

CITRUS ROOTSTOCKS SCENARIO WITH SPECIAL REFERENCE TO INDIA - A REVIEW

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ABSTRACT

Trials conducted in various parts of the country and abroad provided detailed information on usefulness of different rootstocks for citrus fruits which varies greatly with scion variety and agro-climatic conditions. Citrus plants are unusual in that many species and cultivars, including the commercial rootstocks, reproduce true to type from seed. Commercial citrus rootstock cultivars are highly polyembryonic but there can be 1-40 zygotic seedlings in the seed bed. In spite of susceptibility to various *phytophthora* diseases and restricted longevity, rough lemon has been the most time tested and widely used rootstock in India. However, attempts to develop better substitute rootstock have shown Cleopatra mandarin (*Citrus reshni*), Rangpur lime (*Citrus limonia*), pectinifera (*Citrus pectinifera*). Some of the citranges and Alemow (*Citrus macrophylla*) are found to be promising rootstocks in certain parts of the country.

Citrus rootstocks have varied effects on scion vigour and size, fruit yield and quality and tolerance to various biotic and abiotic stresses. These also differ in their adaptability to various soils and mycorrhizal dependency (Castle, 1987; Ford, 1959; Nemec, 1978). Horticultural performance of citrus scion cultivars is affected by rootstocks in several ways viz. (i) Precocity in bearing (ii) Uniform tree size (iii) Cropping and fruit quality control (iv) Tolerance to unfavourable soil factors such as salinity, high pH and poor drainage and (v) Tolerance to *Phytophthora*, parasitic nematodes and viruses (Wutscher, 1979).

Budding or grafting of citrus was common standard practice in the 16th and 17th centuries. *Phytophthora* foot rot disease, which was first observed in the Azores in 18th century and forced European growers to bud on resistant rootstocks (Chapot, 1975). The performance/adaptability of citrus rootstocks varies greatly with scion variety and agro-climatic conditions. Therefore, it is of utmost importance to select the best performing rootstock for a given variety in a given region to attain maximum productivity and quality. Several rootstock trials of citrus have been conducted in India since 1920 using mandarins, sweet

oranges, acid lime, lemon, grapefruit and pummelo as scion variety. Horticultural characteristics of rootstocks are important, especially their influence on yield and fruit quality, but disease resistance became a key aspect of rootstock development since 50 years ago (Fawcett 1934; Wutscher, 1977). The early trials usually compared only sour orange, rough lemon, trifoliate orange, and sometimes Cleopatra mandarin or grapefruit for suitability in particular area (Wutscher, 1979). In India citrus rootstock situation was reviewed by Chadha *et al.* (1970) and Agrawal (1982). Chadha and Singh (1990) summarised the information on the basis of horticultural performance of the rootstocks to the stress (Table 1). The information on the rootstocks used in different parts of India is compiled in Table 2. This review attempts to compile the work done in India and abroad with regards to relationship between various rootstock and scion cultivars by the turn of 21st century.

Rootstock effect on polyembryony of seeds

Citrus is unusual in that many species and cultivars, including the commercial rootstocks, reproduce true to type from seed. The seeds are polyembryonic, the extra embryos arising apomictically by nucellar

Table 1. Characteristics of some selected rootstocks (Chadha and Singh, 1990)

Rootstocks	Horticultural performance				Reaction to the stresses					
	Yield	Quality	Plant vigour	Root system	Biotic Stress				Abiotic	
					Root rot	Exocortis	Tristeza	Nematode	Salt	Drought
Cleopatra mandarin	M	M	M	M	T	R	R	S	HT	D
Carizo citrange	M	G	M	SH	MT	S	MT	T	HS	HS
Sour orange	G	G	M	D	R	T	HS	T	T	MT
Kharna Khatta	G	M	M	D	S	T	-	MT	T	S
Marmalade orange	G	M	G	D	MT	S	R	MT	R	R
Nasharan	M	G	M	M	S	R	T	MT	HT	S
Rangpur Lime	G	M	G	D	MT	S	R	S	R	R
Rough lemon	G	L	G	D	S	R	R	S	T	T
Sweet lime	M	M	G	M	S	S	S	MT	S	S
Sweet orange	G	G	M	M	HS	R	MT	HS	S	S
Trifoliate orange	L	M	L	D	R	H	R	R	HS	HS
Troyer citrange	M	G	M	SH	MT	S	MT	T	HS	HS

G = Good, M = Moderate, L = Low, R = Resistant, T = Tolerant, MT = Moderately tolerant,

S = Susceptible, D = Deep, M = Medium, SH = Shallow, - = No information.

Table 2. Properties of some rootstocks (Samson, 1986)

Rootstocks	Root rot	Tristeza	Exocortis	Nematode	Drought and Salt	Production	Quality
Sour orange	4	0	4	2	2	2	4
Sweet orange	1	4	3	2	2	3	4
Rough lemon	0	3	3	1	2	4	1
Milam lemon	0	4	3	3	2	3	2
Cleopatra mandarin	2	4	0	2	4	4	3
Rangpur lime	2	4	0	2	4	4	3
Sweet lime	3	2	1	1	2	2	2
Troyer citrange	3	4	1	3	1	3	4
<i>P. trifoliata</i>	4	4	0	4	0	2	4

Scale : 0 = Very bad, 1 = Bad, 2 = Moderate, 3 = Good, 4 = Very good

embryony. Some citrus types are monoembryonic. They are usually eliminated as potential rootstocks because they produce only zygotic seedlings, which are highly variable (Castle, 1987). Commercial citrus rootstock cultivars are highly polyembryonic, but there can be, depending on the cultivars, from 1 to 40 % zygotic seedlings in the seedbed (Wutscher, 1979). Seed source should be carefully selected for being true to type and virus free, because seed transmission of psorosis virus is possible (Bridges *et al.*, 1965 and Newcomb, 1977). The polyembryonic seeds have one extra embryo arising apomictically

from the nucellus. The extent of nucellar embryony ranges among rootstocks from 100 %, where virtually all plants in a stand of seedlings are of nucellar origin to less than 50% (Castle 1987). Jambhiri, Italian-76 and Rangpur lime produced 91, 98 and 82 per cent nucellar seedlings respectively.

Motilal (1963) observed that the number of embryos per seed was 4.7 in Jambhiri (*Citrus jambhiri* Lush), 4.45 in Italian lemon and in Galgal (Hill lemon, *Citrus pseudolimon* Tanaka) with a range of 1 to 11 in citrus species. Galgal (*Citrus pseudolimon*, Tanaka) and Sadaphal (*Citrus semperflorens*) had 90 and

95 per cent polyembryonic seeds, respectively. Singh (1964) reported that Jambhiri (*Citrus jambhiri* Lush) had maximum number of embryos (4.7) followed by sweet lime (*Citrus limettioides* Tanaka), Kharna khatta (*Citrus karna* Raff), Hill lemon (*Citrus pseudolimon* Tanaka) with minimum in sour lime (1.35). Prasad and Ravishankar (1982) reported that citrumelo, Cleopatra mandarin, Pomeroy trifoliolate and rough lemon could be ideal rootstocks for obtaining high proportions of nucellar seedlings by virtue of their higher seed number per fruit. Sharma (1982) observed highest polyembryony in Jatti khatti (rough lemon) (46.9 %) followed by Cleopatra mandarin (*C. reshni* Tanaka) (37.98 %), Pectinifera (*C. pectinifera*) (29.66 %) and Kharna khatta (*C. karna* Raf) (10.5 %), Savage citrange (11.3 %), Carrizo citrange (11.1 %) and Rangpur lime (6.9 %) at different stages of fruit maturity. Prasad and Ravishankar (1983) claimed 100 per cent polyembryony in Rusk citrange and trifoliolate orange and 93.3 % in Swingle citrumelo, 86.6 % in Troyer citrange, 73.3 % Carrizo citrange and there was no relationship between percentage polyembryony and seed morphology.

Rootstock effects on bud take

Mukharjee and Singh (1966) observed that October was the best time for budding Pineapple, Sweet orange on *Citrus jambhiri* under Delhi condition Bud-take, sprouting and bud survival of *C. sinensis* and *C. reticulata* on *C. karna* was highest during February under Udaipur conditions (Sen and Kapadia, 1984). Dhillon (1966) reported that budding success rootstock varies to rootstocks. In Punjab, the bud-take of Kinnow on *C. jambhiri* was 98 per cent with better subsequent growth when round buds without wood were used than by using angular buds with or without wood (Sharma and Sharma, 1986).

Mandge and Chakrawar (1981) reported that bud-take of Nagpur mandarin and

nucellar sweet orange cv. mosambi was highest on Rangpur lime (95 %) followed by *Poncirus trifoliata* (90 %), lemon (*Citrus limon*, Burm) and rough lemon (88%) and lowest on Cleopatra mandarin (40%). Ganpathy *et al.* (1985) reported that pinched seedlings of *P. trifoliata* and Rangpur lime gave higher bud-take of Coorg mandarin. Shinde *et al.* (1997) reported the bud-take was highest on *C. macrophylla*, rough lemon, Chethalli and Calamondin rootstock while it was lowest on wood apple and Carrizo citrange rootstocks. Gongales and Figusroa, (1994) reported that Cleopatra mandarin, a sour orange x grapefruit hybrid, R. angpur lime (*Citrus limonia*) and Troyer citranges were grown from seed and evaluated as rootstock for Orlando tangelo % graft success was greatest (100%) with Cleopatra mandarin rootstocks, followed by Sour orange and Grapefruit (90%).

Incompatibility

The rootstock/scion combination that did not produce healthy, vigorous trees and led to early decline is termed as incompatible. Incompatibility may be due to genetic or physiological incongeniality between stock and scion. Naik (1948) observed the incompatibility of acid lime with *Gajanimma* rootstock where only 22.22% of trees had smooth bud joints as compared to 72.22% in acid lime and 61.11% in Jambhiri. Incompatibility of Kagzi lime on *C. Karna* and *Poncirus trifoliata* (Singh, 1961). Carrizo citrange, C-32, C-35 and Cleopatra mandarin showed incompatibility (Lallan Ram *et al.*, 1999). The highest incompatibility ratio on Kharna khatta and lowest on Rubidoux were observed with Kinnow mandarin (Dhillon *et al.*, 1993). Incompatibility of rootstock and scion has been reported in Nagpur mandarin over Kandhia local of Karun (identical to Kichilli) in Orissa (Anonymous, 1960) and in Khasi mandarin over *C. karna* in Assam (Nandi *et al.*, 1943). Singh *et al.* (1978) reported that trees of Kinnow manda-

rin had lowest mortality on Troyer citrange whereas symptoms of bark splitting were prominent on trifoliate orange and Carrizo citrange. Rough lemon, Rangpur lime, Cleopatra mandarin and sour orange exhibited smooth bud union and formed congenial stionic combination (Lallan Ram *et al.*, 1999).

The incompatibility was reported in the combination of Blood Red over rough lemon and citron in Punjab (Bakshi and Dhillon, 1961; Singh and Singh, 1944). Mosambi on Jatti khatti, Troyer and Carrizo citrange, Rangpur lime, citrumelo, pectinifera and Jambhiri showed poor compatibility as plants die at very early stage (Mehrotra *et al.*, 1982). Incompatibility was also reported in case of Mosambi over Rough lemon in erstwhile Bombay State (Nagpal, 1959) and Sathgudi over Jambhiri in Andhra Pradesh (Chellappa *et al.*, 1961). Sharma *et al.* (1978) reported smooth bud union of Jaffa and Valencia late and configuration with Pineapple and mosambi on Troyer citrange. In view of good performance shown by the stionic combination, Rangpur lime induced smooth union (Jagtap *et al.*, 1999).

Root distribution

Aiyappa and Srivastava (1965) reported that the roots of 1.5 year old Coorg mandarin seedlings penetrated vertically upto 41" and spread laterally upto 63" in healthy trees, 45" and 57" in less chlorotic trees and 38" to 36" in severely affected trees. Iyengar *et al.* (1988) reported that in 6 year old Coorg mandarin trees, most of the activity (78-88 %) was located within the top 15 cm of the soil and 80-95 % was confined within the radius of 120 cm. Allurwar and Parihar (1992) stated that on the basis of rootstock grading Coorg was observed to be the best owing to better tap root length, more number and length of lateral roots, higher dry weight of top and feeder roots in comparison to other rootstocks. Cleopatra followed the Coorg but dry weight

of feeder roots was equal in both the rootstocks. Both rough lemon and Rangpur lime which are popular rootstocks in orange growing in Vidarbha region had less spreading root system as compared to Coorg and Cleopatra mandarin and latter rootstocks may substitute the present rootstock in times of water scarcity.

Tayde *et al.* (1985) stated that the Jambhiri had the longest primary roots followed by sour orange and Nasnaran (*C. amblycarpa*) had the shortest primary roots. Mishra *et al.* (1999) reported that most of the feeder roots were confined to the surface layer (0-20 cm) of soil and at closer radial distance (0-60 cm) from the tree trunk in lemon.

Gill *et al.* (1999) observed maximum length of all type of roots in Cleopatra mandarin followed by Jatti khatti and Troyer citrange. The length of feeder roots was highest at a radial distance of 0-75 cm and at a soil depth of 0-15 cm. The maximum fresh and dry weight of all types of roots was recorded in Cleopatra mandarin rootstock. Sukhbir *et al.* (1999) reported that the rootstock Pectinifera (*Citrus pectinifera*) showed significantly more dry weight of fibrous, thin and medium roots in soil depths of 0-20 cm at a radial distance of 60-120 cm, 0-60 cm at a radial distance of 40-60 cm and 20-40 cm at a radial distance of 120-180 cm from the trunk and significantly lesser dry weight of the roots in all the 12 root zones studied of wherever thick roots were observed as compared to Jatti khatti. Roots were mainly affected by the rootstock, however the scion exerted a little influence. Similar observations were recorded at Pant nagar with Grapefruit budded on trifoliate orange wherein maximum volume and dry weight of fibrous roots were recorded at 60-120 cm radial distance x 0-20 cm depth followed by 120-180 cm radial distance x 0-20 cm depth (Singh and Mishra, 2000).

Kurien *et al.* (1992) found the maximum root activity of Troyer citrange and

Kharna khatta with scion of Kinnow within 80 cm radius and 24 cm depth and 120 cm radial and 16 - 24 cm depth respectively. Kurien *et al.* (1991) also reported that acid lime cv. Kagzi lime on Kharna khatta showed most activity (75-80 %) within the radius of 80 cm and depth of 16-24 cm. Devy and Supriyanto (1991) reported the best root system found on Schaub rough lemon, Brazilian sour orange, and *C. amblicarpa* under Indonesia conditions. Bhambota *et al.* (1979) observed the marked difference in the growth habit of root between citrus species as Kharna khatta and Sylhet lime had deep penetration of root system while grapefruit, Galgal and sweet lime was surface feeder. Jatti khatti was in between these groups. The grapefruit roots had the largest number of laterals of the greatest length. Chandra *et al.* (1979) stated that maximum root activity of Eureka round lemon (6 years old) at a depth of 20 cm in summer (April to June) but the difference in root activity was not significant at different radial distances (60, 120 and 180 cm). In post monsoon period (Sept. to Nov.) root activity at different depths showed no significant differences but it was the highest at a radial distance of 60 cm.

Rootstock effect on growth

On Volkamer lemon, Oklawale sweet orange had large canopy volume and high yield in contrast to trees on Savage citrange, Cleopatra mandarin and Alemow (Fallahi, 1992). Over the nine years production period on Palestine sweet lime, three rough lemon rootstocks and *C. volkameriana* were more productive per unit of tree size and their yield than other rootstocks in Cyprus condition on Marsh grapefruit (Economides and Gregorion, 1993). The smallest Nagpur mandarin tree were produced on Flying dragon, Rich 16-6 (both *Poncirus trifoliata*) these rootstock also produced the smallest increase in canopy volume over the three years trial period (Singh and Dass, 1999).

Phadnis (1961) found sweet lemon, Jatti khatti and Jambhiri as most vigorous rootstocks for Nagpur mandarin, whereas sour orange had poor vigour, at Katal (Maharashtra), Deshpande *et al.* (1977) using 6 rootstocks of Galgal, Jambheri, Jatti khatti, Karna khatta, Seville lime and sweet lime found Jambheri and Jatti khatti imparting maximum vigour to Nagpur mandarin scion. Dhillon *et al.* (1993) reported Jatti khatti produced greatest canopy volume (24-26.4 m³) and Rubidoux the smallest in case of Kinnow mandarin (14.8-15.4 m³). Deshmukh *et al.* (1977) using 42 rootstocks for Nagpur mandarin at Katol reported that Jambheri (Kadimbag) performed better while Mahalung and Lucknow lemon proved medium in vigour and rough lemon (Shrirampur) and Kata jamir also seemed worth considering. Trees growth was significantly higher in Troyer citrange followed by Rough lemon and Carrizo citrange (Ramkumar and Ganpathy, 1992). Results from 8 year old plants suggested that Rangpur lime, Roughlemon, Troyer citrange, Citrumelo, Trifoliolate orange and Sunki mandarin were found to be vigorous rootstocks (plant height 2.67 + -0.28 m) followed by Baduvapuli, Cleopatra mandarin and Kodakithuli. Belladakithuli was found to be the least vigorous rootstock with a plant height of 1.73 m recording the lowest girth union of 19 cm compared to the highest 34 cm in Citrumellow (Ganpathy *et al.*, 1999). Plants on Jambheri and Trifoliolate orange produced better growth, yield and survival during 9 years of trial (Mishra *et al.*, 1995). Kinnow trees on Marmalade orange rootstock proved most vigorous and productive (Tayade *et al.*, 1995).

Orlando tangelo trees on Carrizo citrange, Yuma citrange, Taiwanica and Volkamer lemons had longer canopy and higher yield (Fallahi *et al.*, 1991). Plant growth measured as change in canopy diameter and plant height was most vigorous and fruit number,

average weight and diameter were greater in Volkameriana than in those on Cleopatra mandarin (Valburene, 1996).

In a series of experiments conducted at Coorg, Aiyappa *et al.* (1967, 1973) found that out of lime Baduvapalli, Belladakithuli, Naichakotha, rough lemon (Coorg strain), sour orange, pummelo, lime sadaphal, grapefruit, Kodaikithuli lemon, Molepuli and seedling Coorg (control) with Coorg mandarin, sour orange and rough lemon gave higher scion/stock ratio of 0.94, 0.93 and 0.91 respectively as compared to other rootstocks. Bopai *et al.* (1983) reported that trees of Coorg mandarin were appreciably taller than *P. trifoliata* rough lemon strains imparted vigour to scion tree for Nagpur mandarin (Diware *et al.*, 1997). Bhattacharya and Dutta (1952) found that out of Birajora, patilimbu, Panijamir, Sohmyndong, Katajamir, Sohsarkar, Karanjamir, Rababatenga, Salkara and Adajamir, Sohmyndong and Katajamir were very vigorous with Khasi mandarin, the height and spread of the tree being 420 cm to 517.5 cm and 385.4 cm to 487.3 cm, respectively. Singh *et al.* (1978) using 17 rootstocks at IARI, New Delhi, showed that Sohsarkar proved the most vigorous rootstock giving 235 cm plant height and 4.11 m³ volume of Kinnow mandarin. Chohan *et al.* (1978) found that Jatti khatti followed by Karna khatta gave maximum vigour with 26.6 m³ as tree volume of Kinnow mandarin.

In the trials conducted in southern parts of the country particularly Coorg, Hassan and Chickmanglore in Karnataka, Wynaad and Palghat district in Kerala, Ootacamund and Madurai district in Tamilnadu, rough lemon proved best as rootstock for Kinnow mandarin (Srivastava and Bopaiah, 1978). Marmalade orange appeared to be the best rootstock for Kinnow mandarin at Akola and Cleopatra mandarin and Rangpur lime at Bhatinda (Anonymous, 1991). Rangacharlu *et al.* (1958)

observed that sweet-orange rootstock itself was having greater potentialities of success for Sathgudi orange in Kodur area (south India) in comparison of Gajanimma and Jamberi. In case of acid lime Gajanimma was the most suitable rootstock for certain parts of Andhra Pradesh (Rao *et al.*, 1970).

Rao *et al.* (1971) further recommended Sathgudi rootstock for Sathgudi scion. They also observed that woodapple (*Feronia limonia*) had marked dwarfing effects. Mehrotra *et al.* (1977) reported that Blood Red orange on Jatti khatti excelled all other rootstocks in volume followed by Cleopatra mandarin whereas, trees on Rangpur lime on Kharna khatta made poor growth. Mann and Naurial (1978) revealed that Jamberi was the most vigorous rootstock for pineapple sweet orange followed by Jullundhari and grapefruit. Mehrotra *et al.* (1982) observed highest tree volume of Mosambi on Jatti khatti followed by Rangpur lime. Chohan and Kumar (1983) stated that the best results were obtained on Rangpur lime with Mosambi scion. Under Bangalore conditions, 9 rootstocks were evaluated for Mosambi and results revealed that highest tree height (312 cm) and volume (20.41 m³) were recorded on rough lemon followed by Rangpur lime 295 cm and 19.03 m³ (Mustafa and Reddy, 1990). *Poncirus trifoliata* and its hybrids induced dwarfiness.

Chohan *et al.* (1986, 1988 and 1990) revealed the vigorous vegetative growth of grapefruit cultivar Marsh seedless on Carrizo citrange rootstock followed by Jatti khatti and Troyer citrange. Singh and Nagpal (1954) recommended Nasnaran, Kharna khatta and rough lemon as most vigorous rootstocks for Malta local and rough lemon for Blood red malta. Naik (1948) reported performance of unworked tree of acid lime and acid lime budded on Jambhiri, *Gajanimma* and acid lime. Budded trees proved more vigorous and precocious as compared to seedlings. Rao *et al.*

(1970) found Jambhiri to be most vigorous rootstock showing maximum tree spread (724.03 m^3). Raj *et al.* (1973) reported vigorous vegetative growth of acid lime on South African rough lemon, Indian rough lemon, Troyer citrange and *Puthugrama*.

Ghosh *et al.* (1982) reported the variation in growth, characters like height, girth and thickness of rough lemon strains of NEH region. Jawaharlal *et al.* (1987) using five rootstocks at Periyakulam for acid lime and evaluation indicated the suitability of rough lemon followed by Troyer citrange and trifoliate orange.

Effect of rootstock on fruit yield

Phadnis (1961) found Rangpur lime, Jambhiri, Jatti khatti and sweet lime heavy yielders for Nagpur mandarin at Tharsa in Maharashtra. Sinha *et al.* (1977) used 16 rootstocks for Nagpur mandarin found significant increase in total fruit yield in weight and number on Rangpur lime followed by Kharna khatta. Investigation in to the effect of rootstock on production of Nagpur mandarin and Kinnow mandarin revealed that rough lemon was the most vigorous while Rangpur lime recorded a higher fruit yield and quality (Ghosh and Chattopadhyay, 1993).

Aiyappa *et al.* (1967, 1973,) recorded that three rootstocks namely Belladakithuli, Baduvapalli and rough lemon gave significantly higher yield of Coorg mandarin with 623, 590 and 556 fruits/tree/year respectively as compared to control bearing only 287 fruits/tree/year and Sour oranges was found to yield the least (122 fruits/tree/year). Vijay Kumar *et al.* (1990) indicated highest fruit yield of Coorg mandarin was recorded on Rangpur lime followed by rough lemon and on Rangpur lime Puna followed by Rangpur lime, Katol with Nagpur mandarin (Patil and Khobragade, 1999). In Assam Bhattacharya and Dutta (1952) found the rootstock Sohmyndong and Katajamir yielding 637.2 and 432.5 fruits of

Khasi mandarin/tree/year. Chohan *et al.* (1978) reported that Jatti Khatti and Karna Khatta proved good rootstocks for Kinnow in Punjab yielding 450.7 and 415.3 fruits/tree/year respectively. The highest cumulative fruit yield was recorded Singh *et al.*, (1978) reported that Troyer citrange was the most precious rootstock and highest yields were associated with trees on Karna khatta and Sacaton citrumelo. Chaudhari *et al.* (1974) stated that among 16 rootstocks tested for sweet orange at Shrirampur (Maharashtra) yield was maximum on Rangpur lime followed by Sohmyndong and Jambhiri Kodur. The yield of Blood Red sweet orange on rough lemon was higher than on other rootstocks (Bhullar and Nauriyal, 1975).

Chohan *et al.* (1985) indicated greatest yield of sweet orange cv. pineapple on Jatti khatti. Chaudhari and Mali (1978) reported highest yield of Mosambi on Marmalade orange and also on Jatti khatti (Mehrotra *et al.* 1982). Mustafa and Reddy (1990) found highest number of fruits/tree of sweet orange var. Mosambi on Rangpur lime in comparison of Cleopatra mandarin, Citrumelo, Carrizo, Troyer citrange, Pomeroy and Rubidoux trifoliate orange and Kodaikithuli. Mehrotra *et al.* (1984) recorded greatest no. of fruits of sweet orange cv. Valencia and Jaffa on Jatti khatti rootstocks. Raj *et al.* (1973) reported the high yields of acid lime on South African rough lemon, Indian rough lemon, Troyer citrange and Puthugraman rough lemon rootstocks.

Chohan *et al.* (2000) reported that trees on Jatti khatti rootstock showed only 21 % healthy trees with lower mean yield (181fruits/tree) compared to Cleopatra mandarin which showed 100 % healthy trees with more mean yield (265fruits/tree) with sweet orange. Maximum no. of fruits (1009/plant) was recorded on Alemow rootstock with medium canopy volume on acid lime scion (Sonkar *et al.*, 1999b). Singh and Nagpal (1947) reported the corresponding increase in fruit pro-

duction of Marsh seedless grapefruit on Kharna khatta (23%), rough lemon (22%), Shaddock (19%), sweet lime (9%), and citron (13%). Bajwa and Nagpal (1955) revealed that the tree of Marsh seedless grapefruit on Kharna khatta gave the highest annual and cumulative yield and thereon sweet lime and citron the lowest. Chohan *et al.* (1986, 1988 and 1990) recorded the highest yield of grapefruit cv. Marsh seedless on citrange and poorest yield on Karna khatta. Singh (1954) reported Karna khatta, Nasran and rough lemon rootstocks as most productive for Malta local and Kharna khatta and rough lemon for Blood Red Malta. Yields of orange, grapefruit and mandarin were significantly greater with *C. amblycarpa* than with sour orange rootstock and productivity index (kg/m^2) was greater with sour orange rootstock for all scions except mandarin (Simon *et al.*, 1997). The highest yield of Washington Navel orange was obtained from trees on citrange and volkameriana rootstock (Tuzucu *et al.*, 1997).

Rootstocks effect on fruit quality

Mishra and Singh (1990) reported that highest percentage of Pant lemon-1 healthy fruit was obtained from trees on Troyer citrange (70.18%) followed by Rangpur lime (67.01%) and lowest percentage of fruits (52.32) on own root trees. The lowest percentage of fruits with sunscald injury were found in trees on Troyer citrange (18.85%). None of the rootstocks had any significant effects on the percentage of split fruits which ranged from 24.41 to 29.69%. The trees on these rootstocks were hardy, high cropping and had large fruits (Zhongping and Bihou, 1996).

Protopapadakis *et al.* (1998) reported that trees graft on Swingle citrumelo and volkamer lemon had longer and heavier fruits than those on sour orange with Washington navel orange. Fruit colour was the earliest with good fruit size and distribution with X-639 rootstock in Satsuma mandarin (Alexender, 1996).

Dhuria *et al.* (1977) found that heaviest fruits were obtained from Emperor and Nagpur mandarin trees budded on Kharna khatta in Himachal Pradesh condition.

In trials conducted in China on Xuegan orange, the best results in terms of yield and quality were recorded with the *C. reticulata*, Haifengiu and Suanjiu rootstocks (Zhang 1993). Deshpande *et al.* (1977) reported the maximum fruit weight and juice of Nagpur mandarin on Lisbon lemon rootstock closely followed by trifoliate orange and Malta lemon. Sinha *et al.* (1977) found the best sized fruit of Nagpur mandarin on trifoliate orange, Kharna khatta, Baduvapalli, Cleopatra mandarin and Rusk citrange while the sugar/acid ratio was quite satisfactory on sweet lime, sweet orange (Mosambi), trifoliate orange and Rangpur lime. The highest TSS and juice % were recorded on trifoliate orange and Troyer citrange (Anderson and Benatena, 1996). Fruit yield was distinctly superior on Rangpur lime with slightly smaller fruit with Nagpur mandarin (Diware *et al.*, 1999).

The maximum average fruit weight and diameter were observed with Alemow and maximum juice recovery and TSS were on Flying dragon trifoliate with Nagpur mandarin (Sonkar *et al.*, 2001). Dhuria *et al.* (1977) observed the highest fruit weight of Nagpur mandarin on Karna Khatta, titratable acidity on Seville lime, and no significant influence on TSS, reducing, non-reducing and total sugars and vitamin-C.

In Rootstocks trials with Nagpur mandarin at P.K.V., Akola. Highest juice %, no. of fruits/tree and yield/ tree were obtained on Rangpur lime, highest TSS with Pomeroy trifoliate orange, highest acidity with Kodaikithuli and highest ascorbic acid with rough lemon with Mosambi (Mustafa and Reddy, 1990). Phillip and Mennon (1984) reported that in Kerala, Coorg mandarin on trifoliate rootstock produced fruit with higher juice content, sugar,

TSS/acid ratio, lower seeds and thinner rind compared to those on Rangpur lime, rough lemon, Cleopatra mandarin and Troyer and Carrizo citranges. Italian 76 was found to be the best rootstock for Hill mandarin on which the fruit excelled in vitamin-C content (Singh, 1962). Xiecheng (*C. junos*) was used as rootstock for Gangberi Satsuma mandarin in China. After 6 years scion trees grew well, bore early and heavily with fruit maturing earlier with good quality (Jinhua, 1997). The trees of Blood red budded on Cleopatra rootstock had better fruit quality compared to those on Jatti khatti (Chohan *et al.*, 2000).

Ali and Rahim (1960) noted highest ascorbic acid contents in fruits of Valencia late variety of sweet orange on Seville lime (sour orange) rootstock against the lowest on rough lemon and Julundhari Khatti. Mehrotra *et al.* (1984) reported fruit of Valencia orange having highest TSS content on Troyer and Carrizo citrange. Rao *et al.* (1971) stated that Sathgudi orange on Sathgudi seedlings produced better quality fruits with higher TSS/acid ratio and fruit size was also larger than on *C. jambhiri* rootstock whereas vitamin-C of Blood Red orange was higher on sour orange than on other rootstocks (Bhullar and Nauriyal, 1974). Mann and Naurial (1978) reported the juice and TSS contents as highest in fruit of Pineapple sweet orange and vitamin-C on sour orange. Citrumelo rootstocks promoted higher yield, earlier fruit maturity and better fruit and juice quality than mandarin rootstocks (Zekri, 1997) for Ambersweet. The highest mean of Mosumbi fruit weight on rough lemon juice per cent on Rangpur lime, TSS on Pomeroy trifoliate orange, acidity per cent on Kadaikithuli and ascorbic acid contents on rough lemon were recorded (Mustafa and Reddy, 1990).

Prasad (1967) reported highest T.S.S./acid ratio in fruits of Seville orange on Italian-76. Naik (1948) found no significant difference with regards to TSS and acidity of acid lime

fruits on different rootstocks. Rao *et al.* (1969) claimed that the fruit weight and ascorbic acid content of Nepali oblong lemon was higher on Gajanimma than on acid lime and Jambhiri.

Chohan *et al.* (1988 and 1990) reported the best fruit quality on grapefruit cultivar Marsh seedless on Carrizo citrange and Troyer citrange. Fruits with highest juice content were produced on the *Poncirus trifoliata* rootstock and fruits with the highest and lowest TSS contents were produced on citrange and Volkameriana rootstocks respectively (Tuzucu *et al.*, 1997).

Rootstock effect on granulation of fruits

Rootstocks influence the incidence and extent of granulation, though their influence is not much consistent and also depend on the climatic factors (Singh, 2001). Chohan *et al.* (1982) found that the Blood Red sweet orange fruits on Jatti khatti and Kharna khatta rootstock showed more granulation than on Troyer and Carrizo citrange, Rangpur lime, Cleopatra and citrumelo whereas, maximum granulation of Jaffa was observed on Jatti khatti, Troyer and Carrizo, Rangpur lime, pectinifera and citrumelo (Mehrotra *et al.*, 1984). Sweet orange cv. Hamlin on two different rootstocks did not get influenced in respect to physico-chemical parameters of fruit but Cleopatra mandarin produced fewer granulated fruits than those on Jatti khatti (Chohan *et al.*, 1988).

Sadhu and Singh (1989) observed highest degree of granulation in fruits of Jaffa trees grown on Jatti Khatti, followed by Kharna khatta at Bhatinda. Vigorous stocks such as rough lemon or wild grape fruits produce more granulated fruits (Bains, 1949). Less vigorous trees were not severely affected by the granulation (Jawanda *et al.*, 1978).

Rootstock effect on the post-harvest quality of fruits

Jawaharlal *et al.* (1991) revealed that physiological loss of weight (Physiological loss

in weight %) variation of acid lime was significant as influenced by different rootstocks. The highest weight loss (14.3 %) was recorded in the fruits from Troyer citrange closely followed by trifoliolate orange (12 %). Rangpur lime rootstock extended the shelf life of fruits upto 6 days as against 4 days in acid lime seedlings plants compared to rootstock. The physical attributes of Kinnow fruits viz. Compression, peel rupture force and specific gravity showed higher values with Karna rootstock, which are considered desirable characters from post harvest handling and transportation point of view (Saxena.1999). Fruits borne on trifoliolate orange tend to be free from bitterness when canned, while fruit on Rough lemon are very bitter when canned (Kelford and Chandler, 1961).

Effect on nutrients uptake pattern

In a study at Bangalore, among 7 rootstocks, leaf nutrients composition of Coorg and Kinnow mandarin showed higher leaf N content on trifoliolate, Carrizo and Troyer citrange and rough lemon. Cleopatra and Kodakithuli mandarin roots were more efficient in absorbing cations Ca, Mg and K. The leaf Mn content was low in tree of Carrizo and Troyer rootstocks (Iyengar *et al.*, 1982). Bopaiah *et al.* (1983) stated that N,P,K levels had no significant effects on Coorg mandarin with different rootstocks for different vegetative growth. Peynado and Young (1962) observed that Alemow reduced the uptake of boron; Rangpur lime, Cleopatra mandarin, Sunki and Tmkat mandarin rootstock retarded chlorine uptake and sour orange lowered the sodium content. Anjaneyulu and Misra (1983) reported that N and K were highest in Coorg mandarin on rough lemon, Ca and Zn on Belladakithuli and P, Mg, Fe and Mn on Buduvapuli rootstock. Gowda (1983) observed that K, Ca and Mg content in non-fruiting leaves of Coorg and Kinnow mandarin were significantly influenced by different rootstocks.

Kunwar and Singh (1983) reported highest leaf N, P, K, Ca and Mg on hill lemon, Troyer citrange, Malta sweet orange, Buduvapuli and Hill lemon, respectively. Iyengar *et al.* (1984) observed that four lemon cultivars showed higher K, Ca, Mg and Zn content in leaves on rough lemon, Cleopatra and Rangpur lime. Dwarfing rootstocks such as trifoliolate orange and their hybrids resulted in higher contents of N and P in scion leaves. Citrumelo and citrange resulted in very low leaf Mn content than the other rootstocks. Tayde and Joshi (1986) reported that Rangpur lime strain Srirampur and 3 other (Jambheri, Karan and Nebutenga) had higher leaf N, Ca, Mg, Fe, Zn and Cu in comparison of other rootstocks. Significant variation in uptake of N, K, Mg, Fe and Mn while P, Ca, Zn and Cu showed no significant variation in acid lime on trifoliolate orange, Rangpur lime, Cleopatra mandarin and *C. macrophylla* rootstocks. These rootstocks absorbed less amount of Mn and may be suited for acidic soils having Mn toxicity. Sun chu sha rootstock showed balanced amount of nutrient absorption (Marathe *et al.*, 2000).

Rootstock responses to drought

Rao *et al.* (1987) reported that citrus rootstocks have different response to drought conditions as Rangpur lime showed highest tolerance followed by Nasnaran, *Poncirus trifoliata* and Troyer citrange while *Citrus jambhiri* was more susceptible rootstock. Vijaykumar *et al.* (1990) recommended that rough lemon and Rangpur lime were suitable for situation prevailing in Shevroys conditions. Bankar *et al.* (1999) reported Rangpur lime (*Citrus limonia*) to be most drought tolerant as indicated by more accumulation of proline in the leaves as compared to Kagzi lime and rough lemon based on the accumulation of proline in leaves.

Rootstock responses to chlorosis

Sinha *et al.* (1977) found that lemon with Nagpur mandarin had highest percent-

age of chlorotic leaves. Rough lemon, Belladakithuli and Baduvapuli had significantly lesser percentage of chlorosis (36.22 %, 43.32 % and 38.25 %, respectively) as compared to control (50.13%) in rootstocks trial of Coorg mandarin (Aiyappa *et al.*, 1967, 1973, 1977). Jawanda and Mehrotra (1974) found symptoms of chlorosis in citrumelo and Rangpur lime rootstocks and similar observations were also recorded of Jatti khatti for Valencia scion by Singh and Nagpal (1954) and Sharma *et al.* (1978).

Bopaiah *et al.* (1983) stated that chlorosis was lowest (18%) in Coorg mandarin trees on rough lemon receiving 600 g N/tree and highest (30%) in trifoliolate orange receiving the highest P rate (200 g/ tree) Swingle citrumelo performed very poorly in alkaline soil exhibiting lime induced iron chlorosis at early age (Ian and Tolly, 1997). The extent of chlorosis in leaves was highest (78%) in Belladakithuli followed by Coorg mandarin seedling (74%) in Coorg mandarin (Ganpathy *et al.* 1999). Clementine rootstock showed the maximum intensity of chlorosis and die back which affected fruit yield in Sweet orange (Saxena, 1999).

Rootstock responses to salinity

Cleopatra mandarin (Grabstan and Narana), Schaub rough lemon and Rangpur lime (Texas) and Cleopatra mandarin (Tirupati, Coorg and Morocco) were the salinity tolerant rootstocks (Singh *et al.*, 1997). Singh *et al.* (2000), observed Rangpur lime tolerant, rough lemon moderately tolerant and trifoliolate orange as susceptible rootstock to salinity. The most salt tolerant rootstocks included Cleopatra mandarin, Rangpur lime, sweet orange, Carrizo citrange and Troyer citrange. Salt tolerance was lowest with trifoliolate orange (Grieve, 1983).

Bhambota and Kanwar (1968) studied the performance of various sweet oranges on different rootstocks with respect to salinity and revealed that salt tolerance of different

rootstocks varied in the order Kharna khatta (*C. karna*) > Galgal (*C. limon*) > trifoliolate (*P. trifoliata*) > rough lemon (*C. jambhiri*). Out of various scions budded on rough lemon the salt tolerance varied in the order Hamlin > Valencia late > Pineapple > Blood Red. Joolka and Singh (1979) stated that Rangpur lime and Cleopatra mandarin were the most tolerant and Bhadri lemon (*C. limon*) and Jatti khatti (*C. jambhiri*) the most susceptible. Joolka *et al.* (1980) reported that *C. jambhiri* with sweet orange cv. Blood red was least susceptible to high level of salinity in comparison of Troyer citrange. Cleopatra mandarin and Rangpur lime. Volkameriana lemon and Rangpur lime showed greater salt tolerance than other rootstocks in Egypt (El-Desouky and Atawia, 1998).

Rootstock responses to diseases

In Assam pummelo, sweet orange, Adajamir and acid lime were found highly susceptible whereas rough lemon was moderately susceptible and mandarin and sour orange were found resistant to *Phytophthora* (Chowdhury, 1951). In peninsular India, Ramkrishnan (1954) found lemons, citranges, Sathgudi, Jambhiri, grapefruit, mandarin and acid lime as susceptible to *Phytophthora* except sour orange which was found resistant. Singh (1961) reported that sweet lime was immune to collar rot at Saharanpur. Dhillon and Sharma (1977) stated that Cleopatra mandarin in Punjab condition proved to be tolerant to foot rot. Prasad and Rao (1983) found that hybrids of Cleopatra and trifoliolate were most tolerant to *Phytophthora*. In a preliminary trial for resistance against *P. citrophthora* and *P. nicotianae* var. *nicotianae*, only trifoliolate was found resistant whereas Nagpur mandarin and Cleopatra mandarin were highly susceptible.

Tayde *et al.* (1988) reported that Kharna khatta was the most susceptible rootstock to *Phytophthora* for Kinnow mandarin. Varied degree of susceptibility was observed in

acid lime, rough lemon, sweet lime, Billikichilli, grapefruit and Rangpur lime (Naqvi, 1988). Bitters noted that *C. macrophylla* was resistant to tristeza and is a good rootstock for lemon. In another study Bitters *et al.* (1973) stated that *C. macrophylla* besides being resistant to *Phytophthora* was tolerant to exocortis. The other rootstock trials at different locations in the country have shown the variability among the strains of Rangpur lime and rough lemon for the resistance to *P. parasitica*. Limocravo, Brazil, Rangpur lime (Knorr) and Souranthen strain of Rangpur lime and Jatti khatti strain of rough lemon were having better ranking for resistance against *Phytophthora* (Anonymous, 1991).

Flying dragon is resistant to *Phytophthora* root rot and citrus tristeza virus (Cheng and Roos, 1995). Wutscher and Hill (1995) reported after 50 years Norton citrange developed citrus blight. Geraci (1997) reported that CNR P1 (a hybrid between *C. depressa* x *Poncirus trifoliata*) is resistant to *Phytophthora* and tolerant to poor soil conditions. *Poncirus trifoliata* has been and continues to be, a very successful replant rootstock, being resistant to

Phytophthora (Ilan and Tolly, 1997).

Rootstock responses to viruses

Among 16 rootstocks tested for sweet orange, Soimayndong, Jambhiri Kodur, Jambhiri Bombay and Rangpur lime were tolerant to tristeza and greening but were susceptible to *Phytophthora* (Chaudhary *et al.*, 1974). Dhillon and Sharma (1977) stated that young trees of Cleopatra mandarin declined due to tristeza and xyloporosis viruses (Table 3). Choudhari and Mali (1978) reported Mosumbi on marmalade orange is highly tolerant to tristeza. Resistance for tristeza, psorosis, exocortis, *Phytophthora* and greening was evaluated in 137 citrus cultivars and out of these, six of *Citrus jambhiri*, three of *Citrus limonia*, Cleopatra mandarin and *C. amblycarpa* were suitable as rootstocks for sweet oranges (Chaudhari *et al.*, 1980). Mehrotra *et al.* (1982) reported the presence of greening virus in all the combinations of Mosumbi with rootstocks viz., Jatti khatti, Karna khatti, Troyer and Carrizo citrange, Rangpur lime, Citrumelo, Pectinifera and Jambhiri.

Table 3. Rootstocks tolerant against the viruses and/or virus-like agents.

Virus/virus like disease	Tolerant-rootstocks	Reference
Tristeza	Rough lemon and Cleopatra	Balaraman and Ramakrishnan (1977), Cheema <i>et al.</i> (1985)
Exocortis	Rough lemon, Cleopatra mandarin, sweet orange and sour orange	Cheema <i>et al.</i> (1985) Chohan and Knorr (1970) and Kapur <i>et al.</i> (1974)
Xyloporosis	Rough lemon, Cleopatra mandarin several orange and trifoliolate orange	Chohan and Knorr (1970)
Greening	Rough lemon strains, Milan, Miri Volkamer and South Africa I and II	Cheema <i>et al.</i> (1982)

Rootstock responses to nematodes

Mani and Reddy (1986) reported Pomeroy trifoliolate as resistant to nematodes. Chandel and Sharma (1989) reported trifoliolate orange as most resistant, Troyer citrange, Carrizo citrange and scalo citrumelo quite resistant, and Rangpur lime, grapefruit, *Citrus pectinifera* as moderately resistant. Flying

dragon, Pomeroy and Rubidoux trifoliolate oranges and citrumelo 4475 were found highly resistant to *Tylenchulus semipenetrans* but Rangpur lime was highly susceptible (Chang, 1980). Certain citrus hybrids (*C. sinensis* x *P. trifoliata*, *C. depressa* x *P. trifoliata*) appeared to be resistant to *Tylenchulus semipenetrans* (Geraci *et al.*, 1981). The most predominant

and widely distributed nematode was *Tylenchulus semipenetrans* followed by *Basiria graminophila* and *Rotylenchulus reniformis* in Nagpur mandarin under central India conditions (Bansa Singh, 1997).

Rootstock responses to insect-pests

Makar *et al.* (1979) reported the lowest mean no. of mites per 5 leaves (0.6) on Philippine Red lime (*C. aurantifolia*) followed by Cleopatra mandarin, Morocco (2.1) and mites were noticed on Grabstan (3.6) while the highest number of mites were noticed on tangelo (57.5) and Kharna khatta (55.4) under Shrirampur conditions.

Promising rootstocks

The promising rootstocks shown in the Table 4 are based on the work compiled before 1982 (Agrawal, 1982) and the other promising rootstock are based on the work compiled after 1982 and onwards till commencement of the 21st century. The promising performance of Kodaikithuli, Rangpur lime, and citrange in south Coorg and Rangpur lime and Cleopatra mandarin in north Coorg of Karnataka was reported by Vijaykumar *et al.* (1989, 1990) for Coorg mandarin.

Chohan *et al.* (1982) reported that trees of Blood Red sweet orange on rough lemon and Cleopatra mandarin did best. Chohan *et al.* (1986) further indicated that Jatti khatti followed by Pineapple proved best rootstock for sweet orange cv. Valencia late. Ten years studies on rootstock trial revealed that rough lemon was found to be significantly superior in respect of growth, yield and rough lemon, marmalade orange and Cleopatra mandarin for Mosumbi, marmalade orange for Kinnow, rough lemon and Rangpur lime for acid lime at Periyakulam, Cleopatra mandarin for Kinnow at Bhatinda proved promising (Anonymus, 1993). Considering the growth, yield and fruit quality attributes, Rangpur lime and *C. volkameriana* may prove suitable for Khasi mandarin in mid hills of Meghalaya (Sheo

Govind *et al.*, 1994). C-32 produced highest yields with all scions except lemon (Roos, 1996).

Xiecheng was used as a rootstock for Gongben Satsuma mandarin and it was noted that scion trees grew well, bore early and healthy, fruits matured earlier and had good eating quality of mandarin fruits in China (Jianhua, 1997). Sour orange and Swingle citrumelo were the most promising rootstocks for Washington navel oranges (Protopapadakis *et al.*, 1998). Yuma sacatan and Swingle citrumelo were observed to be promising rootstocks for grapefruit in South Africa (Breedt and Koekemoer, 1996). Rich 16-6, a trifoliolate selection, was found suitable for *Citrus limon* cv. Lisbon Frost giving highest yield (321 fruits/tree) out of 13 trifoliolate selections and its hybrids in Monte Grande, Argentina (Foguet *et al.*, 1997).

CONCLUSIONS

Rootstock development is an unending process because success depends on the interaction of genetic potential with soil, climate, disease, pests and cultural practices. Emphasis needs to be laid on production and maintenance of virus free nucellar line for important varieties and budwood from these virus free trees should be used for raising plants for future rootstock trials. As it is well known that all the virus diseases are bud transmissible except the xyloporosis which is seed transmitted, it is the need of the hour to use virus free budwood and nucellar seedlings. Physiological and anatomical studies of rootstocks-scion interaction, rootstock effect on scion performance, pathogen induced response, new method for early and rapid evaluation for tolerance to various biotic and abiotic stresses and prediction of incompatibility at an early stage need to be studied. It is therefore necessary to initiate investigation to select suitable rootstock suiting to prevailing soil and climatic conditions for citrus.

Table 4. Best performing rootstocks for various citrus scions in different regions (Agarwal, 1982)

Area	Scion	Rootstock	Attributes
Punjab	Sweet oranges		
	Malta local	Karna khatta	High vigour and yield
	Malta Blood Red	Rought lemon	-do-
	Blood red organe	Jatti khatti	-do-
	Mosambi	-do-	High vigour
	Valencia orange	-do-	-do-
	Valencia Campbelli	-do-	High vigour and yield
	Jaffa	-do-	High vigour
	Pineapple	-do-	-do-
	Mandarins		
	Sangtra local	Kharna khatta	-do-
	Kinnow	Jatti khatti	High vigour and yield
	Grapefruits		
	Marsh seedless	Kharna khatta	-do-
Uttar Pradesh	Sweet oranges		
	Mosambi	Sweet lime	High vigour, precociousness, good fruit quality and resistance to collar rot.
	Vanille	Italian-76	High vigour, resistance
	Hill	Italian-76	High vigour, yield and resistance to collar rot.
Assam	Sweet oranges		
	Valencia	Katajamir	High vigour and yield
	Mandarins		
	Khasi	Sohmydong	High vigour, yield and resistance to gummosis
Maharashtra	Sweet oranges		
	Ganeshkhind	Rangpur lime	High vigour and yield
	Dessa	-do-	-do-
	Nucellar mosambi	-do-	-do-
Andhra Pradesh	Sweet oranges		
	Sathgudi	Sathgudi	Disease resistance and good fruit quality
Karnataka (Coorg)	Acid lime		
	Acid lime	Gajinimma	High vigour and yield
	Mandarins		
	Coorg	Belladakithuli	High vigour and yield
		Baduvapuli	-do-
		Rough Lemon	-do-

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