was done and is detailed below :

(*a*) *Collar rot disease.* Lime Sylhet and Seville orange stocks were observed to be fairly susceptible to this disease. Florida Rough, Italian 76 and Sweet lime were found to be quite resistant, whereas Karna Khatta and Jambheri stocks were ranked moderately resistant to this disease.

(*b*) *Zinc deficiency.* Almost all Srinagar trees on different root-stocks under the trial showed the interveinal chlorosis, although the extent of symptoms varied considerably. The plants on Florida Rough and Italian 76 were observed to show the minimum symptoms of zinc deficiency, while the trees on Lime Sylhet and Jambheri had pronounced symptoms. Seville orange, Sweet lime and Karna Khatta stocks had moderately pronounced symptoms.

(c) *Winter chlorosis.* Yellowing of leaves with veinal chlorosis was termed as winter chlorosis. Srinagar trees on Florida Rough and Karna Khatta were observed to have the least symptoms of this malady, whereas the trees on Lime Sylhet and Sweet lime had the most pronounced symptoms.

DISCUSSION AND CONCLUSION

THE present investigations reveal that Florida Rough excelled all other rootstocks, viz., Jambheri, Lime Sylhet, Seville orange, Italian 76, Sweet lime and Karna Khatta, in an overall assessment of their merits and de-merits for Srinagar scion variety of mandarins. The trees on this stock were maximum in stock girth, gave the largest sized fruits and were quite resistant to collar rot, zinc deficiency and winter chlorosis disorders. In scion girth and volume, the trees were second to those on Italian 76, whereas the yields were second only to those on Lime Sylhet stocks. However, this rootstock produced fruits of an average good quality as determined by physico-chemical analysis.

Karna Khatta was second in order of merit and had high juice percentage and vitamin C content, next only to those on Lime Sylhet. It produced trees of average vigour with average yields, fruit size and T. S. S./Acid ratio. The stock was moderately resistant to collar rot, zinc deficiency and winter chlorosis.

The trees on Lime Sylhet were rather moderate in vigour and produced highest yields with maximum juice percentage and vitamin C content. However, the fruits on this stock were lowest in T. S. S./Acid ratio and plants were very susceptible to collar rot, zinc deficiency and winter chlorosis.

Italian 76 proved to be superior to Jambheri in vigour, yield, T. S. S./Acid ratio and resistance to collar rot, winter chlorosis and zinc deficiency. The plants on Jambheri bore fruits of largest size next only to Lime Sylhet with average good quality.

Seville orange was observed to be the most inferior stock for Srinagar variety of mandarins and was preceded by Sweet Lime. The trees on Seville orange were poorest in vigour, juice percentage, yield and vitamin C content next only to Lime Sylhet stocks. Surprisingly enough the fruits on Seville orange had the best T. S. S./Acid ratio. Sweet lime stock gave the lowest yield with trees of poor vigour, fruit size, juice percentage and fair susceptibility to collar rot, zinc-deficiency and winter chlorosis.

Bhattacharya and Dutta (1) reported that Soh-myndong and Kata jamir (both *Citrus jambhiri*) were perfectly compatible with Khasi mandarins. Soh-sarkar (*C. karna*), however, produced normal trees but declined in later stages. The present results of Srinagar on Florida Rough support the conclusions of these workers with regard to their performance on *Citrus jambhiri* but differ with the performance of Karna Khatta. The performance of Srinagar scion on Karna Khatta was the second best and the trees were very healthy and vigorous. The performance of *C. jambhiri* as a suitable rootstock is supported by the performance of Hill variety of mandarin on Italian 76 and Florida Rough (8) and also by the results reported by various other workers (4, 9, 10).

Sour orange has been reported to be a poor rootstock by Dass (3), Phadnis (4) and Bhattacharya and Dutta (1) for mandarins. The present results with the Srinagar scion and those of Hill variety of mandarin reported earlier (8) are in full consonance with the results of these workers. The performance of Sweet lime rootstock with Srinagar variety of mandarin does not tally with the results of Brown

Table VII.—Showing the randing of different rootstocks for various characters

Characters	*Stock girth*	*Scion girth*	*Volume*	*Yield*	*Fruit size*	*Juice per cent.*	*Vitamin 'C'*	*T. S. S. Acid Ratio*	*Collar rot*	*Zinc Deficiency*	*Winter Chlorosis*
Jambheri	4	3	3	3	6	5	1	2	6.5	2	2
Florida Rough	7	6	6	6	7	4	4	3	5	6.5	7
Seville orange	1	1	1	2	4	1	2	7	1.5	3	3
Sweet lime	2	2	2	1	2	2	5	6	3	4	2
Italian 76	6	7	7	5	1	3	3	4.5	4	6.5	5
Lime Sylhet	3	4	4	7	5	7	7	1	1.5	1	1
Karna Khatta	5	5	5	4	3	6	6	4.5	6.5	5	6

(2) who reported Sweet lime to be the best rootstock for Sangtra. The present results find their support, also, from those of Hill variety reported by the author (8).

The comparative merits and de-merits of different rootstocks for Srinagar scion are summarized in Table VII. The performance of Srinagar on Florida Rough was found to be outstanding in the present studies. Karna Khatta occupied the second position while Seville orange gave the most unsatisfactory results.

SUMMARY

1. The performance of mandarin variety Srinagar was studied on Jambheri, Florida Rough, Seville orange, Sweet lime, Italian 76, Lime Sylhet and Karna Khatta rootstocks at the Horticultural Research Institute, Saharanpur.

2. Florida Rough was found to be the outstanding rootstock for the variety under study. Vigorous plants with high yields, large sized fruits and of good resistance to collar rot, zinc deficiency and winter chlorosis were the main qualities of this stock.

3. Karna Khatta was next to Florida Rough and produced fruits of high juice percentage and vitamin C content.

4. Seville orange, Sweet lime and Jambheri proved to be the inferior stocks while Lime Sylhet and Italian 76 were ranked average ones.

Under the wet sub-tropics with high temperatures, Florida Rough is recommended as the optimum stock for Srinagar variety of mandarin.

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