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GENETIC DIVERSITY OF CITRUS GERMPLASM IN NORTHEASTERN REGION OF INDIA

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ABSTRACT
Citrus diversity in India is mainly intense to the Northeastern and Northwestern region of India. A vast reservoir of Citrus diversity exists in wild and semi wild form and is distributed all over the region without commercial cultivation. Out of the 27 species reported in India, 23 belong to North-eastern Region. However, these species are now going to be extinct. Therefore, special attention should be needed for conserving the germplasm to make it available for further utilization of the species. A total of 7 wild and 3 semi wild citrus species were rated as endangered citrus species of this region. The diversity within a genus and species needs to be preserved for the posterity. The current research efforts are addressed to eco-geographic survey, collection, characterization, evaluation and quality assessment of citrus genotypes that were identified in different areas of North-eastern region. A total of 27 Citrus genotypes from different areas were characterized and evaluated. The collected available genotypes and bud races were maintained for future use at field condition in germplasm block of Citrus Research Station, Assam Agricultural University, Tinsukia. All the collected germplasm was primarily grown in nursery and after that they were transplanted into the main field. The evaluation in respect of plant growth, fruit yield and physio-chemical characters of fruits indicated wide range of variation amongst and within the same species. Based on certain desirable characters, some of the genotypes and bud races were evaluated for commercial cultivation or rootstock uses. Moreover, 57 of the landraces of widely cultivated Khasi mandarin representing North-eastern states of Assam, Arunachal Pradesh, Meghalaya, Manipur, Mizoram and Tripura have been found having high commercial value. Further studies need to be conducted for these genotypes to be recommended for commercial farming.

KEY WORDS: Diversity, Citrus, Northeastern region, Conservation, Cultivation.

INTRODUCTION

Northeastern region of India is one of the richest reservoirs of genetic diversity of citrus. A large number of citrus species are believed to have originated from this region. Out of the 27 Citrus species reported in India, 23 belong to North-eastern Region of India (Sharma *et al.*, 2004, Ramani, 2013, Barbora *et al*., 2015). The availability of so huge diversities has earned this area a special status as a treasure house of Citrus germplasm. It has been described as a major region for diverse producers for citrus in both wild and cultivated forms. However, the rich citrus genetic diversity in the NE region is under a serious threat of rapid extinction. Numerous wild and semi-wild forms of Citrus are under threat of loss due to deforestation and also as it is frequently removed from farmers' field in exchange for crops of higher economic value. Out of 6000 nos. of citrus accessions listed worldwide, India have 1495 nos. of accessions inclusive of wild species, rootstocks, old cultivars, advanced cultivars, and breeding lines (Singh and Singh, 2006). A total of 7 wild citrus species, *e.g.*, *Citrus indica, Citrus macroptera, Citrus megaloxycarpa, Citrus assamensis, Citrus latipes, Citrus rugulosa* and *Citrus ichangensis* and 3 semi wild type sweet orange were rated as endangered citrus species of this region. These wild citrus species have potentially promising resistance ability which if exploited could lead to solution of many problems of citrus industry in India. Citrus fruits play an important role in human health as it is rich in vitamins and minerals. Additionally, they are rich in plant compounds that have various health benefits, including anti-inflammatory and antioxidant effects. The flavours provided by citrus are among the most preferred in the world. Currently, in *India, Citrus* is cultivated over an *area* of about 1,055 thousand hectares with a *production* of 12,746 thousand metric tons and the productivity of 12.08 MT/ha. Out of this, Mandarin alone occupies an area of 429 thousand hectares with a *production* of 4754 thousand metric tons and the productivity of 11.08 MT/ha. However, in North Eastern states mandarin occupies an area of about 117.96 thousand hectares with a *production* of 691.26 thousand metric tons and the productivity of 5.86 MT/ha (Horticultural Statistics at a Glance, 2017).

Citrus fruits, particularly Khasi mandarin (*Citrus reticulata*), Assam lemon (*Citrus limon*), rough lemon (*Citrus jambhiri*) and pummelo (*Citrus grandis*) are of the major commercial horticultural crops grown widely and plays a vital role in the socio-economic development of the people in this region. Apart from these Citrus species, many other species native to this region is cultivated and they also grow wild in forests. The health benefits of Citrus have been well known for centuries, but it has therapeutic values that have long been utilized in conventional herbal medicine. Experimental studies show

that its bioactive compounds have tremendous pharmaceutical activity like, antibacterial, antimicrobial, antiviral, antioxidant, cancer preventing *etc*. which clearly indicate the potential of the crop for the pharmaceutical industry. In the world, citrus is dominated by sweet orange with a 64% contribution followed by mandarins with 20%, limes and lemons with 10% and rest of the 6% contributed by grapefruit and other citrus fruits (Anonymous, 2016).

Although genetic diversity of citrus has got immense potentiality to raise the quality fruit production and productivity, the conservation and use of these genotypes have not yet been carried out in depth in a systematic manner. In absence of identification, conservation and utilization of indigenous citrus genotypes, the losses of such valuable genotypes will occur and continues to occur. Therefore, identification of elite valuable genotypes, their proper use and conservation of these valuable unique resources are essential to increase quality production for internal consumption as well as for export markets (Budathoki *et al.* (2004). Citrus fruits found in the region are needed to be protected, either at natural habitat or through concerted conservation programme. Conservation implies preservation and enhancement of natural environment and effective conservation required both off site and in situ preservation. The growers of the region, generally prefers to grow more economically important species than others; as a result, there is a threat of gradual erosion of citrus species and citrus germplasm base. So, in future, there is every possibility and chance that some of the species in the region will become completely extinct. It is high time and urgent need to collect all available citrus genotypes and bud races and maintain them in field gene bank for future use. To meet the above objective, Citrus Research Station, Assam Agricultural University, Tinsukia has been maintaining a field citrus germplasm block where Citrus germplasm collected from different sources are preserved, evaluated and maintained for future use. This will explore the opportunities of these genotypes for the benefit of large number of farmers, market and consumers; thereby, reduce poverty and enhance food security in the rural areas in the country.

MATERIALS AND METHODS

The study consisted of survey, collection, characterization, evaluation and quality assessment of citrus germplasm that were identified in different areas of Northeastern states. Field survey was carried out by using participatory rural appraisal (PRA) to assess the genetic diversity. Genetic diversity was studied by using IPGRI produced citrus descriptors. Discussion with focus group, interview with individual fruit growers and in situ observation of orchards, fruit tree was also carried out in each site. During field survey, elite plants with valuable traits were selected and these trees were marked with code number by using colored enamel paints for future identification. The laboratory analysis was undertaken at Citrus Research Station, AAU, Tinsukia for quality assessment of the fruits collected from different orchards.

Germplasm of most of the species of Citrus both cultivated and wild type were collected either through seeds or bud wood or seedlings from indigenous sources. Planting materials are are produced from the collected germplasm at nursery and then the planting materials were transplanted in the germplasm block by following recommended package of practices. Plant growth, fruit yield and quality were observed as per procedure. The quality parameters were fruit size, rind thickness, number of segments, seed number, TSS, juice content and acidity.

RESULTS AND DISCUSSION:

Collection

A total of 110 genotypes from 27 Citrus species are collected and maintained at the centre. The collected germplasm included indigenous species to this region mostly Khasi mandarin, Sweet orange, Limon, Citron, Rough lemon, Pummelo, Grapefruit, Sour pummelo, Acid lime, Sweet lime, King mandarin, Karna khatta, Galgal, Adajamir, Khasi papeda, Volkamariana, Rangpur lime, Trifoliate orange, Trifoliate hybrid, Taiwainica etc. presented in Table 1.

Moreover, 56 of the local landraces of widely cultivated Khasi mandarin (Table 2) representing Northeastern states of Assam, Arunachal Pradesh, Meghalaya, Manipur, Mizoram and Tripura have been found having high commercial value. This 56 Khasi mandarin germplasm have also also been maintained at the centre. Further studies need to be conducted for these genotypes to be recommended for commercial farming.

It has been reported that there are about 17 species, 52 varieties and 7 possible hybrids of citrus (Singh, 1990) in North-eastern region. Some of the citrus species are indigenous to this region as reported by Bhattacharya and Dutta (1956) such as *Citrus limon* Burm, *C. medica* Linn., *C. jambhiri* Lush, *C. inchangenis* Swing, *C. lalipes* Tanaka, *C. macroptera* Montr, *C. assamensis* Dutta and Bhattacharya, *C. indica* Tanaka, *C. aurantium* Linn., *C. karna* Raf., *C. aurantifolia* Swing, *C. limetta* Risso, *C. nolulis* Lour., *C. sinensis* Osbeck., *C. grandis* L. and *C. megaloxycarpa* Lush. The natural hybrids indigenous to this region are Soh-Khyllah No. 1, Soh-Khyllah No. 2, Soh-Khyllah No. 3, Hashkhuli, Sarbati, Nieholsray and Dewa tenga (Shadeque, 1989).

Evaluation and conservation

All the collected germplasm was primarily grown in nursery and after that they were transplanted into the main field. Some of the accessions are in fruiting and some accessions are still in vegetative phase with good growth. However, some accession showed poor performance with regards to plant growth. All the plants in germplasm block are being maintained under uniform cultural practices including plant protection measures. Management of Citrus genotypes in germplasm block had proved to be difficult due to their variation in adoptability or more susptability to insect pest and disease incidence. Wide range of variability was observed among different accessions in respect of plant growth, flowering, fruit characters and incidence of insect pest and diseases. Similar variability among different species also observed by Bhattacharyya and Dutta (1956), Verma and Ghosh (1979), Govind and Yadav (1999) and Sing *et al* (1999). Maximum plant height and canopy volume was observed in grapefruit (8.33 m) followed by Khasi papeda (5.75m), and Pummelo (5.41m) with spreading growth habit. The minimum plant height and canopy volume were observed

in Ada jamir (1.47m), Acid lime (2.48m) and Karna khatta (2.98 m) (Table 3). Lemon, Citron and Galgal are bushy type with spreading habit. Pummelo, Rough lemon and Mandarin were also of spreading habit. Rangpur lime was in medium growth habit with rounded tops. Trifoliate and its hybrid exhibited cylindrical growth habit and were observed to be deciduous in nature.

Analysis of physico-chemical characters of fruits (Table 4) revealed the specific traits and the range of variation within the fruits of different species. The variation in fruit size, rind thickness, seeds per fruit, juice content and acidity were found to be more pronounced. Variability among genotypes have also been earlier reported by Bhattacharyya and Dutta (1956), Verma and Ghosh (1979) and Govind and Yadav (1999). Based on the yield and physico-chemical properties of fruits, certain Mandarin, Lemon, Sweet orange, Pummelo, Grapefruit have been screen out for commercial cultivation in the State.

Khasi mandarin (*Citrus reticulata* Blanco.) is economically most important Citrus crop available in Northeastern region and plays a vital role in the socio-economic development of the people. Khasi mandarin is well known for its quality, fruit colour, unique sugar acid blend and shelf life which make it the most popular citrus cultivar in North-Eastern region (Barbora *et al.* 2019). The four citrus species, viz., Khasi mandarin (*C. reticulata*), Assam lemon (Citrus limon), Pummelo (*C. grandis*) and Rough Lemon (*C. jambhiri*) are commercially grown all over the region. Apart from these, other promising natives so far identified in different groups having scope for commercialization are other Lemons (*C. limon*) like Elachi Nemu, Pati Nemu etc., Citrons (*C. medica*) like Bira jora, Bor jora, Tipani jora etc., Sweet lime (*C. lamittoides*), Sour orange (*C. aurantium*), Sweet pumello (*C. grandis*), Sour pumello (*C. megaloxycarpa*), Khasi papeda (*C. latipes*), various types of Rough lemon (*C. jambhiri*) like Mitha chakala, Mitha tulia, *etc* (Barbora *et al.,* 2015). Rough lemon, Volkamariana, Rangpur lime, Cleopetra mandarin and Trifoliate orange are being used as rootstock for Khasi mandarin. Two more rootstocks namely Pummelo and Letipes are being evaluated for Khasi mandarin with promising results.

TABLE 1: Germplasm collected and maintained from North-eastern region of India at Citrus Research Station, AAU, Tinsukia

Sl. No.	Common Name	Species	Variety / local name	Status	Distribution
1	Khasi mandarin	*Citrus reticulata* Blanco	Sumthira/sontora/Komola (Assam), Soh-niamtra, Soh-Syiem Soh-umkhudai, (Meghalaya) Naga Santra, Narengi (Nagaland), Komla (Manipur) Narengi (Arunachal Pradesh)	Cultivated and edible	Assam, Arunachal Pradesh, Meghalaya, Mizoram, Manipur, Tripura, Nagaland, Sikkim
2	Sweet orange	*Citrus sinensis* Osbeck	Mosambi, Mitha chakala, Chakala tenga, (Assam), Soh bitara, Soh-niangriang (Meghalaya), Tasa (Arunachal Pradesh).	Cultivated and edible	Assam, Meghalaya Arunachal Pradesh, Mizoram, Nagaland
3	Lemon	*Citrus limon* Burmf.	Assam lemon, (Nemu tenga, Kazi nemu locally known in Assam) Soh Synthang (Meghalaya) *Pati-Nenu/lebu, Shasni-Nemu/ lebu, Soh-madrit,* Elachi-nemu, Pani-jamir Baramasia, Seville, Nepali oblong, Nepali lemon, Italian lemon and Eureka lemon, Kata-jamuri, Godhpati-nemu/lebu, Galgal, Kata jamuri, Khatta-lebu or Ghora-nemu/lebu,	Cultivated and edible, round the year flowering, strongly sour lemon,	Assam, Arunachal Pradesh, Meghalaya, Mizoram, Manipur, Tripura, Nagaland, Sikkim
			Soh-liang	Flowering once in a year	Meghalaya
			Pani jamir (sweet lemon)	Sweet pulp	Meghalaya
4	Citron	*Citrus medica* L	Mitha jora, Pinchipunia, Pati jora, Bira jora, Gandharaj, Citron pongam, Jora-tenga, Bira-jora, Bon-jora, Sipa-egra, Singking, Tashing, Soh manong, Haijange, Naya-Changney	Cultivated and edible	Assam, Arunachal Pradesh, Meghalaya, Mizoram, Manipur, Nagaland, Sikkim
5	Rough lemon	*Citrus jambhiri* Lush	Gul nemu, Nemu tenga, Lemon Borapani, Hati nemu, Soh	Cultivated and edible	Assam, Meghalaya

			myndong, Champa umthambi, Rough lemon, Sindhuri lemon, Soh khaylla, Nainty zambiri, Soh-jhalia, Kata jamir, Sinduri nemutenga, Kachai lemon		Arunachal Pradesh Manipur
6	Pummelo	*Citrus grandish* Osbeck	Soh-myngor, Pummelo red, Pummelo white, Chakotra, Gagar, Pink fleshed, Kanapora, Bhogote, Sagothra, Rabab tenga, Jambura,	Cultivated and edible	Assam, Meghalaya
7	Sour pummelo,	*Citrus megaloxycarpa*	Bortenga, Holong tenga, Hukna tenga, Jimir tenga	Inedible	Assam, Tripura
8	Grapefruit	*Citrus paradisi* Macf	Grapefruit	Cultivated and edible	Assam, Meghalaya, Arunachal Pradesh, Mizoram
9	Acid lime	*Citrus auriantifolia* (Chirstm)	Kagzi lime, Abhayapuri lime, Karimganj lime	Cultivated and edible	Assam Plains (Lower Assam and Barak valley) Nagaland, Meghalaya
10	Sweet lime	*Citrus limettioides*	Sorbati, Mitha nemu, Mitha Kagzi	Cultivated and edible	Garo and Jaintia hills of Meghalaya, Assam, Arunachal Pradesh, Mizoram
11	King orange	*Citrus nobilis* Lour	Jeneru tenga	edible	Plains of upper Assam district
12	Karna khatta	*Citrus karna* Raf	Soh- sarkar	inedible	Mizoram, Meghalaya (Khasi hills)
13	Hill lemon (Galgal)	*Citrus pseudolimon*	Galgal, Jamir	Semi wild, edible	Meghalaya
14	Ginger Citrus	*Citrus assamensis* (Dutta and Bhattacharya)	Adajamir, Soh-Sying,	Semi wild, edible	Barak valley of Assam, Khasi hills and lower Jaintia hills of Meghalaya
15	Khasi papeda	*Citrus latipes* Tanaka	Soh Shyrkhoit	Extremely rare in cultivation, the fruit is edible	Khasi hills of Meghalaya, Nagaland
16	Volkameriana	*Citrus volkemeriana*	Volkama lemon	Very vigorous rootstock, Cultivated and edible	Meghalaya, Assam
17	Rangpur lime	*Citrus limonia*	Rangpur lime, lemandarin	cultivated, edible rootstock,	Meghalaya, Assam
18	Cleopetra mandarin	*Citrus reshni*	Cleopetra orange		Meghalaya
19	Calamandin mandarin	*citrus mitis*	Calamandin, Philippine lime	edible	Meghalaya
20	Taiwainica	*Citrus taiwainica*	Taiwainica		Meghalaya
21	Trifoliate orange	*Poncirus trifoliate*	Trifoliate, Rubidoux trifoliate	Inedible	Meghalaya
22	Troyer citrange	*Trifoliate hybrid*	Troyer citrange	Inedible	Meghalaya
23	Sour orange	C. aurantiwn	Karan jamir, Gandha-Hantara, Karun Jamir, Sohmyndong, Mole kaipuli	Inedible	Nagaland, Meghalaya, Assam Arunachal

					Pradesh
24	Indian Wild orange	*Citrus indica* Tanaka	Mimang Narang	Inedible	Some pockets of Assam, Meghalaya, Mizoram, Manipur, Nagaland,
25	Narengi	*Citrus. crenatiifolia* Lush.	Kokni, keonla, Reshmi orange, Narangi	Inedible Semi-wild	Barak valley of Assam, Meghalaya
26	Melamesian papeda	*Citrus macroptera*	Satkara, Tithkara, Soh-Kwit, Hampur-arong, Chamarbaphang, Hareb	Inedible, Semi-wild	Assam, Meghalaya, Tripura, Manipur
27	Ichang papeda	*Citrus ichanggensis*	Kettsa-shopify	Inedible Semi-wild	Nagaland and adjacent hilly areas of Assam

TABLE 2: Collection of Elite Khasi mandarin (*Citrus reticulata*) Blanco germplasm representing North-eastern states of Assam, Arunachal Pradesh, Meghalaya, Manipur and Tripura maintained at CRS, Tinsukia

Sl. No.	Accessions	Valuable traits	Place of collection
1.	CRS-1	Yield - 1223.33 fruits/plant, unique sugar-acid blend (TSS: Acid- 16.53),	Tinsukia, Assam
2.	CRS-2	Yield - 1453.67 fruits/plant, tolerant to gummosis, Early maturity (220days)	Tinsukia, Assam
3.	CRS-3	Yield - 1314.00 fruits/plant, lesser number of seeds in fruits (5)	Tinsukia, Assam
4.	CRS-4	Yield - 1782.67 fruits/plant, unique sugar-acid blend (TSS: Acid- 18.53), fruit juiciness at harvest maturity - more than 48%, Shelf-life – 21.60 days	Tinsukia, Assam
5.	CRS-5	Yield - 1556.00 fruits/plant, tolerant to trunk borer	Tinsukia, Assam
6.	CRS-6	Yield - 1683.00 fruits/plant, more sweetness	Tinsukia, Assam
7.	CRS-7	Yield - 1173.00 fruits/plant, Biotic stress tolerant, Shelf-life – 18.60 days	Tinsukia, Assam
8.	CRS-8	Yield - 1292.67 fruits/plant, late matured (Time taken for maturity 250 days)	Tinsukia, Assam
9.	CRS-KM-AR-L-1a	Yield - 1612.00 fruits/plant, TSS at harvest maturity: More than 30° brix	Lohit, Arunachal Pradesh
10.	CRS-KM-AR-L-1b	Biotic stress tolerant, pleasant-taste, more sweetness	Lohit, Arunachal Pradesh
11.	CRS- KM-AR-L-1c	Yield - 1092.00 fruits/plant, unique sugar-acid blend, tolerant to gummosis	Lohit, Arunachal Pradesh
12.	CRS- KM-AR-ES-2a	Yield - 1360.50 fruits/plant, Good size and colour of fruits	East Siang, Arunachal Pradesh
13.	CRS- KM-AR-ES-2b	Number of seeds per fruit at harvest maturity- less than 5	East Siang, Arunachal Pradesh
14.	CRS- KM-AR-ES-2c	Yield - 1392.67 fruits/plant, TSS at harvest maturity - More than 23° brix	East Siang, Arunachal Pradesh
15.	CRS- KM-AR-LDV-3a	Yield - 1468.60 fruits/plant, Fruit rind (epicarp) colour at harvest maturity - Dark orange, late maturity (Time taken for maturity 260 days)	Lower Dibang Valley, Arunachal Pradesh
16.	CRS- KM-AR-LDV-3b	Yield - 1292.67 fruits/plant, Fruit juiciness at harvest maturity - More than 45%	Lower Dibang Valley, Arunachal Pradesh
17.	CRS- KM-AR-LDV-3c	Yield - 1592.67 fruits/plant, unique sugar-acid blend, tolerant to gummosis, Shelf-life – 25.60 days	Lower Dibang Valley, Arunachal Pradesh
18.	CRS- KM-ML-EKH-1a	Biotic stress tolerant, Number of seeds per fruit at harvest maturity - less than 5	East Khasi Hills, Meghalaya
19.	CRS- KM-ML-EKH-1b	Yield - 1560.67 fruits/plant, total soluble solids at harvest maturity: More than 21° brix	East Khasi Hills, Meghalaya
20.	CRS- KM-ML-EKH-1c	Big size, Fruit rind (epicarp) colour at harvest maturity - Dark orange	East Khasi Hills, Meghalaya
21.	CRS- KM-ML-WGH-2a	Yield - 1402.67 fruits/plant Number of seeds per fruit at harvest maturity - less than 5	West Garo Hills, Meghalaya
22.	CRS- KM-ML-WGH-2b	Yield - 1430.00 fruits/plant, Biotic stress tolerant, tolerant to trunk borer	West Garo Hills, Meghalaya

23.	CRS- KM-ML-WGH-2c	Yield - 1570.00 fruits/plant tolerance to various biotic and abiotic stresses	West Garo Hills, Meghalaya
24.	CRS- KM-ML-RB-3a	Yield - 2530.00 fruits/plant, Big size fruit, Fruit rind (epicarp) colour at harvest maturity - Dark orange	Ri Bhoi, Meghalaya
25.	CRS- KM-ML-RB-3b	Yield - 1530.00 fruits/plant Fruit juiciness at harvest maturity: More than 45%	Ri Bhoi, Meghalaya
26.	CRS- KM-ML-RB-3c	Yield - 1330.00 fruits/plant Total soluble solids at harvest maturity: More than 26° brix	Ri Bhoi, Meghalaya
27.	CRS- KM-MN-T-1a	Yield - 1665.00 fruits/plant Biotic stress tolerant,	Tamenglong, Manipur
28.	CRS- KM-MN-T-1b	Big size, Fruit rind (epicarp) colour at harvest maturity - Dark orange	Tamenglong, Manipur
29.	CRS- KM-MN-T-1c	Number of seeds per fruit at harvest maturity: More than 5	Tamenglong, Manipur
30.	CRS- KM-MN-T-1d	Yield - 1690.00 fruits/plant, unique sugar-acid blend	Tamenglong, Manipur
31.	CRS- KM-MN-T-1e	Big size, Fruit rind (epicarp) colour at harvest maturity - Dark orange	Tamenglong, Manipur
32.	CRS- KM-MN-B-2a	Yield - 1580.00 fruits/plant, Good Flavour, tolerance to various biotic and abiotic stresses	Bishnupur, Manipur
33.	CRS- KM-MN-B-2b	Yield - 1645.00 fruits/plant, Biotic stress tolerant,	Bishnupur, Manipur
34.	CRS- KM-MN-B-2c	Yield - 2430.00 fruits/plant, tolerance to various biotic and abiotic stresses	Bishnupur, Manipur
35.	CRS- KM-MN-B-2d	unique sugar-acid blend, tolerance to various biotic and abiotic stresses	Bishnupur, Manipur
36.	CRS- KM-MN-B-2e	Good size and colour of fruits, Fruit weight at harvest maturity: 180 – 200 g	Bishnupur, Manipur
37.	CRS- KM-MN-N-3a	Fruit rind (epicarp) colour at harvest maturity: Dark orange	Noney, Manipur
38.	CRS- KM-MN-N-3b	Total soluble solids at harvest maturity: More than 11° brix	Noney, Manipur
39.	CRS- KM-MN-N-3c	Good size and colour of fruits Fruit weight at harvest maturity: 170 – 190 g,	Noney, Manipur
40.	CRS- KM-MN-N-3d	Number of seeds per fruit at harvest maturity: More than 5	Noney, Manipur
41.	CRS- KM-MN-N-3e	Fruit juiciness at harvest maturity: More than 45%	Noney, Manipur
42.	CRS- KM-TR-K-3a	Yield - 1230.00 fruits/plant	Khowai, Tripura
43.	CRS- KM-TR-K-3b	Fruit juiciness at harvest maturity - More than 45%	Khowai, Tripura
44.	CRS- KM-TR-K-3c	Fruit rind (epicarp) colour at harvest maturity - Dark orange	Khowai, Tripura
45.	CRS- KM-TR-K-3d	Good size and colour of fruits, Fruit weight at harvest maturity: 150 – 190 g	Khowai, Tripura
46.	CRS- KM-TR-K-3e	Number of seeds per fruit at harvest maturity- less than 5	Khowai, Tripura
47.	CRS- KM-TR-S-1a	Yield - 1890.00 fruits/plant, Good size and colour of fruits, Fruit weight at harvest maturity: 180 – 200 g	Sipahijala, Tripura
48.	CRS- KM-TR-S-1b	Fruit rind (epicarp) colour at harvest maturity - Dark orange	Sipahijala, Tripura
49.	CRS- KM-TR-S-1c	Yield - 2380.00 fruits/plant, Fruit juiciness at harvest maturity: More than 45%	Sipahijala, Tripura
50.	CRS- KM-TR-S-1d	Yield - 1089.00 fruits/plant, Total soluble solids at harvest maturity: More than 24° brix	Sipahijala, Tripura
51.	CRS- KM-TR-S-1e	Yield - 1789.00 fruits/plant, Number of seeds per fruit at harvest maturity- less than 5	Sipahijala, Tripura
52.	CRS- KM-TR-G-2a	Fruit juiciness at harvest maturity - More than 45%	Gomati, Tripura
53.	CRS- KM-TR-G-2b	Yield - 1830.00 fruits/plant	Gomati, Tripura
54.	CRS- KM-TR-G-2c	Yield - 1970.00 fruits/plant, unique sugar-acid blend	Gomati, Tripura
55.	CRS- KM-TR-G-2d	Yield - 1390.00 fruits/plant, Good size and colour of fruits	Gomati, Tripura
56.	CRS- KM-TR-G-2e	Yield - 3400.00 fruits/plant	Gomati, Tripura
57.	Honey orange	Yield - 1230.00 fruits/plant	Mizoram

TABLE 3: Evaluation of growth and yield characters of some elite citrus germplasm at Tinsukia

Sl. No	Species	Plant ht (m)	Stem girth (cm)	N-S spread (m)	E-W spread (m)	Canopy volume (m^3)	Fruits/ tree	Fruit yield (kg/plant)	Fruit yield (t/ ha)	Fruit weight (gm/ fruit)
1	Khasi mandarin, *C. reticulata*	4.52	34.5	3.13	3.25	27.11	185	22.54	9.16	124
2	Sweet orange, *C. sinensis*	4.16	33.9	2.53	2.29	27.39	105	2.04	0.81	408
3	Citron, *C. medica*	3.45	23.8	3.87	3.25	25.77	335	51.25	20.50	153
4	Lemon, *C.limon*	2.99	19.2	2.75	2.98	9.43	85	2.65	1.06	106
5	Rough lemon, *C. jambhiri*	3.25	21.6	3.16	3.24	19.61	94	3.36	1.34	140
6	Pummelo, *C. grandis*	5.41	74.4	7.66	7.87	192.54	145	130.93	52.37	903
7	Grapefruit, *C. paradisi*	8.33	58.10	7.76	9.44	365.18	165	78.87	31.54	478
8	Sour pummel, *C. megaloxycarpa*	4.22	37.9	5.41	5.92	79.83	105	83.47	33.38	795
9	Acid lime, *C. auriantifolia*	2.48	18.15	2.17	2.78	10.76	60	0.82	0.32	82
10	Sweet lime, *C. limettoides*	3.89	19.10	3.98	3.15	29.14	25	0.82	0.32	133
11	King orange, *C. nobilis*	3.65	40.16	3.45	3.42	25.38	45	14.71	5.88	327
12	Karna khatta, *C. karna*	2.98	38.75	3.68	4.20	27.27	25	9.30	3.72	372
13	Galgal, *C. pseudolimon*	3.55	20.12	3.85	3.76	30.29	13	1.88	0.75	145
14	Adajamir, *C. assamensis*	1.47	21.05	1.57	2.37	3.36	13	1.20	0.48	403
15	Khasi papeda, *C. letipes*	5.75	127.10	6.25	6.86	145.65	131	84.49	33.49	645
16	Volkameriana, *C. volkameriana*	4.13	30.28	3.15	2.98	22.87	98	15.19	6.07	155
17	Rangpur lime, *C. limonia*	3.19	22.81	3.77	3.05	21.86	56	3.19	12.76	57
18	Cleopetra mandarin, *C. reshui*	4.10	31.85	3.16	3.89	30.03	115	3.45	1.38	30
19	Trifoliate orange, Poncirus trifoliate	5.10	26.95	4.44	4.58	61.15	115	8.62	3.44	75
20	Troyer citrange, Trifoliate hybrid	3.19	25.51	4.46	3.99	33.56	95	5.13	2.05	54
21	Calamandin mandarin, *C. mitis*	4.51	32.15	3.89	3.25	31.97	115	10.46	4.84	91
22	Taiwainica, *C. taiwinica*	3.54	22.65	3.56	3.45	25.63	10	3.10	1.24	310

TABLE 4: Variation in physico-chemical characters of fruit of different species of Citrus germplasm of Tinsukia

Sl. No	Species	Fruit size (cm)		Rind thickness (mm)	Segment/ fruit	Seed/ fruit	Juice/ fruit (ml)	TSS (%)	Acidity (%)
		Length	Diameter						
1	Khasi mandarin, *C. reticulata*	6.35	6.20	1.90	11.50	22.00	105.0	10.61	0.45
2	Sweet orange, *C. sinensis*	9.18	9.31	5.57	13.00	18.00	86.50	12.27	0.92
3	Citron, *C. medica*	15.84	13.0	4.90	12.50	10.00	85.00	6.00	4.70
4	Lemon, *C.limon*	26.48	15.65	15.25	12.50	19.00	73.50	6.87	3.65
5	Rough lemon, *C. jambhiri*	4.07	4.80	3.25	13.00	12.50	16.50	7.42	3.70

6	Pummelo, *C. grandis*	11.29	9.95	16.75	18.50	45.00	165.0	9.65	2.69
7	Grapefruit, *C. paradisi*	7.60	8.10	6.9	13.50	46.00	185.5	9.89	2.12
8	Sour pummel, *C. megaloxycarpa*	5.35	5.25	5.05	12.50	25.00	150.0	10.20	3.95
9	Acid lime, *C. auriantifolia*	3.15	2.63	1.55	9.00	8.50	11.50	7.25	5.45
10	Sweet lime, *C. limettoides*	4.00	4.45	1.65	9.00	8.50	20.00	7.80	3.50
11	King orange, *C. nobilis*	7.00	7.43	2.55	12.00	10.00	55.00	13.20	0.94
12	Karna khatta, *C. karna*	7.35	7.32	10.32	12.00	9.00	66.00	11.25	0.45
13	Galgal, *C. pseudolimon*	9.08	7.20	5.46	9.00	29.50	30.00	7.79	3.85
14	Adajamir, *C. assamensis*	5.50	6.00	4.54	10.50	13.50	24.50	6.89	4.15
15	Khasi papeda, *C. letipes*	7.20	6.88	4.55	13.50	42.50	91.00	8.10	4.10
16	Volkameriana, *C. volkameriana*	4.70	4.52	3.25	12.50	15.00	16.50	7.23	4.09
17	Rangpur lime, *C. limonia*	5.00	5.00	2.00	12.50	12.50	110.0	11.45	6.20
18	Cleopetra mandarin, *C. reshui*	2.50	3.5	1.13	13.00	8.00	27.50	8.70	3.38
19	Trifoliate orange, Poncirus trifoliate	4.50	4.00	0.54	10.00	12.50	10.00	5.65	3.91
20	Troyer citrange, Trifoliate hybrid	5.00	4.50	0.55	11.00	18.50	16.00	5.75	4.00
21	Calamandin mandarin, *C. mitis*	3.01	3.45	1.04	12.50	12.00	40.00	7.65	3.96
22	Taiwainica, *C. taiwinica*	4.25	4.12	2.15	12.50	16.50	30.35	6.85	2.70

CONCLUSION

The North Eastern states of India offer tremendous potential for boosting Citrus fruit processing industries as well as for export marketing. Systematic study and large-scale cultivation are required for promoting the citrus based industry in this region. In view of the genetic erosion taking place at an alarming rate, there is an urgent need for collection and conservation of germplasm of different Citrus species and wild relatives. Citrus Research Station of Assam Agricultural University is maintaining one of the richest Citrus Germplasm blocks. It has actively participated in collection, characterization, conservation and evaluation of citrus germplasm. Management of Citrus genotypes in germplasm block had proved to be difficult due to their variation in adoptability or susceptibility to insect pest and disease incidence. Many of the germplasm are under the deteriorated condition due to several factors. These genotypes are needed to be re-establishing under controlled conditions.

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