Agric. Res. J. Kerala 1SSP. 26 (2) 183-197

# EARLY PERFORMANCE OF MANDARIN ORANGES *(Citrus reticulata Blanco.) OH* DIFFERENT ROOTSTOCKS IN THE SUBMONTANE REGION OF WYNAD IN KERALA

V. S. Devadas, Jessy M. Kuriakose and K. Kannan

*Regional Agric. Research Station, Ambalavayal 673593, India*

Several studies have been conducted in India and abroad on the performance of commercial varieties of mandarin organge on different rootstocks (Brown, 1920; Singh and Nagpal, 1954; Singh and Singh, 1942; Batchelor and Bitters, 1952; Bajuo *et al.,* 1955; Aiyappa *et al.,* 1974). In the sub-montane region of Wynad in Kerala, mandarin orange cultivation was flourishing in the first half of this century. It received a serious set back in the forties and fifties on account of the baffling problem of what is generally known as si; citrus die-back syndrome. Stionic incompatibility was presumed to *ba* one of the several causes attributed to this malady. Earlier studies at Ambalavayal with Coorg mandarin budded on six rootstocks had indicated better, though inconsistent, performance on Carrizo citrange, Rough lemon and Troyer citrange (Indrasenan and Mammen, 1982). The present studies were initiated in 1980 at the Regional Agricultural Research Station, Ambalavayal, Kerala with five mandarin orange varieties and four rootstocks.

## Materials and Methods

The scions and rootstocks employed were:

| *Scions* | *Rootstocks* |
|---|---|
| 1 Kinnow mandarin | 1 Rough lemon *(C.jambhiri* Lush.] |
| 2 Satsuma ,, | 2 Trifoliate orange *(Poncirus trifoliata* (L) Raf.) |
| 3 Nagpur ,, | 3 Troyer citrange *(C sinensis x* |
| 4 Khasi ,, | *Poncirus trifoliata)* |
| 5 Coorg ,, | 4 Cleopatra mandarin (C. *reshni* Tenaka) |

The trial was planted in a randomised block design with three replications and 20 stionic combinations. There wera four plants/treatment/replication. Total number of experimental plants were 240.

The plants received uniform cultural, manurial and plant protection treatments. Growth measurements such as height, stock girth, scion girth and spread (north-south and east-west) were recorded every year during November-December. The stionic compatibility was evaluated in terms of scion/stock ratio (Singh, 1962). Age at first bearing and fruit yield were recorded. Qualitative evaluation of the fruits was also conducted as suggested by AOAC (1968).

## Results and Discussion

Measurements of tho plant height, spread, scion-girth and stock-girth were recorded from 1981 and the data for 1984, 1985 and 1986 are presented in Tables 1 and 2.

*Height*

The varieties differed significantly with respect to the height and the influence of rootstocks on plant height was also statistically significant. The interaction of scions x stock was not statistically significant. Among the scions, Coorg mandarin had the maximum height in all the season. It was superior to the other four scions, which were on par with each other. With respect to the rootstocks, Rough lemon was the most invigorating and it was on par with Cleopatra mandarin. Trifoliate orange induced dwarfness to the scions and its effect was statistically significant. Scions grown on Troyer citrange stocks were also comparatively smaller. The shoots and branches infested by shoot borer, were periodically removed. This has led to a reduction of plant height in certain combinations in 1985 and 1986.

*Spread*

North-south and east-west spread were also statistically significant between varieties and between rootstocks. The maximum spread in both direction was observed in Satsuma and Kinnow mandarins in all the years and these two varieties were on par with each other; Coorg mandarin was on par with Kinnow with respect to spread. The minimum spread of plants was for Nagpur and Khasi mandarins. The effect of rootstocks on the spread of scions was also statistically significant. Rough lemon induced more spread on scions; other rootstocks were on par with each other; the lowest spread of varieties was seen in those grown on Troyer citrange stocks, followed by those on Trifoliate orange.

*Scion girth*

The girth of scions above bud joint was significantly different between varieties only in 1985. However, in all the three years, the maximum girth of scion was recorded in Coorg mandarin. The girth of the scions was significantly influenced by the rootstocks. The maximum girth of scions was seen on varieties budded on Rough lemon, followed by those on Cleopatra, and the influences of these two stocks were on par. The lowest girth of scions was seen on scions budded on Trifoliate orange and Troyar citrange rootstocks. There was no significant scion x stock interaction with respect to the girth of scions.

*Stock girth*

The girth of rootstocks differed significantly in all the three years. However the influence of scions on stock girth was significant only in 1984. Girth of Rough lemon was the highest and was significantly higher than the other three stocks, The girths of Troyer citrange, Trifoliate orange and Cleopatra mandarin were on par.

*Scion/stock ratio*

The scion/stock ratio, a parameter of the stionic compatibility, was not influenced by the varieties, except in 1986. In 1983, stionic combinations with Coorg mandarin and Cleopatra mandarin had the highest scion/stock ratio. The scion/stock ratio was highly influenced by the rootstocks and the differences were statistically significant. The maximum scion/stock ratio and stionic compatibility was

observed whsn Cleopatra and Rough lemon were used as the stock. All the scions budded on Cleopatra stock showed smooth bud union with minimum stock scion girth difference and maximum scion/stock ratio in all the years followed by those budded on Rough lemon and Troyer citrange. Trifoliate orange showed severe bottleneck and minimum scion/stock ratio and its incompatibility was statistically significant.

*Precocity*

The plants started flowering and fruiting in 1983, about four years after planting, cent percent plants flowered in the stionic combinations Khasi on Rough lemon, Coorg mandarin on Trifoliate and Troyer citrange and Kinnow on Troyercitrange. Percentage of plants flowered in all the stionic combinations of Cleopatra stock was comparatively low.

*Fruit yield*

The mean number of fruits/plant and the average weight offruits during 1984, 19S5 and 1986 seasons are furnished in Table 3. In general, the yield was medium in 1984, highest in 1935 and very low in 1986. In 1986, many plants did not give any yield and hence the mean yield and other parameters recorded are also very low. The effect of scions on the yield of fruits was significantly different. In general, the highest yielders were Kinnow mandarin, Coorg mandarin and Satsuma. The lowest yielder, Nagpur mandarin was on par with Khasi mandarin. Satsuma was found to be a more or less stable variety with respect to the yield. Kinnow on Troyer citrange produced the highest yield both in number (461.25) and in weight (29.06 kg) per tree The over bearing of this stionic combination resulted in severe wilting and defoliation. The influence of rootstocks on the yield was found statistically significant only in 1984. However, the maximum yields were obtained from stionic combinations with Rough lemon stocks. Since the plants have not attained steady bearing it is too early to come to any conclusion with regard to the superiority in production of any stionic combination.

*Physical characteristics of fruits*

The mean physical characteristics of fruits such as volume, diameter, flesh weight, seeds, segments, juice percentage, percentage of rind and rind thickness and the score for organoleptic evaluations are presented in Table 4. It showed that the varieties differed significantly with respect to number of seeds, number of segments, percentage of rind and thickness of rind. Kinnow fruits significantly superior and had the maximum seeds/fruits (34.83), segments (11.68), percentage of rind (34.37) and rind (4.75). Satsuma fruits had minimum seeds/fruit (3.89) and segments (9.08). Fruit characters of other varieties were statistically insignificant. The percentage of rind and number of seeds of fruits were found to be decided by the root stocks. In general, fruits produced on Rough lemon had highest percentage of rind and those on Troyer citrange had the maximum seed. The effect of scion x stock interaction was significant with regard to seed content of fruits.

Table 1

Mean growth measurements of different stionic combinations

| Stionic combinations | Plant height (m) | | | Spread in N–S direction (m) | | | Spread in E-W direction (m) | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1984 | 1985 | 1986 | 1984 | 1985 | 1986 | 1984 | 1985 | 1986 |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| Kinnow on Rough lemon | 3.11 | 3.43 | 3.09 | 2.15 | 2.84 | 1.94 | 2,20 | 2.58 | 1.76 |
| Satsuma | 3.08 | 2.79 | 2.75 | 2.87 | 2.88 | 2.62 | 2.58 | 2.55 | 2.75 |
| Nagpur | 2.91 | 2.91 | 3.03 | 1.55 | 1.76 | 1.48 | 1.27 | 1.64 | 1.40 |
| Khasi ,, | 3.13 | 3.07 | 3.11 | 1.61 | 2.16 | 1.65 | 1.62 | 2.05 | 1.53 |
| Coorg | 3.69 | 3.87 | 3.61 | 2.19 | 3.10 | 1.74 | 2.17 | 2.88 | 1.67 |
| Kinnow on Trifoliate orange | 2.14 | 2.17 | 2.20 | 1.64 | 1.77 | 1.72 | 1.58 | 1.73 | 1.55 |
| Satsuma | 2.39 | 2.09 | 2.05 | 1.98 | 2.22 | 2.08 | 1.70 | 2.24 | 1.20 |
| Nagpur | 2.67 | 2.91 | 3.05 | 1.40 | 2.23 | 1.62 | 1.33 | 1.70 | 1.51 |
| Khasi | 2.85 | 2.86 | 2.88 | 1.46 | 1.89 | 1.64 | 1.88 | 1.91 | 1.68 |
| Coorg | 3.37 | 3.29 | 3.47 | 1.48 | 1.92 | 1.71 | 1.45 | 1.97 | 1.74 |
| Kinnow on Troyer citrange | 2.79 | 2.73 | 2.86 | 1.78 | 2.25 | 1.98 | 1.71 | 2.08 | 1.95 |
| Satsuma | 2.27 | 2.54 | 2.53 | 1.70 | 1.93 | 1.94 | 1.71 | 1.34 | 2.05 |
| Khasi | 2.98 | 3.23 | 3.17 | 1.34 | 1.90 | 1.64 | 1.25 | 1.94 | 1.61 |
| Coorg | 3.26 | 3.31 | 3.74 | 1.53 | 1.61 | 2.25 | 1.41 | 1.57 | 2.10 |
| Kinnowon Cleopatra | 3.25 | 3.19 | 3.14 | 2.21 | 2.69 | 2.11 | 2.26 | 2.26 | 1.80 |
| Satsuma | 2.77 | 2.91 | 2.67 | 2.48 | 2.52 | 2.36 | 2.60 | 2.44 | 2.32 |
| Nagpur | 3.18 | 3.24 | 3.39 | 1.50 | 1.77 | 1.71 | 1.59 | 1.74 | 1.60 |
| Khasi | 3.19 | 3.04 | 2.72 | 1.20 | 1.61 | 1.42 | 1.12 | 1.65 | 1.42 |
| Coorg | 3.17 | 3.26 | 3.20 | 1.49 | 1.93 | 1.65 | 1.39 | 2.02 | 1.60 |

**Table 1** (contd.)

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|
| *Varietal means* | | | | | | | | | |
| Kinnow | 2.82 | 2.88 | 2.82 | 1.94 | 2.39 | 1.94 | 1.94 | 216 | 1.77 |
| Satsuma | 2.63 | 2.59 | 2.50 | 2.26 | 2.39 | 2.25 | 2.15 | 2.27 | 2.28 |
| Nagpur | 2.84 | 2.98 | 3.08 | 1.38 | 1.82 | 1.50 | 1.30 | 1.66 | 1.43 |
| Khasi | 3.04 | 3.05 | 2.97 | 1.40 | 1.89 | 1.59 | 1.47 | 1.89 | 1.56 |
| CD for comparing varieties | 0.50** | 0.37** | 0.42** | 0.38** | 0.39** | 0.40** | 0.37** | 0.43** | 0.44** |
| *Rootstock means* | | | | | | | | | |
| Rough lemon | 3.18 | 3.21 | 3.12 | 2.07 | 2.55 | 1.89 | 1.96 | 2.34 | 1.82 |
| Trifoliate orange | 2.69 | 2.67 | 2.73 | 1.59 | 2.01 | 1.75 | 1.59 | 1.91 | 1.70 |
| Troyer citrange | 2.78 | 2.93 | 3.03 | 1.48 | 1.84 | 1.80 | 1.42 | 1.80 | 1.79 |
| Cleopatra | 3.11 | 3.13 | 3.02 | 1.78 | 2.10 | 1.85 | 1.79 | 2.02 | 1.75 |
| CD for comparing rootstocks | 0.34* | 0.33** | 0.28* | 0.34** | 0.35** | NS | 0.33** | 0.37** | NS |
| CD for variety x Rootstock interaction | NS | NS | NS | NS | 0.77** | NS | 0.74** | NS | NS |

* Significant at 5% level ** Significant at 1% level NS Not significant

Table 2

Mean girth of scion, stock and scion/stock ratio of different stionic combinations

| Stionic combinations | Plant height (m) | | | Spread in N - S direction (m) | | | Spread in E—W direction (m) | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1984 | 1985 | 1986 | 1984 | 1985 | 1986 | 1984 | 1985 | 1986 |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| Kinnow on Rough lemon | 24.83 | 28.83 | 29.11 | 30.38 | 35.62 | 36.81 | 0.82 | 0.81 | 0.79 |
| Satsuma | 26.83 | 28.89 | 29.33 | 32.83 | 36.24 | 39.00 | 0.82 | 0.80 | 0.76 |
| Nagpur | 22.62 | 24.02 | 28.06 | 26.92 | 28.71 | 31.17 | 0.83 | 0.83 | 0.89 |
| Khasi | 23.17 | 25.23 | 26.67 | 29.83 | 32.33 | 34.83 | 0.80 | 0.78 | 0.76 |
| Coorg | 30.05 | 32.40 | 32.92 | 37.17 | 41.03 | 41.25 | 0,81 | 0.79 | 0.80 |
| Kinnow on Trifoliate orange | 15.83 | 17.14 | 17.78 | 22.67 | 24.12 | 24.33 | 0.70 | 0.71 | 0.73 |
| Satsuma | 13.67 | 18.01 | 18.41 | 19.74 | 25.62 | 26.36 | 0.71 | 0.73 | 0.70 |
| Nagpur | 16.83 | 19.78 | 22.67 | 24.58 | 29.90 | 31.83 | 0.69 | 0.66 | 0.71 |
| Khasi | 18.92 | 21.75 | 23.78 | 29.00 | 33.00 | 34.44 | 0.66 | 0.66 | 0.69 |
| Coorg | 20.42 | 23.13 | 26.97 | 29.58 | 30.68 | 37.77 | 0.69 | 0.76 | 0.71 |
| Kinnow or Troyer citrange | 19.42 | 22.05 | 22.75 | 23.50 | 29.11 | 31.75 | 0.83 | 0.80 | 0.81 |
| Satsuma | 18.39 | 21.57 | 21.99 | 21.78 | 25.50 | 26 39 | 0.82 | 0.84 | 0.71 |
| Nagpur | 16.53 | 20.06 | 20.67 | 20.53 | 25.81 | 29.56 | 0.80 | 0.78 | 0.70 |
| Khasi | 21.53 | 24.69 | 24.99 | 26.58 | 29.87 | 31.31 | 0.81 | 0.82 | 0.77 |
| Coorg | 21.08 | 23.63 | 29.33 | 26.92 | 31.05 | 37.00 | 0.78 | 0.76 | 0.79 |

Table 2. (contd.)

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|
| Kinnow on Cleopatra | 24.62 | 27.70 | 27.50 | 28.58 | 31.40 | 32.27 | 0.86 | 0.88 | 0.85 |
| Satsuma | 22.05 | 25.05 | 25.08 | 26.33 | 29.25 | 30.92 | 0.86 | 0.86 | 0.80 |
| Nagpur | 22.17 | 26.64 | 31.17 | 26.54 | 31.60 | 34.42 | 0.83 | 0.84 | 0.90 |
| Khasi | 21.00 | 23.48 | 24.78 | 24.58 | 28.97 | 30.58 | 0.85 | 0.81 | 0.81 |
| Coorg | 22.42 | 27.21 | 28.00 | 26.50 | 29.74 | 30.75 | 0.85 | 0.91 | 0.91 |
| *Varietal means* | | | | | | | | | |
| Kinnow | 21.18 | 23.95 | 24.29 | 26.28 | 30.06 | 32.54 | 0.78 | 0.80 | 0.81 |
| Satsuma | 20.35 | 23.39 | 23.70 | 25.17 | 29.15 | 30.67 | 0.80 | 0.81 | 0.74 |
| Nagpur | 19.49 | 22.77 | 25.64 | 24.64 | 30.01 | 31.75 | 0.79 | 0.76 | 0.83 |
| Khasi | 21.15 | 23.79 | 24.80 | 27.50 | 31.04 | 32.79 | 0.78 | 0.77 | 0.76 |
| Coorg | 23.60 | 26.59 | 27.81 | 30.04 | 33.13 | 36.69 | 0.79 | 0.78 | 0.83 |
| CD for comparing varieties | NS | 3.30** | NS | 3.70 * | NS | NS | NS | NS | 0.08** |
| *Rootstock means* | | | | | | | | | |
| Rough lemon | 25.50 | 27.87 | 29.22 | 31.43 | 34.85 | 36.61 | 0.82 | 0.80 | 0.82 |
| Trifoliate orange | 17.13 | 19.96 | 21.92 | 25.11 | 28.67 | 30.20 | 0.69 | 0.70 | 0.71 |
| Troyercitrange | 19.39 | 22.51 | 2395 | 23.86 | 28.27 | 31.20 | 0.81 | 0.79 | 0.78 |
| Cleopatra | 22.51 | 26.04 | 27.39 | 26.51 | 30.19 | 31.79 | 0.85 | 0.84 | 0.86 |
| CD for comparing rootstocks | 3.65** | 2.20** | 4.79** | 4.43** | 4.13** | 3.86** | 0.05** | 0.06** | 0.07" |
| CD for variety x rootstock interaction | NS | NS | NS | NS | NS | NS | NS | NS | NS |

Significant at 5% level  Significant at 1% level  NS Not significant

Table 3

Mean fruit yield per plant of different stionic combinations

| Stionic combinations | Weight (kg) | | | Number | | | Average weight of fruits | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1984 | 1985 | 1986 | 1984 | 1985 | 1986 | 1984 | 1985 | 1986 |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| Kinnow on Rough lemon | 7.46 | 12.05 | 0.00 | 104.39 | 186.67 | 0.00 | 71.10 | 82.83 | 0.00 |
| Satsuma " | 11.74 | 10.03 | 12.65 | 140.66 | 115.97 | 109.42 | 70.76 | 87.68 | 78.27 |
| Nagpur | 4.62 | 10.36 | 2.38 | 47.22 | 119.00 | 24.06 | 102.15 | 82.30 | 66.56 |
| Khasi " | 5.49 | 9.27 | 2.20 | 39.67 | 116.44 | 26.00 | 160.89 | 86.27 | 88.72 |
| Coorg " | 6.59 | 20.12 | 5.94 | 47.92 | 196.17 | 38.09 | 139.83 | 103.83 | 93.26 |
| Kinnow on Trifoliate orange | 8.61 | 8.48 | 2.84 | 152.11 | 114.01 | 10.67 | 70.37 | 82.05 | 27.49 |
| Satsuma " | 1.28 | 7.18 | 3.91 | 10.17 | 112.31 | 40.44 | 82.91 | 65.50 | 32.25 |
| Nagpur | 2.27 | 7.34 | 1.23 | 18.75 | 68.75 | 13.58 | 116.66 | 106.17 | 57.65 |
| Khasi | 1.14 | 7.99 | 5.38 | 9.87 | 69.17 | 17.34 | 75.92 | 115.66 | 95.74 |
| Coorg | 4.54 | 7.81 | 8.08 | 35.17 | 75.33 | 80.72 | 104.19 | 98.66 | 91 37 |
| Kinnow on Troyer citrange | 12.37 | 29.08 | 0.09 | 188.67 | 461.25 | 9.92 | 67.67 | 70.62 | 33.33 |
| Satsuma " | 6.05 | 4.60 | 2.42 | 47.30 | 45.77 | 22.00 | 97.58 | 78.09 | 36.58 |
| Nagpur | 2.00 | 4.78 | 0.36 | 15.86 | 44.39 | 4.64 | 125.35 | 107.33 | 44.08 |
| Khasi | 2.05 | 4.84 | 1.32 | 20.17 | 64.78 | 15.33 | 98.26 | 76.02 | 56.99 |
| Coorg | 3.44 | 17.02 | 3.81 | 32.58 | 184.50 | 17.25 | 102.55 | 103.21 | 51.30 |

Table 3. (contd.)

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|
| Kinnow on Cleopatra | 3.87 | 16.95 | 0.31 | 47.40 | 230.03 | 4.75 | 85.63 | 82.52 | 43.26 |
| Satsuma | 5.18 | 8.64 | 4.04 | 45.97 | 99.59 | 47.58 | 114.64 | 98.67 | 99.07 |
| Nagpur | 1.43 | 5.96 | 0.09 | 12.67 | 51.32 | 0.89 | 104.95 | 113.90 | 26.67 |
| Khasi | 0.63 | 10.56 | 0.03 | 8.67 | 170.40 | 0.75 | 48.73 | 61.08 | 12.96 |
| Coorg | 4.61 | 6.81 | 1.01 | 40.94 | 76.08 | 13.00 | 73.68 | 93.80 | 75.42 |
| *Varietal means* | | | | | | | | | |
| Kinnow | 8.08 | 16.64 | 0.81 | 123.14 | 247.99 | 4.08 | 73.69 | 79.50 | 26.02 |
| Satsuma | 6.06 | 7.61 | 5.75 | 61.03 | 93.41 | 54.86 | 91.47 | 82.49 | 61.54 |
| Nagpur | 2.58 | 7.11 | 1.01 | 23.62 | 70.86 | 10.79 | 112.28 | 102.43 | 48.74 |
| Khasi | 2.32 | 8.17 | 2.23 | 19.59 | 150.20 | 14.86 | 95.95 | 84.76 | 63.60 |
| Coorg | 4.80 | 12.94 | 4.71 | 39.15 | 133.02 | 37.27 | 105.06 | 99.88 | 77.84 |
| CDforcomparingvarieties | 3.52** | 5.95" | 3.44* | 54.96** | 109.67** | NS | NS | 18.19* | 33.67* |
| *Rootstock means* | | | | | | | | | |
| Rough lemon | 7.18 | 12.37 | 4.63 | 75.97 | 146.85 | 39.51 | 108.95 | 88.58 | 65.36 |
| Trifoliate orange | 3.57 | 7.76 | 4.29 | 45.21 | 87.91 | 32.55 | 90.01 | 93.61 | 60.90 |
| Trover citrange | 5.18 | 12.06 | 1.60 | 60.92 | 160.14 | 12.03 | 98.28 | 87.06 | 44.45 |
| Cleopatra | 3.14 | 9.78 | 1.10 | 31.13 | 125.48 | 13.39 | 85.53 | 89.99 | 51.48 |
| CD for comparing rootstocks | 3.15** | NS | NS | NS | NS | NS | NS | NS | NS |
| CD for comparing root stock interaction | NS | NS | NS | NS | NS | NS | NS | NS | NS |

* Significant at 5% level ** Significant at 1% level NS -Not significant

Table 4

Mean physical characteristics of fruits

| Stionic combinations | Volume (cc) | Diameter (cm) | Weight of flesh (g) | No. of seeds per fruit | No.of segments per fruit | % of juice | % of rind to total weight | Thickness of rind (mm) | Score for organoleptic evaluation (10 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | |
| Kinnow on Rough lemon | 120.33 | 6.32 | 71.75 | 36.20 | 12 | 54.21 | 36.15 | 5.54 | 54 |
| Satsuma | 102.71 | 5.85 | 63.42 | 13.05 | 9 | 58.15 | 31.85 | 4.10 | 53 |
| Nagpur | 80.17 | 5.21 | 58.00 | 22.33 | 10 | 61.79 | 31.94 | 3.36 | 56 |
| Khasi | 84.67 | 5.26 | 63.39 | 21.96 | 10 | 60.56 | 30.59 | 3.41 | 72 |
| Coorg | 122.97 | 6.30 | 81.22 | 27.33 | 11 | 64.17 | 26.04 | 3.18 | 74 |
| Kinnow on Trifoliate orange | 100.13 | 5.38 | 76,33 | 30.33 | 12 | 54.56 | 32.99 | 4.61 | 63 |
| Satsuma | 102.17 | 5.25 | 53.58 | 3.02 | 9 | 65.79 | 30.72 | 3.59 | 72 |
| Nagpur | 114.19 | 6.22 | 81.48 | 20.73 | 11 | 64.42 | 24.61 | 2.89 | 84 |
| Khasi | 113.43 | 6.33 | 86.58 | 22.38 | 11 | 65.61 | 24.25 | 3.03 | 78 |
| Coorg | 121.67 | 6.31 | 86.67 | 25.55 | 11 | 64.14 | 21.74 | 6.28 | 75 |
| Kinnow on Troyer citrange | 106.88 | 5,96 | 63.42 | 38.12 | 12 | 59.65 | 33.00 | 4.28 | 43 |
| Satsuma | 102.33 | 5.77 | 62.67 | 4.56 | 9 | 64.68 | 29.85 | 3.36 | 59 |
| Nagpur | 138.11 | 6.40 | 90.89 | 25.68 | 1 ! | 64.47 | 25.68 | 3.23 | 81 |
| Khasi | 93.00 | 5.55 | 77.97 | 26.15 | 10 | 62.05 | 29.11 | 2.87 | 74 |
| Coorg | 103.17 | 5.73 | 72.33 | 26.11 | 11 | 58.38 | 24.91 | 2.22 | 58 |

Table 4 contd.

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|
| Kinnow on Cleopatra | 101 00 | 5.97 | 53.67 | 34.66 | 11 | 74.66 | 35.34 | 4.57 | 44 |
| Satsuma | 95.50 | 5.70 | 59.67 | 4.00 | 9 | 67.79 | 29,08 | 3.41 | 71 |
| Nagpur | 125.92 | 6.31 | 83.67 | 22.53 | 10 | 59.55 | 25,13 | 3.05 | 66 |
| Khasi | 62.17 | 4.91 | 52.33 | 18.53 | 11 | 44.49 | 31.37 | 2.17 | 77 |
| Coorg | 122.07 | 6.31 | 82.40 | 24.23 | 11 | 60.48 | 25.46 | 2,75 | 85 |
| *Varietal means* | | | | | | | | | |
| Kinnow | 107.09 | 6.16 | 66.29 | 34.83 | 11.68 | 60.77 | 34.37 | 4 75 | 51 |
| Satsuma | 100.68 | 5.64 | 59.33 | 3.89 | 9.08 | 64.10 | 30.37 | 3.61 | 63.75 |
| Nagpur | 114.60 | 6.04 | 78.51 | 22.82 | 10.40 | 62.56 | 26.84 | 3.13 | 74.25 |
| Khasi | 93.32 | 5.51 | 70.07 | 22.26 | 10.56 | 58.18 | 28.83 | 2.87 | 75.25 |
| Coorg | 117.47 | 6.16 | 80.66 | 25.81 | 13.52 | 61.79 | 24.54 | 2.71 | 73.00 |
| C D for comparing varieties | NS | NS | NS | 5.13** | 1.07** | NS | 6.34** | 0.89* | — |
| *Rootstock means* | | | | | | | | | |
| Rough lemon | 102.17 | 5.79 | 67.56 | 22.18 | 10.49 | 59.78 | 31.31 | 3.92 | 63.80 |
| Trifoliate orange | 114.32 | 6.10 | 76.93 | 20.59 | 10.42 | 62.90 | 26.86 | 3.36 | 74.40 |
| Troyercitrange | 108.70 | 5.88 | 73.45 | 24.13 | 10.55 | 61.85 | 28.51 | 3.19 | 63.00 |
| Cleopatra | 101.33 | 5.84 | 66.35 | 20.79 | 10.34 | 61.39 | 29.28 | 3.19 | 68.60 |
| CD for comparing rootstocks | NS | NS | NS | 3.49* | NS | NS | 4.32* | NS | — |
| CD for variety x rootstock interaction | NS | NS | NS | 2.29" | NS | NS | NS | NS | — |

Significant at 5% level »* Significant at 'l %level NSi Not significan

Table 5

Mean quality parameters of fruit juice

| Stionic combination | TSS % | Acidity % | Reducing sugars % | Non-reducing sugars % | Total sugars % | Sugar/ acid ratio |
|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| Kinnow on Rough lemom | 7.33 | 0.15 | 1.54 | 0.49 | 2.03 | 13.53 |
| Satsuma | 5.73 | 0.21 | 2.26 | 3.75 | 6.01 | 28.62 |
| Nagpur | 6,20 | 0.20 | 3.32 | 0.67 | 3,99 | 19.95 |
| Khasi | 5.27 | 0.51 | 1.77 | 1.82 | 3.65 | 7.16 |
| Coorg | 7.07 | 0.98 | 1.91 | 0.27 | 2.18 | 2.22 |
| Kinnow on Trifoliate orange | 6.40 | 2.15 | 1.41 | 0.34 | 1.75 | 0.81 |
| Satsuma | 7.13 | 0.15 | 1.89 | 1.08 | 2.97 | 19.80 |
| Nagpur | 6.73 | 1.50 | 3.48 | 0.55 | 4.03 | 2.69 |
| Khasi | 7.87 | 0.97 | 2.14 | 3.64 | 5.78 | 5.96 |
| Coorg | 7.07 | 0.95 | 1.02 | 2.02 | 3.04 | 3.20 |
| Kinnow on Troyer citrange | 8.07 | 2.22 | 1.55 | 0.75 | 2.30 | 1.04 |
| Satsuma | 5.47 | 0.83 | 1.05 | 0.88 | 1.93 | 2.33 |
| Nagpur | 7.13 | 0.95 | 1.19 | 0.31 | 1.50 | 1.58 |
| Khasi | 7.13 | 0.77 | 1.07 | 1.91 | 2.97 | 3.86 |
| Coorg | 7.20 | 0.81 | 2.34 | 0.94 | 3.28 | 4.05 |

**Table 5 contd.**

| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|
| Kinnow on Cleopatra | 8.53 | 2.19 | 1.58 | 0.84 | 2.42 | 1.11 |
| Satsuma ,, | 7.27 | 0.89 | 2.21 | 1.59 | 3.80 | 4.27 |
| Nagpur | 7.33 | 1.27 | 1.27 | 0.51 | 1.78 | 1.40 |
| Khasi | 6.20 | 1.21 | 1.87 | 0.84 | 2.70 | 2.23 |
| Coorg ,, | 7.33 | 0.94 | 1.09 | 0.86 | 1.95 | 2.07 |
| *Varietal means* | | | | | | |
| Kinnow | 7.58 | 1.68 | 1.52 | 0.60 | 2.12 | 1.26 |
| Satsuma | 6.40 | 6.52 | 1.85 | 1.82 | 3.68 | 7.08 |
| Nagpur | 6.85 | 0.98 | 2.31 | 0.51 | 2.83 | 2.89 |
| Khasi | 6.62 | 0.86 | 1.71 | 2.05 | 3.78 | 4.40 |
| Coorg | 7.17 | 0.92 | 1.59 | 1.02 | 2.61 | 2.84 |
| CD for comparing varieties | 0.80** | 0.02** | 0.26** | 0.26** | 0.17** | |
| *Rootstock means* | | | | | | |
| Rough lemon | 6.32 | 0.41 | 2.16 | 1.40 | 3.57 | 8.71 |
| Trifoliate orange | 7.04 | 1.14 | 1.99 | 1.92 | 3.51 | 3.08 |
| Troyer citrange | 7.00 | 1.12 | 1.44 | 2.96 | 2.40 | 2.14 |
| Cleopatra | 7.33 | 1.30 | 1.60 | 0,93 | 2.53 | 1.95 |
| C D for comparing rootstocks | 0.71** | 0.02** | 0.23** | 0.24** | 0.15** | |
| C D for variety x rootstock interaction | 1.59 * | 0.04** | 0.51** | 0.53 | 0.34** | |

Significant at 5% level  Significant at 1% level  NS Not significant

The maximum score (85) under organoleptic test was secured by fruits of Coorg on Cleopatra stock and Nagpur on Trifoliate (84). In general, quality fruits were produced by Khasi, Nagpur and Coorg and those produced on Trifoliate and Cleopatra stocks had better taste.

*Quality of fruitjuice*

The mean quality parameters of fruit juice such as percentage of total soluble solids (TSS), acidity (citric) reducing sugars, non-reducing sugars and total sugars are furnished in Table 5. The varieties differed significantly with respectto the quality of fruit juice. The effect of rootstocks and the rootstock x scion interaction also significantly influenced the quality of fruit juice. The highest percentage of TSS was observed in Kinnow and Coorg mandarins and these were on par. The acidity, reducing sugar, non-reducing sugar and total sugar were also maximum in Kinnow fruits. The proper balance of sugar and acidity, indicated by sugar/acid ratio was found better in Kinnow, Coorg and Nagpur oranges and Satsuma was inferior to all other varieties. With regard to the rootstocks, Cleopatra induced the maximum TSS and minimum sugar/acid ratio; fruits produced on Cleopatra stocks were better in quality. The quality of fruits produced on Rough lemon stocks was comparatively poor, with the lowest TSS and highest sugar/acid ratio.

The study revealed that Rough lemon was the most invigorating rootstock, followed by Cleopatra. The stionic compatibility was also higher on Rough lemon and Cleopatra stocks. Trifoliate orange and Troyer citranges were found to induce dwarfness on the scions; trifoliate stocks had the highest stionic incompatibility too. Among the scions, Coorg and Kinnow mandarins were superior with regard to the growth parameters. Among tha stionic combinations, Coorg mandarin on Rough lemon was the best in respect of all biometric characters. Superiority of Rough lemon as a vigorous rootstock for Coorg mandarin in Coorg, a region of similar agroclimatic conditions as Wynad, had been reported earlier (Aiyappa, 1964 and Aiyappa, 1974). The invigorating nature of Rough lemon and dwarfing effects of Trifoliate orange as rootstocks were also reported by Janick (1979) and Castle (1987).

With regard to precocity, Coorg mandarin on Rough lemon was slightly late to flower, compared to other scions budded on Rough lemon. Cleopatra delayed flowering of all the scions while Trifoliate orange and Troyer citrange induced early flowering.

Since the plants are only about six years old, it is too early to draw any conclusions on the productivity in various stionic combinations. However, comparatively higher yields and poor quality of fruits obtained on stionic combinations with Rough lemon rootstock and the better quality fruits obtained from stionic combinations with Cleopatra rootstocks are in conformity with the reports of Janick (1979) and Castle (1987), More definite conclusions can be drawn only after continuing the experiment for some more years.

## Summary

Twenty stionic combinations involving scions of five mandarin orange varieties and four rootstocks were evaluated for their performance under the agro-climatic conditions of Wynad, Kerala since 1980. The first six years study showed that Coorg mandarin on Rough lemon was the most vigorous combination in respect of all the biometric characters recorded. Rough lemon was the most invigorating rootstock, while Trifoliate stock induced dwarfness of scions. Though it was too premature to assess the yield potential, data recorded in 1984, 1985 and 1986 showed that Coorg mandarin on Rough lemon was comparatively higher in yield than most other combinations. With regard to quality also, it was on par with other combinations. Further studies will be continued.


## References


Aiyappa, K. M. 1964. *A. Rep. Reg. Fruit Res. Stn.* Chethali, Coorg

Aiyappa, K. M., Srivastava, K. C. anc Nanaya, K. A. 1974. Results of rootstock trial on mandarin in Coorg. *Indian J. Hort.* **31** (3): 199-212

AOAC, 1968. *Official Methods of Analysis.* 10th edn. Association of Official Agricultural Chemists, Washington, D. C.

Bajuo, Singh, B. and Nagpal, R. L. 1955. Citrus rootstock trials in Punjab. *Indian J. Agric. Sci.* 12:91-107

Batchelor, L. D. and Bitters, W. P. 1952. Two promising rootstocks in citrus in California. *Calif. Citrogr,* 37:390

Brown, W. R. 1920. The orange—A trial of rootstocks of Pashwar. *Pusa agric. Res. Inst. Bull.* 93:7-12

Castle, W. S. 1987. Citrus rootstocks. *Rootstocks for Fruit Crops.* ed. Rom. R. C. and Carlson, R. F., John Wiley & Sons, New York. pp. 369-387

Indrasenan, G. and Mammen, M. K. 1932. Performance of Coorg mandarin on different rootstocks under the agro-climatic conditions of Wynad. *Agric. Res. J. Kerala* 20 (1):19-25

Janick, J. 1979. *Horticultural Reviews—Volume I.* AVI Pub. Co. Inc., West Fort pp. 239-255

Singh, L, and Singh, S. 1942. Citrus rootstock trials in Punjab-1. Vigour of young trees of sweet orange, mandarin and grapefruit influenced by different rootstocks. *Indian J. agric. Sci.* 12:381-399

Singh, S. and Nagpal. R. L, 1954. Citrus rootstocks trial in Punjab. *Indian •>' agric. Sci.* 24:73-108.

Singh, L. B. 1962. Studies on the rootstocks for mandarins in the wet subtropics. 1. Variety: Srinagar. *Indian J. Hort.* 19:1-9.