

Exploration, Collection and Characterization of Citrus Genetic Diversity from Manipur and Tripura

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To collect citrus genetic diversity the National Research Centre for Citrus, Nagpur led 2 exploration missions during the year 2003, specially for North-east hill region of India. Total 40 accessions of *Citrus* belonging to different citrus species *C. jambhiri*, *C. macroptera*, *C. grandis*, *C. medica*, *C. sinensis*, *C. limon*, *C. reticulata*, *C. aurantifolia* were collected from different districts of Manipur and Tripura. Passport data were documented. A wide range of variability was observed in collected material, especially fruit weight which ranged from 35.2 g to 1342 g. One dwarf genotype (plant height 2-3 m) known as *Elaichi Nimbu* was located in Teliamura area of West Tripura and another high yielding (yield potential 72-80 tonnes per ha) landrace locally known as *Kachai lemon* was identified in Ukhrul district of Manipur. Shifting cultivation and farmers choice for commercial types only, are identified as potential threat to diversity of *Citrus* occurring in these areas.

Key Words: Citrus, Exploration, Germplasm, Rootstock, Threat

The North-eastern region of India is considered as one of the main centre of diversity for *Citrus* spp. A large number of citrus species are reported from this region (Bhattacharya and Dutta, 1951 & 56, Dutta, 1958; Hodgson *et al.*, 1963; Kaul, 1981; Sarkar, 1994; Sheo Govind and Yadav, 1999; Singh, 1981; Singh and Singh, 1967; Singh and Singh, 1968; Singh and Chadha, 1993; Singh and Singh, 2001; Singh, 1977; Tanaka, 1937 and 1958). Many citrus species were observed growing wild and semi-wild in different pockets of the region (Borthakur, 1993; Hore, *et al.*, 1997; Singh *et al.*, 2001; Ghosh, 1977; Sheo Govind and Singh 2002; Singh and Singh, 2003). Vavilov (1940) reported this region to be the primary as well as secondary centre of origin of a large number of plants. However, a large genetic diversity in the region is under threat due to several factors. It warrants urgent steps for collection and conservation of the diverse flora. Therefore, extensive survey were conducted by National Research Centre for Citrus (NRCC), Nagpur, Maharashtra to collect available citrus genetic diversity for utilization and their conservation.

Materials and Methods

Grid Points of Exploration

To collect the genetic diversity, explorations were carried out during December 6-13, 2003 in different districts of Manipur (Bishnupur, Tamenglong, Imphal East, Imphal West and Ukhrul) and from November 4-11, 2003 in different areas of Tripura. The areas explored in Tripura were Lembucherra, Kamalghat, Mohanpur, Agartala, Bishalgarh, Bishramganj, Melaghar, Sopnamura,

Teliamura, Zirania and Khowi (West Tripura), Udaipur, Birchndramanu, Shantirbazar and Subrum (South Tripura), Ambasa, Manu, Nalkata and Kumarghat (Dhalai District), Kanchanpur and Jampui Hills (North Tripura). Fruit samples collected were brought to NRCC, Nagpur and observations were recorded for fruit weight, fruit size, number of segments per fruit, seed number, peel thickness, total soluble solids (TSS) and acidity.

Route Map of Exploration

The route map followed for exploring the area showing various grid points is shown in Fig. 1

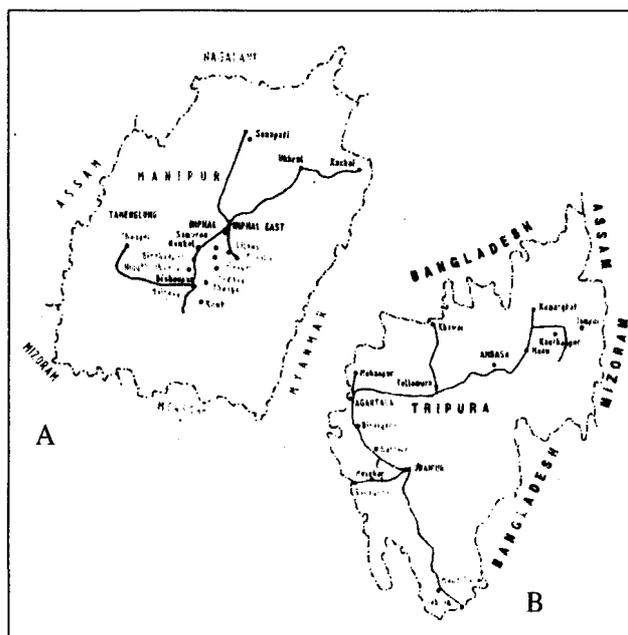


Fig. 1: Route map of Manipur (A) and Tripura (B) for collecting citrus diversity

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Soil and Climatic Conditions

The climate of Manipur is sub-tropical humid. The soil types range from black, sandy loam, alluvial and very shallow to deep ones. Most of the Imphal east and Imphal west area comes under valley whereas other are hill slopes. On hill slope, soil erosion is very common. The rainfall pattern varied from 2000 mm to 2500 mm per year. Temperature ranged from 4°C to 35°C. The terrain of Tripura is hilly and due to this it was earlier known as hill Tripura. The topographic feature of the state is its close association of undulating lands locally known as *tillas* interspaced with nearby valleys locally known as *lungas*. The soil is very deep, well drained and usually very fertile. The texture varies from sandy to loamy sand and is generally acidic with pH values varying from 4.85 to 5.80. It has tropical, moist climate with fairly distributed rainfall of 2200 mm/annum between April to October. The humidity ranges between 42% in April to about 100% in June. The maximum and minimum temperature ranges between 7°C to 35 °C without any frost formation. The habitat from where samples were collected covered physiographic locations like plain, farmer's field, hilly area, home gardens, valley and forest area representing altitude ranging from 16 to 900 m above mean sea level.

Results and Discussion

Citrus Genetic Diversity in Manipur

Manipur comes under the North eastern region of India and it has bounded on the North, West, South with Nagaland, Assam and Mizoram respectively and North-east and East by the international boundary of Myanmar (Burma). This is one of the potential State for collecting citrus genetic diversity since it is adjoining to Myanmar where maximum diversity is reported. A total of 23 accessions of citrus belonging to different species were collected from Manipur (Table 1). Various available statistics estimate that out of total tonnage of citrus produced in the state, maximum emerge from Tamenglong and Ukhrul districts, besides Tipaimukh and Tinsung of Churachandpur district, Chandel and Jiribam of Imphal East. In Manipur, mandarin, different strains of rough lemon and semi-wild type of Heiribob (*C. macroptera*) are grown on commercial scale. Among all citrus fruits available in Manipur, Heiribob fruits are most costly owing to greater demand. It is sold in Imphal market at Rs 15 per fruit as compared to Mandarin fruit (Rs 2 per fruit). Its cultivation is restricted near Burma border in Khoibu village, Chandel District. One landrace was collected from Kachai village in Ukhrul district. Perhaps this would be first village in the historical calendar

of citrus cultivation that one single variety is grown on such a large scale with very high production. The preliminary report says that the combination of soil and micro-climate is largely attributed to quality development of Kachai lemon in this area as such a quality of Kachai lemon is not found even in nearby villages. Although Kachai lemon is not a true lemon, it gives very high yield and two crops are obtained in a season. One matures in November-December whereas the other matures in the months of May and June. Fruit of Kachai lemon is very popular among the locals and therefore very remunerative for the farmers. The village has established one community orchard of Kachai lemon. In contrast mandarin orchards have more than 2,000 fruits with beautiful colour but without optimum fruit size coupled with a medium taste. This is due to poor soil fertility (deficiency of nutrients like Mg, N, P, Zn and B in Tamenglong and Kachai areas), conditioned by comparatively difficult to amend sub-soil acidity. It is difficult to find any orchard practicing the standard cultural practices. Due to the absence of any analysis to unravel the soil fertility and plant nutritional factors contributing to fruit quality development and subsequently the development of soil and climate specific agro-techniques.

Mandarin, Heribob and Kachai lemon germplasm are mostly maintained in farmers, field whereas others are maintained in home garden. Manipur valley has abundant pummelo and large variability in pummelo germplasm was observed. However, farmers are not getting any price in the market since there is no demand of pummelo fruits. This resulted in reduction of farmers maintaining pummelo germplasm. Rich genetic diversity was observed in rough lemon and citron. Different shape, size and colour were collected from different areas. The majority of citrus plantation exists on steep slopes having slope of 70-80% without any protection against soil erosion. When these orchards are raised on terraced land, over the years (25-30 years, which is an as the average orchard life) the top fertile soil is nearly lost, leading to exposure of unfertile sub-soil with very high acidity. However, orchards of 45-50 years can also be easily located (e.g. Thangal village) indicating that there is a potential of longer orchard life. The plants remaining consistently under moisture stress apart from poor soil fertility, especially in terraced citrus orchards are bound to produce under-sized fruits.

Citrus Genetic Diversity in Tripura

Citrus belonging to 5 different species were observed to grow in Tripura. Total 17 accessions belonging *C. grandis*,

C. medica, *C. aurantifolia*, *C. limon* and *C. reticulata* were collected from all districts of Tripura (Table 1). Rich diversity in pummelo germplasm was observed near Bangladesh border and maximum concentration was observed in Agartala city where large number of plants were maintained in home garden. Hore *et al.* (1997) also reported rich diversity of citrus in Tripura. Before 1949, Tripura was under separate kingdom. Tripura is culturally very rich and this is the main reason that most of the pummelo plants are maintained in home garden, as it is mostly utilized for religious purpose. Great demand of this fruits was observed during the Hindu festival namely *Vishwakarma puja*, *Durga puja*, *Kali puja* and other tribals festival. Therefore, farmers are getting good price in the market unlike other states where less demand of

pummelo creates marketing problem. However, due to modernization, tribal people of Tripura are removing pummelo plants for construction of concrete houses. Before 1950 every house in Tripura usually had one small pond and on the border of pond they used to plant pummelo and other fruits. But now they are converting pond for house construction and therefore removing pummelo plants too. In rural area these materials are well protected since more than 60% area of Tripura is under forest. When author visited Tripura in 1986 and 1993, Agartala city bordering Bangladesh was full of pummelo. This time it was observed that most of the plants were uprooted and we could not find any young plantation of pummelo. This indicates serious threat to pummelo variability in Agartala which was collected by tribals through many generations.

Table 1. List of citrus germplasm collected during exploration from Manipur and Tripura

S. No.	Collector (s) no.	Species	Common name	Local name	Area of collection (District)	Status Wild, cultivated, semi-cultivated
1	IPS-433	<i>C. medica</i>	Citron	Citron	Bishnupur, Manipur	Semi-cultivated
2	IPS-434	<i>C. jambhiri</i>	Rough lemon	Rough lemon	Bishnupur, Manipur	Semi-cultivated
3	IPS-435	<i>C. jambhiri</i>	Rough lemon	<i>Gole nimbu</i>	Bishnupur, Manipur	Semi-cultivated
4	IPS-436	<i>C. medica</i>	Citron	<i>Heijerang var. Gandhraj</i>	Bishnupur, Manipur	Semi-cultivated
5	IPS-437	<i>C. macroptera</i>	Satkara	<i>Heiribob</i>	Bishnupur, Manipur	Semi-wild
6	IPS-438	<i>C. medica</i>	Citron	Citron	Bishnupur, Manipur	Semi-cultivated
7	IPS-439	<i>C. jambhiri</i>	Rough lemon	<i>Sindhuritunga</i>	Bishnupur, Manipur	Semi-cultivated
8	IPS-440	<i>C. jambhiri</i>	Rough lemon	<i>Gol nimbu</i>	Bishnupur, Manipur	Semi-cultivated
9	IPS-441	<i>C. medica</i>	Citron	Citron	Tamenglong, Manipur	Semi-cultivated
10	IPS-442	<i>C. jambhiri</i>	Rough lemon	<i>Gol nimbu</i>	Tamenglong, Manipur	Semi-cultivated
11	IPS-443	<i>C. jambhiri</i>	Rough lemon	Rough lemon	Tamenglong, Manipur	Semi-cultivated
12	IPS-444	<i>C. jambhiri</i>	Rough lemon	Rough lemon	Tamenglong, Manipur	Semi-cultivated
13	IPS-445	<i>C. reticulata</i>	Khasi mandarin	Khasi mandarin	Tamenglong, Manipur	Cultivated
14	IPS-446	<i>C. medica</i>	Citron	Citron	Ukhrul, Manipur	Semi-cultivated
15	IPS-447	<i>C. sinensis</i>	Sweet orange	<i>Haithumb</i>	Imphal East, Manipur	Semi-cultivated
16	IPS-448	<i>C. medica</i>	Citron	<i>Hejjang</i>	Imphal East, Manipur	Semi-cultivated
17	IPS-449	<i>C. medica</i>	Citron	Citron	Imphal East, Manipur	Semi-cultivated
18	IPS-450	<i>C. jambhiri</i>	Rough lemon	Rough lemon	Imphal East, Manipur	Semi-cultivated
19	IPS-451	<i>C. jambhiri</i>	Rough lemon	<i>Kata jamir</i>	Imphal East, Manipur	Semi-cultivated
20	IPS-452	<i>C. jambhiri</i>	Kachai lemon	<i>Kachai lemon</i>	Ukhrul, Manipur	Cultivated
21	IPS-453	<i>C. jambhiri</i>	Rough lemon	Rough lemon	Ukhrul, Manipur	Semi-cultivated
22	IPS-454	<i>C. reticulata</i>	Khasi mandarin	Khasi mandarin	Ukhrul, Manipur	Cultivated
23	IPS-455	<i>C. grandis</i>	Pummelo	Pummelo	Ukhrul, Manipur	Semi-cultivated
24	IPS-416	<i>C. grandis</i>	Pummelo	Pummelo	West Tripura	Semi-cultivated
25	IPS-417	<i>C. grandis</i>	Pummelo	Pummelo	West Tripura	Semi-cultivated
26	IPS-418	<i>C. aurantifolia</i>	Kagzi lime	<i>Nimboo</i>	West Tripura	Cultivated
27	IPS-419	<i>C. grandis</i>	Pummelo	Pummelo	South Tripura	Semi-cultivated
28	IPS-420	<i>C. limn</i>	Lemon	<i>Elaichi Nimboo</i>	South Tripura	Cultivated
29	IPS-421	<i>C. medica</i>	Citron	<i>Pati Nimboo</i>	South Tripura	Cultivated
30	IPS-422	<i>C. grandis</i>	Pummelo	Pummelo	West Tripura	Semi-cultivated
31	IPS-423	<i>C. medica</i>	Citron	Citron	Dhalai, Tripura	Semi-cultivated
32	IPS-424	<i>C. medica</i>	Citron	Citron	Dhalai, Tripura	Semi-cultivated
33	IPS-425	<i>C. reticulata</i>	Khasi mandarin	<i>Kamala</i>	North Tripura	Cultivated
34	IPS-426	<i>C. limon</i>	Lemon	<i>Elaichi Nimboo</i>	Dhalai (Tripura)	Cultivated
35	IPS-427	<i>C. grandis</i>	Pummelo	Pummelo	West Tripura	Semi-cultivated
36	IPS-428	<i>C. limon</i>	Lemon	<i>Elaichi Nimboo</i>	West Tripura	Cultivated
37	IPS-429	<i>C. limon</i>	Lemon	<i>Elaichi Nimboo</i>	West Tripura	Cultivated
38	IPS-430	<i>C. limon</i>	Lemon	<i>Elaichi Nimboo</i>	West Tripura	Cultivated
39	IPS-431	<i>C. limon</i>	Lemon	<i>Elaichi Nimboo</i>	West Tripura	Cultivated
40	IPS-432	<i>C. grandis</i>	Pummelo	Pummelo	West Tripura	Semi-cultivated

Except mandarin and lemon, most of citrus germplasm are maintained in home garden. Mandarin is commercially grown only in North Tripura at Jampui hills bordering Mizoram. These hills were once famous for quality mandarin fruit but now these are facing serious decline mainly due to powdery mildew disease which results in poor quality production of mandarin in Jampui hills of Tripura. Fruits available in market were bitter in taste as also reported by state department of horticulture. The main reason for poor quality is attributed to decline of orchards, where force ripening is experienced due to early colour development in infected plants. Farmers sell their produce in market before ripening. During survey we tested mandarin fruits in all major market which indicated that fruits are harvested before ripening. In Jampui hills farmers also agreed that they harvest mandarin before ripening, or else fruits will drop and not fetch any price. Therefore, utmost priority should be given to save Jampui mandarin which is facing severe decline problem mainly due to powdery mildew disease. Even water is not available for spraying to control the diseases. After mandarin in Jampui hills another citrus crop which is getting popularity in state is *Elaichi Nimboo*. This is now commercially grown in Teliamura area in West Tripura. Its plants are bushy type and dwarf (height 2-3 m). This genotype is very good for high density plantation (2 x 2 m). Farmers are getting good price, Rs 250 to 500 per plant at spacing of 2x2 m. Besides these, many citron types were observed growing mainly in home garden throughout Tripura. Shifting cultivation was found to be serious threat to genetic diversity in both the areas.

Characterization of Collected Materials

A wide range of variability was observed for physico-chemical characters in fruits of collected germplasm (Table 2). Maximum fruit weight (1342.0g) was recorded in accession IPS-422 (pummelo) followed by IPS-441 (oblong type citron) and lowest (35.2 g) in IPS-418 accession. Maximum variability was observed in fruit length. Highest fruit length (200 mm) was recorded in citron (IPS-441) followed by IPS-448 (177 mm). Number of segment per fruit varied from 8 to 17. Variability was also observed in peel thickness (1.43 mm to 46 mm). Acidity ranged from 0.55 % to 7.0 %. It was observed that accession (IPS-430) *Elaichi Nimbu* has highest percentage of juice (56.0%) followed by Kachai lemon 55% (IPS-452). Accession IPS-427 has highest seeds/fruit (85.0) and accession IPS-420 has lowest value for seed (3.0 seeds/fruit). These findings are in agreement with the finding of other workers (Hore

et al., 1997; Singh and Sheo Govind, 1999; Sheo Govind and Singh, 2002; Singh *et al.*, 2001; Singh and Singh 2003) where they also reported wide range of variability in physico-chemical characters in fruits of different citrus species found in NEH region. The mission indicated that Manipur has maximum diversity of rough lemon, citron, *Satkara* and one wild type sweet orange. Therefore, in future collection there should be focus in bordering areas of Myanmar. In case of Tripura, maximum diversity was observed for pummelo and lemon. Therefore, in future collections in North and West Tripura only should be targeted.

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Table 2. Characterization of citrus germplasm based on physico-chemical characteristics of fruits

S.No.	Collector Number	Cultivars/Species	Fruit wt (g)	Fruit length (mm)	Fruit breadth (mm)	Peel thickness (mm)	Juice (%)	No. of segment	Seeds/ Fruit	TSS	Acidity (%)
1	IPS-433	Citron (<i>C. medica</i>)	348.0	118.0	77.0	5.0	23.0	10.0	29.0	6.0	4.5
2	IPS-436	Heijerang (<i>C. medica</i>) var. Gandhraj	746.0	200.0	86.0	7.0	8.2	10.0	37.0	7.0	3.10
3	IPS-438	Citron (<i>C. medica</i>)	139.0	88.0	55.0	4.0	10.0	9.0	36.0	8.0	4.2
4	IPS-441	Citron (<i>C. medica</i>)	1076.0	200.0	112.0	46.0	6.2	10.0	43.0	7.0	1.20
5	IPS-446	Citron (<i>C. medica</i>)	343.0	137.0	70.0	18.0	4.0	12.0	19.0	8.0	2.40
6	IPS-448	Heijrang (<i>C. medica</i>)	622.0	177.0	88.0	23.0	4.6	9.0	66.0	8.0	2.4
7	IPS-449	Citron (<i>C. medica</i>)	616.0	122.0	99.0	15.0	22.0	11.0	9.0	7.0	8.8
8	IPS-423	Citron (<i>C. medica</i>)	177.0	88.0	67.0	5.4	41.0	10.0	48.0	6.0	4.44
9	IPS-424	Citron (<i>C. medica</i>)	79.0	56.0	50.0	3.8	31.0	11.0	8.0	7.0	5.10
10	IPS-421	Pati Nimboo (<i>C.medica</i>)	197.0	89.0	70.4	7.2	29.0	10.0	13	5.2	3.2
11	IPS-437	Heiribob (<i>C. macroptera</i>)	398.0	84.0	101.0	7.0	41.0	14.0	16.0	8.8	6.4
12	IPS-434	Rough lemon (<i>C. jambhiri</i>)	218.0	80.0	80.0	4.0	37.0	10.0	25.0	8.0	3.73
13	IPS-435	Gole nimbu (<i>C. jambhiri</i>)	36.0	39.0	41.0	1.7	32.0	8.0	7.0	8.0	2.88
14	IPS-439	Sindhuritenga (<i>C. jambhiri</i>)	180.0	70.0	71.0	5.0	21.0	10.0	19.0	8.0	3.90
15	IPS-440	Gol nimbu (<i>C. jambhiri</i>)	40.0	41.0	40.0	3.0	32.0	9.0	5.0	9.0	3.30
16	IPS-442	Gol nimbu (<i>C. jambhiri</i>)	42.0	44.0	41.0	2.5	25.0	8.0	14.0	7.0	4.5
17	IPS-443	Rough lemon (<i>C. jambhiri</i>)	86.0	55.0	54.0	2.3	44.0	9.0	15.0	9.0	4.8
18	IPS-444	Rough lemon (<i>C. jambhiri</i>)	103.0	57.0	56.0	2.0	40.0	9.0	7.0	8.5	5.6
19	IPS-450	Rough lemon (<i>C. jambhiri</i>)	123.0	64.0	61.0	3.0	50.0	8.0	18.0	7.0	4.13
20	IPS-451	Kata jamir (<i>C. jambhiri</i>)	39.0	42.0	41.0	3.0	26.0	9.0	10.0	6.0	4.1
21	IPS-452	Kachai lemon (<i>C. jambhiri</i>)	98.0	53.0	57.0	2.0	55.0	9.0	17.0	7.4	4.4
22	IPS-453	Rough lemon (<i>C. jambhiri</i>)	67.0	52.0	48.0	3.5	21.0	10.0	21.0	7.0	4.4
23	IPS-445	Khasi mandarin (<i>C. reticulata</i>)	97.0	52.0	59.0	2.0	44.5	9.0	14.0	10.0	0.8
24	IPS-454	Khasi mandarin (<i>C. reticulata</i>)	91.0	57.0	62.0	3.0	43.0	10.0	11.0	9.0	0.72
25	IPS-425	Khasi mandarin (<i>C. reticulata</i>)	176.0	59.0	73.0	2.0	46.0	12.0	23.0	10.0	0.89
26	IPS-447	Haihumb (<i>C.sinensis</i>)	389.0	64.0	74.0	3.0	53.0	11.0	20.0	9.0	1.68
27	IPS-418	Kagzi lime (<i>C. aurantifolia</i>)	35.2	42.0	35.0	1.43	37.8	12.0	11.0	6.8	5.12
28	IPS-422	Pummelo (<i>C.grandis</i>)	1342.0	130.0	155.0	23.0	21.0	13.0	35.0	8.0	0.96
29	IPS-455	Pummelo (<i>C.grandis</i>)	1074.0	126.0	134.0	18.0	12.0	17.0	68.0	9.0	1.7
30	IPS-416	Pummelo <i>C.grandis</i>)	927.4	60.2	64.0	13.0	29.5	14.0	23.0	9.75	1.10
31	IPS-417	Pummelo <i>C.grandis</i>)	1060.0	148.0	153.0	20.0	16.0	13.0	32	8.5	0.64
32	IPS-427	Pummelo(<i>C.grandis</i>)	878.0	123.0	122.0	10.0	27.0	14.0	85.0	7.8	1.1
33	IPS-419	Pummelo <i>C.grandis</i>)	720.4	113.0	109.5	9.0	40.0	12.0	16.0	8.1	0.96
34	IPS-432	Pummelo (<i>C.grandis</i>)	700.0	99.0	111.0	8.0	41.0	15.0	43.0	10.0	0.55
35	IPS-420	<i>Elaichi Nimboo</i> (<i>C. limon</i>)	264.0	89.0	71.0	6.3	44.0	11.0	3.0	6.5	4.10
36	IPS-426	<i>Elaichi Nimboo</i> (<i>C. limon</i>)	226.0	73.0	73.0	4.0	52.0	13.0	42.0	6.0	7.0
37	IPS-428	<i>Elaichi Nimboo</i> (<i>C. limon</i>)	288.0	112.0	68.0	3.8	50.0	10.0	23.0	6.0	5.1
38	IPS-429	<i>Elaichi Nimboo</i> (<i>C. limon</i>)	142.0	68.0	63.0	5.7	26.0	13.0	4.0	5.3	4.1
39	IPS-430	<i>Elaichi Nimboo</i> (<i>C. limon</i>)	135.0	64.0	64.0	5.6	56.0	12.0	4.0	5.4	2.6
40	IPS-431	<i>Elaichi Nimboo</i> (<i>C. limon</i>)	151.0	84.0	59.0	4.1	24.0	12.0	45.0	5.8	5.1

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