

Study on morphological characterization of *Citrus macroptera* Mont collected from garo hills district Meghalaya, India

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Abstract

The work was undertaken to study the variability in *Citrus macroptera* from five Garo hills district. Many important horticultural plant species, viz. Citrus are known to have originated from this region. *Citrus macroptera* Mont. is one of the endangered, semi-wild species which have found to exist in various parts of NE region, including Meghalaya. Thirty accession of *Citrus macroptera* from five different districts of Garo Hills, Meghalaya were collected to study its variability in quantity and quality parameters. In the study significant to highly significant differences were observed among the genotypes. The analysis of variance for different parameters such as tree height, tree girth, leaf length, leaf width, fruit width, fruit length, fruit weight, number of fruit segment, rind thickness, number of seeds per segment, seed length, and seed width varied significantly among accession. Variability among accession collected from different location shows the great scope for genetically potential genotypes for cultivation and also for their exploitation in plant breeding programme.

Keywords: *Citrus macroptera*; Diversity; Endangered species; Morphological characterization

1. Introduction

The North-eastern region (NER) of India has vast geographical and climatic conditions and is therefore a natural storehouse for many important horticultural species of the genus *Citrus* L. It is also considered to be the center of origin of this genus which encompasses one of the major groups of fruits belonging to the family Rutaceae with high species diversity [5], [6], [7], [12]. Due to the wide intraspecific diversity in the NER, this region has gained the prestigious status of being the “treasure house” for *Citrus* sp. [6]. The state of Meghalaya, in particular has been bestowed with several wild and semi-wild species of citrus [7].

C. macroptera Mont., belonging to the Rutaceae family is one of the endangered, semi-wild citrus species with restricted distribution in NER states of Meghalaya, Manipur, Mizoram and Tripura. It is adequately found in the found in the hilly areas of Meghalaya, especially in all the five districts of Garo Hills. It is locally known as ‘Chambil’. The fruit is popular among the locals for treating various ailments like fever, jaundice, alimentary disorders etc. It has also long been used to treat food poisoning in humans and animals. The fruits reportedly have numerous pharmaceutically important bioactive compounds which are cytotoxic, antimicrobial, antihypertensive, antipyretic, anti-diabetic and appetite stimulant potentials [11], [12], [14], [8]. The peel is rich in caffeic acid, making it a strong antioxidant compound which helps in preventing fibrosis, oxidative stress and even cancer [10]. Despite its multifaceted therapeutic importance, various biotic and abiotic stresses as well as over-exploitation by humans are major factors causing an alarming decrease in the natural population of this species in Meghalaya.

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2. Material and methods

Several survey and selection of promising accessions were undertaken from five districts of Garo Hills, in the state of Meghalaya, namely, West Garo Hills, East Garo Hills, South Garo Hills, North Garo Hills, and South West Garo Hills (Fig. 1). Identification of *Citrus macroptera* was done following the descriptor based on International Plant Genetic Resource Institute Descriptors for Citrus (IPGRI, 1999). Completely randomized design was followed since there is only one source of variation, i.e., location.

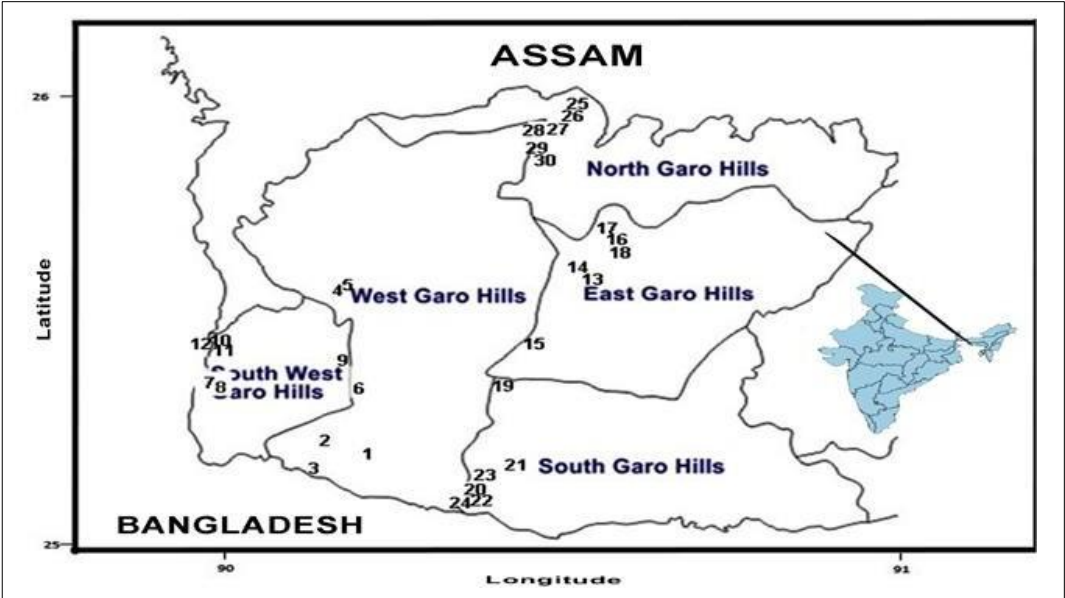


Figure 1 Geographical locations of 30 collections of *Citrus macroptera* Mont. collections from Garo Hills, Meghalaya

The morphological parameters taken for characterization were tree height, tree girth, tree shape, leaf colour, leaf length, leaf width, lamina shape, lamina attachment, leaf margin, petiole wing shape, petiole wing width, inflorescence position, fruit weight, fruit shape, fruit base shape, fruit length, fruit diameter, fruit skin colour, fruit skin surface, peel thickness, number of fruit segment, pulp color, juice content, TSS, seed length, seed width, number of seed per segment, seed shape, seed surface and seed colour. The experimental data were analyzed using Oneway Analysis of variance (ANOVA).

Table 1 Genotypes of *Citrus macroptera* Mont. collected from five districts of Garo Hills along with geographical locations of their sampling sites

S.No.	Species	Collection Id	Place	Latitude	Longitude
1	<i>Citrus macroptera</i>	WGHT1R2	Didok	25°15'26.1" N	90°21'14.3" E
2	<i>C. macroptera</i>	WGHT1R2	Mongolagri	25°16'41.3" N	90°12'24.4" E
3	<i>C. macroptera</i>	WGHT1R3	Chanapara	25°14'21.2" N	90°12'39.1" E
4	<i>C. macroptera</i>	WGHT2R1	Chasingre	25°33'13.6" N	90°14'11.46" E
5	<i>C. macroptera</i>	WRGT2R2	Nengja	25°33'39.2" N	90°14'24.4" E
6	<i>C. macroptera</i>	WGHT2R3	Gongangri	25°20'56.7" N	90°14'46.8" E
7	<i>C. macroptera</i>	SWGHT1R1	Dinapara	25°24'48.6" N	89°58'42.5" E
8	<i>C. macroptera</i>	SWGHT1R2	Boldakgri	25°23'38.9" N	89°58'48.9" E
9	<i>C. macroptera</i>	SWGHT1R3	Nokatgri	25°33'40.5" N	90°15'9.7" E
10	<i>C. macroptera</i>	SWGHT2R1	Malchapara	25°31'49.8" N	89°58'49.2" E
11	<i>C. macroptera</i>	SWGHT2R2	Ajongri	25°30'38.6" N	89°59'13.9" E

12	<i>C. macroptera</i>	SWGHT2R3	Bolsalgri	25°31'39.1" N	89°58'49.5" E
13	<i>C. macroptera</i>	EGHT1R1	Mikkilsimgri a	25°34'25.3" N	90°34'45.6" E
14	<i>C. macroptera</i>	EGHT1R2	Mikkilsimgri b	25°34'26.6" N	90°34'43.5" E
15	<i>C. macroptera</i>	EGHT1R3	Sakalgri	25°31'29.2" N	89°58'48.9" E
16	<i>C. macroptera</i>	EGHT2R1	Wagopgri	25°37'41.3" N	90°36'12.1" E
17	<i>C. macroptera</i>	EGHT2R2	Jengjelgri	25°38'0.2" N	90°35'57.6" E
18	<i>C. macroptera</i>	EGHT2R3	Nengjengri	25°35'34.4" N	90°36'46.4" E
19	<i>C. macroptera</i>	SGHT1R1	Imaragri	25°20'6.8" N	90°18'04.3" E
20	<i>C. macroptera</i>	SGHT1R2	Rongsugri	25°12'59.2" N	90°20'45.5" E
21	<i>C. macroptera</i>	SGHT1R3	Doragri	25°25'34.7" N	90°36'11.6" E
22	<i>C. macroptera</i>	SGHT2R1	Dindinagri	25°12'42.7" N	90°20'55.4" E
23	<i>C. macroptera</i>	SGHT2R2	Damal Nokatgri	25°14'40.1" N	90°21'1.3" E
24	<i>C. macroptera</i>	SGHT2R3	Rongsepgri	25°12'32.9" N	90°20'28.1" E
25	<i>C. macroptera</i>	NGHT1R1	Rompara a	25°52'16.2" N	90°36'34.2" E
26	<i>C. macroptera</i>	NGHT1R2	Rompara b	25°51'58.1" N	90°36'26.4" E
27	<i>C. macroptera</i>	NGHT1R3	Dingrepa	25°50'44.4" N	90°28'20.5" E
28	<i>C. macroptera</i>	NGHT2R1	Dingrepa	25°50'44.0" N	90°28'20.5" E
29	<i>C. macroptera</i>	NGHT2R2	Kitmagri	25°47'32.68" N	90°25'08.68" E
30	<i>C. macroptera</i>	NGHT2R3	Rari	25°47'22.32" N	90°25'45.68" E

3. Results and discussion

The study showed significant variation among the accessions collected from five different districts of Garo hill. The tree grows more than 10m in height and was found to be ellipsoid in shape. Leaf showed dark green, longipetiolate leaf attachment with orbicular leaf lamina shape, and entire leaf margin. It has broad petiole wing with obovate in shape. Fruit was spheroid in shape with concave fruit base, rough surface texture, yellowish pulp colour, axillary inflorescence position and arrangement of flower is in an inflorescence. Seed was creamish in colour with wrinkled surface and semi-deltoid in shape (Table 2). These findings are in line with Malik et. al. [7], Sanabam et. al. [13]

Plants height as shown in the table (3) varied significantly. EGHT2R3 recorded highest plant height of 14.99 m, 15.19m and 15.09 m in the first year, second year and pooled data respectively. On contrary, during first year (8.12), second year (8.29) and pooled data (8.20), the minimum plant height was observed in SWGHT1R3. Similarly the plant girth of 152.77, 155.97 and 154.37 cm during the First year, second year and pooled data was recorded highest in EGHT2R3, Whereas the minimum plant girth was recorded with SGHT2R1 (42.73cm, 52.50cm and 47.62cm) in the first year, second year and pooled data respectively. Variation in tree character depending upon location was reported by chetry et al. [2], Dorji et al [3],Yadlod et. al. [15].. Variation in tree height and its girth may be due to its topography and environmental condition.

Significant variation was seen for leaf length and leaf width among *Citrus macroptera* (table 3). The longest leaf length during first year, second year and pooled data (138.71m, 137.86m and 138.29m respectively) was recorded with SGT2R1, whereas the leaf length of 112.79m, 102.44m and 107.62 in the first year, second year and pooled data respectively recorded lowest with SWGHT1R3. The highest leaf width was recorded in WGHT2R1 with 50.79, 48.28 and 49.53 during first year, second year and pooled data respectively.

Table 2 Qualitative characters of leaf, fruit and seed of *Citrus macroptera* following IPGRI

Sl No.	Location	Place	Leaf Color	Leaf Attachment	Leaf Lamina shape	Leaf Margin	Petiole Wing Shape	Petiole wing width	Fruit Shape	Fruit Base	Peel colour	Fruit Surface texture	Pulp colour	Seed Shape	Seed surface	Seed colour
1	WGHT1R1	Didok	Dark	Longipetiolate	Orbicular	Entire	Obcordate	Broad	Spheroid	Concave	Yellowish	Rough	Yellowish	Semi-deltoid	Wrinkled	Yellowish
2	WGHT1R2	Mongolagri	Dark	Longipetiolate	Orbicular	Entire	Obcordate	Broad	Spheroid	Concave	Yellowish	Rough	Yellowish	Semi-deltoid	Wrinkled	Yellowish
3	WGHT1R3	Chanapara	Dark	Longipetiolate	Orbicular	Entire	Obcordate	Broad	Spheroid	Concave	Yellowish	Rough	Yellowish	Semi-deltoid	Wrinkled	Yellowish
4	WGHT2R1	Chasingre	Dark	Longipetiolate	Orbicular	Entire	Obcordate	Broad	Spheroid	Concave	Yellowish	Rough	Yellowish	Semi-deltoid	Wrinkled	Yellowish
5	WGHT2R2	Nengja	Dark	Longipetiolate	Orbicular	Entire	Obcordate	Broad	Spheroid	Concave	Yellowish	Rough	Yellowish	Semi-deltoid	Wrinkled	Yellowish
6	WGHT2R3	Gongangri	Dark	Longipetiolate	Orbicular	Entire	Obcordate	Broad	Spheroid	Concave	Yellowish	Rough	Yellowish	Semi-deltoid	Wrinkled	Yellowish
7	SWGHT1R1	Dinapara	Dark	Longipetiolate	Orbicular	Entire	Obcordate	Broad	Spheroid	Concave	Yellowish	Rough	Yellowish	Semi-deltoid	Wrinkled	Yellowish
8	SWGHT1R2	Boldakgri	Dark	Longipetiolate	Orbicular	Entire	Obcordate	Broad	Spheroid	Concave	Yellowish	Rough	Yellowish	Semi-deltoid	Wrinkled	Yellowish
9	SWGHT1R3	Nokatgri	Dark	Longipetiolate	Orbicular	Entire	Obcordate	Broad	Spheroid	Concave	Yellowish	Rough	Yellowish	Semi-deltoid	Wrinkled	Yellowish
10	SWGHT2R1	Malchapara	Dark	Longipetiolate	Orbicular	Entire	Obcordate	Broad	Spheroid	Concave	Yellowish	Rough	Yellowish	Semi-deltoid	Wrinkled	Yellowish
11	SWGHT2R2	Ajongri	Dark	Longipetiolate	Orbicular	Entire	Obcordate	Broad	Spheroid	Concave	Yellowish	Rough	Yellowish	Semi-deltoid	Wrinkled	Yellowish
12	SWGHT2R3	Bolsalgri	Dark	Longipetiolate	Orbicular	Entire	Obcordate	Broad	Spheroid	Concave	Yellowish	Rough	Yellowish	Semi-deltoid	Wrinkled	Yellowish
13	EGHT1R1	Mikkilsimgri a	Dark	Longipetiolate	Orbicular	Entire	Obcordate	Broad	Spheroid	Concave	Yellowish	Rough	Yellowish	Semi-deltoid	Wrinkled	Yellowish
14	EGHT1R2	Mikkilsimgri b	Dark	Longipetiolate	Orbicular	Entire	Obcordate	Broad	Spheroid	Concave	Yellowish	Rough	Yellowish	Semi-deltoid	Wrinkled	Yellowish

15	EGHT1R3	Sasatgre	Dark	Longipetiolate	Orbicular	Entire	Obcordate	Broad	Spheroid	Concave	Yellowish	Rough	Yellowish	Semi-deltoid	Wrinkled	Yellowish
16	EGHT2R1	Wagopgri	Dark	Longipetiolate	Orbicular	Entire	Obcordate	Broad	Spheroid	Concave	Yellowish	Rough	Yellowish	Semi-deltoid	Wrinkled	Yellowish
17	EGHT2R2	Jengjelgri	Dark	Longipetiolate	Orbicular	Entire	Obcordate	Broad	Spheroid	Concave	Yellowish	Rough	Yellowish	Semi-deltoid	Wrinkled	Yellowish
18	EGHT2R3	Nengjengri	Dark	Longipetiolate	Orbicular	Entire	Obcordate	Broad	Spheroid	Concave	Yellowish	Rough	Yellowish	Semi-deltoid	Wrinkled	Yellowish
19	SGHT1R1	Imaragri	Dark	Longipetiolate	Orbicular	Entire	Obcordate	Broad	Spheroid	Concave	Yellowish	Rough	Yellowish	Semi-deltoid	Wrinkled	Yellowish
20	SGHT1R2	Rongsugri	Dark	Longipetiolate	Orbicular	Entire	Obcordate	Broad	Spheroid	Concave	Yellowish	Rough	Yellowish	Semi-deltoid	Wrinkled	Yellowish
21	SGHT1R3	Doragri	Dark	Longipetiolate	Orbicular	Entire	Obcordate	Broad	Spheroid	Concave	Yellowish	Rough	Yellowish	Semi-deltoid	Wrinkled	Yellowish
22	SGHT2R1	Dindinagri	Dark	Longipetiolate	Orbicular	Entire	Obcordate	Broad	Spheroid	Concave	Yellowish	Rough	Yellowish	Semi-deltoid	Wrinkled	Yellowish
23	SGHT2R2	Damal Nokatgri	Dark	Longipetiolate	Orbicular	Entire	Obcordate	Broad	Spheroid	Concave	Yellowish	Rough	Yellowish	Semi-deltoid	Wrinkled	Yellowish
24	SGHT2R3	Rongsepgri	Dark	Longipetiolate	Orbicular	Entire	Obcordate	Broad	Spheroid	Concave	Yellowish	Rough	Yellowish	Semi-deltoid	Wrinkled	Yellowish
25	NGHT1R1	Rompara	Dark	Longipetiolate	Orbicular	Entire	Obcordate	Broad	Spheroid	Concave	Yellowish	Rough	Yellowish	Semi-deltoid	Wrinkled	Yellowish
26	NGHT1R2	Bangadura	Dark	Longipetiolate	Orbicular	Entire	Obcordate	Broad	Spheroid	Concave	Yellowish	Rough	Yellowish	Semi-deltoid	Wrinkled	Yellowish
27	NGHT1R3	Dingrepa	Dark	Longipetiolate	Orbicular	Entire	Obcordate	Broad	Spheroid	Concave	Yellowish	Rough	Yellowish	Semi-deltoid	Wrinkled	Yellowish
28	NGHT2R1	Dingrepa	Dark	Longipetiolate	Orbicular	Entire	Obcordate	Broad	Spheroid	Concave	Yellowish	Rough	Yellowish	Semi-deltoid	Wrinkled	Yellowish
29	NGHT2R2	Kitmagri	Dark	Longipetiolate	Orbicular	Entire	Obcordate	Broad	Spheroid	Concave	Yellowish	Rough	Yellowish	Semi-deltoid	Wrinkled	Yellowish
30	NGHT2R3	Rari	Dark	Longipetiolate	Orbicular	Entire	Obcordate	Broad	Spheroid	Concave	Yellowish	Rough	Yellowish	Semi-deltoid	Wrinkled	Yellowish

Table 3 Tree parameters of *Citrus macroptera* collected from different districts

Sl. No	Collection Id	Plant Height			Plant Girth			Leaf length			Leaf width		
		1st year	2nd Year	Pooled	1st year	2nd Year	Pooled	1st year	2nd Year	Pooled	1st year	2nd Year	Pooled
1	WGHT1R2	8.25	8.61	8.43	83.50	87.30	85.40	134.26	133.74	134.00	41.07	40.41	40.74
2	WGHT1R2	9.84	10.22	10.03	90.63	94.33	92.48	125.10	116.83	120.96	41.63	40.32	40.98
3	WGHT1R3	10.93	11.05	10.99	77.47	78.47	77.97	133.23	133.22	133.23	40.61	41.83	41.22
4	WGHT2R1	8.73	9.07	8.90	59.97	63.77	61.87	135.37	134.36	134.87	50.79	48.28	49.53
5	WRGT2R2	10.85	11.09	10.97	77.17	82.13	79.65	136.55	134.40	135.47	44.02	44.16	44.09
6	WGHT2R3	8.25	8.46	8.36	76.83	84.10	80.47	122.58	120.55	121.57	39.92	37.44	38.68
7	SWGHT1R1	11.04	11.20	11.12	103.73	103.17	103.45	129.41	121.88	125.65	34.79	36.18	35.48
8	SWGHT1R2	9.50	9.91	9.70	80.50	83.93	82.22	122.20	110.79	116.49	33.34	33.67	33.50
9	SWGHT1R3	8.12	8.29	8.20	104.27	107.20	105.73	113.80	102.44	108.12	38.47	33.93	36.20
10	SWGHT2R1	8.15	8.51	8.33	63.43	65.63	64.53	130.71	132.78	131.75	42.35	42.34	42.34
11	SWGHT2R2	8.77	8.99	8.88	82.50	83.90	83.20	124.95	127.11	126.03	42.55	43.52	43.03
12	SWGHT2R3	8.28	8.43	8.35	52.27	53.37	52.82	124.60	125.88	125.24	42.56	41.04	41.80
13	EGHT1R1	11.85	12.06	11.96	86.37	87.03	86.70	129.31	129.53	129.42	40.28	40.89	40.59
14	EGHT1R2	9.33	9.71	9.52	130.83	132.87	131.85	131.84	135.74	133.79	48.65	47.14	47.90
15	EGHT1R3	7.78	8.17	7.98	58.07	56.53	57.30	131.96	128.65	130.31	41.06	38.22	39.64
16	EGHT2R1	10.07	10.37	10.22	73.50	74.70	74.10	112.79	110.17	111.48	35.53	33.78	34.66
17	EGHT2R2	9.56	9.77	9.66	49.53	54.57	52.05	121.56	120.05	120.81	40.91	40.67	40.79
18	EGHT2R3	14.99	15.19	15.09	152.77	155.97	154.37	127.01	127.91	127.46	33.26	33.13	33.20
19	SGHT1R1	8.39	8.66	8.53	78.77	82.47	80.62	131.39	131.00	131.20	44.26	42.48	43.37
20	SGHT1R2	9.23	9.38	9.30	102.67	111.67	107.17	118.28	121.72	120.00	44.47	43.70	44.09
21	SGHT1R3	9.12	9.16	9.14	65.60	70.37	67.98	116.07	116.90	116.49	45.89	41.82	43.86
22	SGHT2R1	8.50	8.64	8.57	42.73	52.50	47.62	138.71	137.86	138.29	47.89	45.86	46.88

23	SGHT2R2	12.91	13.51	13.21	124.47	126.27	125.37	135.42	139.15	137.28	42.57	43.73	43.15
24	SGHT2R3	9.53	9.64	9.59	58.77	61.47	60.12	124.98	123.95	124.47	45.28	43.96	44.62
25	NGHT1R1	8.58	8.79	8.69	82.90	87.33	85.12	114.69	110.17	112.43	34.63	35.56	35.10
26	NGHT1R2	8.54	8.69	8.61	91.97	100.60	96.28	117.48	115.43	116.46	36.01	35.94	35.98
27	NGHT1R3	11.58	11.17	11.37	52.57	57.70	55.13	126.00	112.47	119.24	37.05	36.36	36.70
28	NGHT2R1	10.99	10.99	10.99	59.43	61.63	60.53	134.80	110.23	122.52	36.46	34.97	35.72
29	NGHT2R2	13.17	13.53	13.35	142.73	144.20	143.47	119.28	103.92	111.60	34.81	34.50	34.65
30	NGHT2R3	12.39	12.73	12.56	106.27	112.03	109.15	123.24	118.38	120.81	36.25	35.89	36.07
Mean		9.91	10.13	10.02	83.74	87.24	85.49	126.25	122.91	124.58	40.58	39.72	40.15
Sem±		0.60	0.61	0.43	2.88	2.70	1.97	1.86	2.01	1.37	0.72	0.45	0.43
SE (d)		0.85	0.86	0.61	4.08	3.82	2.79	2.64	2.85	1.94	1.02	0.64	0.60
CD at 5%		1.70	1.73	1.20	8.16	7.63	5.53	5.27	5.70	3.84	2.04	1.28	1.19
CV		10.53	10.43	10.48	5.96	5.36	5.66	2.56	2.84	2.70	3.08	1.98	2.60

Table 4 Fruit parameters of *Citrus macroptera* collected from different districts

Sl. No	Collection Id	Fruit weight			Fruit length			Fruit width			No. of segment per fruit		
		1st year	2nd Year	Pooled	1st year	2nd Year	Pooled	1st year	2nd Year	Pooled	1st year	2nd Year	Pooled
1	WGHT1R2	292.67	288.33	290.50	6.87	6.98	6.93	8.28	8.57	8.43	14.13	14.00	14.07
2	WGHT1R2	440.67	440.00	440.33	9.09	8.96	9.03	10.42	10.57	10.50	13.07	13.47	13.27
3	WGHT1R3	238.00	268.00	253.00	7.23	7.45	7.34	8.85	9.29	9.07	13.40	13.00	13.20
4	WGHT2R1	280.33	274.00	277.17	7.39	7.15	7.27	8.92	8.63	8.78	13.80	13.93	13.87
5	WRGT2R2	320.67	315.67	318.17	7.86	7.47	7.67	9.88	9.37	9.62	13.00	13.67	13.33
6	WGHT2R3	245.67	243.33	244.50	7.21	7.02	7.12	8.23	8.24	8.23	13.80	14.13	13.97
7	SWGHT1R1	353.33	337.33	345.33	8.53	8.40	8.47	8.87	8.95	8.91	13.33	13.07	13.20
8	SWGHT1R2	240.67	242.00	241.33	7.20	7.01	7.11	7.81	7.65	7.73	13.20	13.40	13.30
9	SWGHT1R3	241.33	249.33	245.33	7.10	6.93	7.02	8.22	8.41	8.32	13.87	13.80	13.83

10	SWGHT2R1	223.33	217.33	220.33	7.07	7.02	7.04	7.51	7.90	7.71	13.47	13.00	13.23
11	SWGHT2R2	417.67	400.67	409.17	8.99	9.09	9.04	9.61	8.70	9.16	13.00	13.80	13.40
12	SWGHT2R3	240.67	226.00	233.33	7.07	6.98	7.03	7.85	7.75	7.80	13.93	13.33	13.63
13	EGHT1R1	277.00	265.67	271.33	7.40	7.64	7.52	9.01	8.88	8.94	13.67	13.20	13.43
14	EGHT1R2	298.00	283.33	290.67	7.66	7.50	7.58	8.73	8.15	8.44	13.53	13.53	13.53
15	EGHT1R3	256.67	247.00	251.83	7.16	7.19	7.17	8.28	8.02	8.15	12.33	12.33	12.33
16	EGHT2R1	263.67	235.33	249.50	7.51	7.65	7.58	8.96	8.58	8.77	13.47	13.47	13.47
17	EGHT2R2	226.67	245.33	236.00	7.11	6.82	6.97	8.18	8.18	8.18	14.20	14.20	14.20
18	EGHT2R3	300.00	344.00	322.00	7.27	7.38	7.33	8.38	8.31	8.35	13.20	13.20	13.20
19	SGHT1R1	339.33	350.67	345.00	8.18	8.09	8.14	10.07	10.18	10.12	13.00	13.00	13.00
20	SGHT1R2	284.67	290.00	287.33	7.18	7.12	7.15	8.71	8.63	8.67	13.67	13.67	13.67
21	SGHT1R3	234.00	203.00	218.50	6.64	6.99	6.81	8.21	8.08	8.15	13.00	13.00	13.00
22	SGHT2R1	274.67	265.33	270.00	7.36	7.19	7.28	8.43	8.55	8.49	13.93	13.93	13.93
23	SGHT2R2	358.33	330.00	344.17	7.41	7.39	7.40	9.54	9.38	9.46	13.67	13.67	13.67
24	SGHT2R3	247.67	251.67	249.67	6.80	6.89	6.85	8.37	8.35	8.36	13.53	13.53	13.53
25	NGHT1R1	355.67	378.00	366.83	9.05	8.88	8.97	9.27	8.94	9.11	12.33	12.33	12.33
26	NGHT1R2	371.67	383.00	377.33	8.20	8.38	8.29	8.71	8.62	8.67	13.47	13.47	13.47
27	NGHT1R3	262.67	231.00	246.83	6.26	6.55	6.41	8.46	8.60	8.53	14.20	14.20	14.20
28	NGHT2R1	229.33	196.67	213.00	7.13	7.18	7.16	8.38	8.31	8.35	13.20	13.20	13.20
29	NGHT2R2	327.33	320.33	323.83	7.45	7.64	7.54	8.96	9.12	9.04	13.00	13.07	13.03
30	NGHT2R3	261.00	253.67	257.33	7.31	7.13	7.22	9.02	9.01	9.02	13.67	13.73	13.70
Mean		290.11	285.87	287.99	7.49	7.47	7.48	8.74	8.66	8.70	13.44	13.44	13.44
Sem±		7.83	8.45	5.76	0.14	0.10	0.09	0.11	0.11	0.08	0.14	0.14	0.10
SE (d)		11.08	11.96	8.15	0.20	0.14	0.12	0.16	0.16	0.11	0.19	0.19	0.14
CD at 5%		22.15	23.92	16.13	0.40	0.28	0.24	0.31	0.32	0.22	0.38	0.39	0.27
CV		4.68	5.12	4.90	3.31	2.33	2.86	2.20	2.28	2.24	1.75	1.77	1.76

Table 5 Fruit parameters of *Citrus macroptera*

Sl. No	Collection Id	No. of fruits per tree			Peel thickness			Juice content			TSS		
		1st year	2nd Year	Pooled	1st year	2nd Year	Pooled	1st year	2nd Year	Pooled	1st year	2nd Year	Pooled
1	WGHT1R2	486.00	469.67	477.83	10.32	10.60	10.46	24.21	26.34	25.27	7.84	7.53	7.69
2	WGHT1R2	699.67	634.00	666.83	15.48	15.50	15.49	21.12	32.30	26.71	7.01	7.28	7.15
3	WGHT1R3	464.33	446.00	455.17	10.96	11.17	11.06	24.26	29.36	26.81	6.77	7.43	7.10
4	WGHT2R1	690.00	643.33	666.67	10.41	10.26	10.34	22.61	26.86	24.73	6.79	7.65	7.22
5	WRGT2R2	545.33	539.33	542.33	10.86	11.05	10.95	21.84	24.40	23.12	7.00	7.20	7.10
6	WGHT2R3	613.33	603.33	608.33	12.37	12.16	12.27	21.17	27.48	24.32	7.07	7.20	7.13
7	SWGHT1R1	619.67	603.00	611.33	12.84	13.01	12.93	21.41	24.94	23.18	7.20	7.13	7.17
8	SWGHT1R2	503.33	530.00	516.67	10.63	11.07	10.85	22.15	29.04	25.60	7.23	7.33	7.28
9	SWGHT1R3	869.33	863.33	866.33	12.72	13.64	13.18	25.19	26.11	25.65	7.47	7.37	7.42
10	SWGHT2R1	450.00	439.67	444.83	13.63	13.67	13.65	23.92	28.88	26.40	7.23	6.87	7.05
11	SWGHT2R2	380.00	380.00	380.00	13.60	13.26	13.43	21.38	25.58	23.48	7.43	7.67	7.55
12	SWGHT2R3	423.00	431.33	427.17	12.22	12.62	12.42	20.30	27.03	23.66	7.60	7.57	7.58
13	EGHT1R1	695.00	681.00	688.00	13.15	13.35	13.25	21.27	25.04	23.16	7.27	7.47	7.37
14	EGHT1R2	596.00	609.33	602.67	13.63	13.46	13.55	22.30	26.53	24.42	7.10	7.13	7.12
15	EGHT1R3	480.00	500.00	490.00	12.95	12.96	12.95	20.87	29.40	25.14	7.27	7.27	7.27
16	EGHT2R1	437.33	455.00	446.17	14.16	14.01	14.09	21.66	28.18	24.92	7.47	7.40	7.43
17	EGHT2R2	640.67	627.33	634.00	13.48	13.60	13.54	20.37	23.42	21.90	7.47	7.73	7.60
18	EGHT2R3	464.33	488.67	476.50	12.60	12.41	12.51	20.08	26.67	23.38	7.07	8.03	7.55
19	SGHT1R1	490.00	450.00	470.00	13.39	13.21	13.30	21.19	24.12	22.65	7.30	7.37	7.33
20	SGHT1R2	578.67	558.67	568.67	12.99	13.12	13.05	19.97	26.32	23.15	6.97	7.00	6.98
21	SGHT1R3	613.33	610.00	611.67	13.01	13.72	13.36	22.58	27.17	24.87	7.40	7.60	7.50
22	SGHT2R1	555.00	555.00	555.00	14.20	14.37	14.28	21.49	25.04	23.27	7.37	7.73	7.55

23	SGHT2R2	540.00	533.33	536.67	15.12	15.20	15.16	24.38	25.60	24.99	7.30	7.33	7.32
24	SGHT2R3	642.67	633.33	638.00	14.42	14.23	14.32	23.57	28.63	26.10	7.27	7.33	7.30
25	NGHT1R1	600.00	620.00	610.00	11.03	11.81	11.42	24.09	27.33	25.71	7.40	7.33	7.37
26	NGHT1R2	555.00	552.00	553.50	12.53	12.38	12.46	25.45	24.85	25.15	7.40	7.60	7.50
27	NGHT1R3	389.33	389.33	389.33	13.33	13.06	13.20	24.74	24.83	24.79	7.20	7.13	7.17
28	NGHT2R1	530.33	552.00	541.17	12.08	12.42	12.25	22.79	26.61	24.70	7.00	7.27	7.13
29	NGHT2R2	418.33	394.33	406.33	14.12	14.07	14.10	29.11	26.95	28.03	7.17	7.60	7.38
30	NGHT2R3	493.33	478.67	486.00	15.29	15.06	15.17	26.51	28.38	27.44	7.33	7.80	7.57
Mean		548.78	542.37	545.57	12.92	13.01	12.97	22.73	26.78	24.76	7.25	7.41	7.33
Sem±		51.11	40.16	32.50	0.13	0.17	0.11	1.32	1.33	0.94	0.19	0.20	0.14
SE (d)		72.29	56.79	45.96	0.19	0.24	0.15	1.86	1.88	1.32	0.27	0.29	0.20
CD at 5%		144.59	113.60	91.00	0.38	0.48	0.30	3.72	3.77	2.62	0.54	0.58	0.39
CV		16.13	12.82	14.59	1.80	2.28	2.06	10.03	8.61	9.26	4.57	4.78	4.68

Table 6 Seed characters of *Citrus macroptera* collected from different districts

Sl. No	Collection Id	No. seed per segment			Seed length			Seed width		
		1st year	2nd Year	Pooled	1st year	2nd Year	Pooled	1st year	2nd Year	Pooled
1	WGHT1R2	1.70	1.47	1.58	16.30	16.56	16.43	6.79	6.56	6.67
2	WGHT1R2	1.47	1.60	1.53	15.65	15.70	15.67	7.03	6.70	6.86
3	WGHT1R3	1.87	1.97	1.92	15.66	15.54	15.60	6.51	6.25	6.38
4	WGHT2R1	1.73	1.70	1.72	15.46	15.55	15.50	6.43	6.47	6.45
5	WRGT2R2	1.46	1.43	1.45	15.13	16.40	15.76	6.41	6.52	6.46
6	WGHT2R3	1.30	1.58	1.44	15.60	15.66	15.63	6.17	6.26	6.21
7	SWGHT1R1	1.56	1.64	1.60	16.53	16.40	16.47	6.60	6.51	6.56
8	SWGHT1R2	1.37	1.35	1.36	15.99	16.00	16.00	5.96	5.81	5.89
9	SWGHT1R3	1.31	1.44	1.37	15.43	15.54	15.48	6.14	6.20	6.17
10	SWGHT2R1	2.29	2.22	2.26	16.14	16.11	16.12	6.43	6.22	6.33
11	SWGHT2R2	1.17	1.34	1.25	16.27	16.29	16.28	6.60	6.48	6.54
12	SWGHT2R3	1.79	1.78	1.79	15.41	15.49	15.45	6.06	6.16	6.11
13	EGHT1R1	1.61	1.28	1.45	16.53	16.56	16.55	6.71	6.49	6.60
14	EGHT1R2	1.69	1.90	1.80	15.93	15.60	15.77	6.53	6.52	6.53
15	EGHT1R3	1.79	1.67	1.73	15.59	15.73	15.66	6.21	6.24	6.22
16	EGHT2R1	1.83	1.33	1.58	15.14	15.00	15.07	5.86	5.86	5.86
17	EGHT2R2	1.34	1.63	1.48	14.56	14.45	14.51	5.76	5.81	5.79
18	EGHT2R3	1.89	1.57	1.73	14.03	14.03	14.03	6.06	6.14	6.10
19	SGHT1R1	1.82	1.83	1.83	13.97	13.89	13.93	6.35	6.35	6.35
20	SGHT1R2	1.92	1.92	1.92	14.54	14.37	14.45	5.43	5.42	5.42
21	SGHT1R3	1.44	1.67	1.56	13.00	12.96	12.98	5.70	5.65	5.68
22	SGHT2R1	1.80	1.80	1.80	17.46	17.12	17.29	6.70	6.91	6.80
23	SGHT2R2	1.64	1.64	1.64	17.78	17.66	17.72	8.04	7.86	7.95
24	SGHT2R3	1.42	1.47	1.45	15.28	15.33	15.30	6.50	6.51	6.50
25	NGHT1R1	1.64	1.57	1.61	15.52	15.58	15.55	5.54	5.75	5.65
26	NGHT1R2	1.79	1.77	1.78	14.51	14.31	14.41	6.32	6.46	6.39
27	NGHT1R3	2.00	1.68	1.84	14.57	14.64	14.61	5.88	5.82	5.85
28	NGHT2R1	2.08	2.06	2.07	15.08	15.04	15.06	5.45	5.45	5.45
29	NGHT2R2	1.27	1.83	1.55	15.58	15.68	15.63	6.26	6.28	6.27
30	NGHT2R3	1.69	1.99	1.84	15.49	15.55	15.52	5.83	5.70	5.77
Mean		1.66	1.67	1.66	15.47	15.49	15.48	6.28	6.25	6.26
Sem±		0.11	0.12	0.08	0.09	0.11	0.07	0.09	0.09	0.06
SE (d)		0.16	0.16	0.11	0.12	0.15	0.10	0.13	0.13	0.09
CD at 5%		0.31	0.33	0.22	0.24	0.30	0.19	0.26	0.26	0.18
CV		11.47	12.01	11.74	0.96	1.19	1.08	2.49	2.58	2.54

The lowest leaf width was recorded in SWGHT1R2 with 33.34, 33.67 and 33.50 (for first year, second year and third year respectively). Difference in leaf parameters was observed in others studies

As shown in table (4) WGHT1R2 recorded highest for fruit weight with 440.67g, 440.00g and 440.33g during the first year, second year and pooled data respectively, Whereas SWGHT2R1 showed lowest during first year with the value 223.33g, second year (196.67g) and pooled data (210.00g). Similarly fruit length recorded highest with WGH1R2 during first year second year and pooled data as well (9.10cm, 6.98cm, and 9.80cm respectively). Least fruit length was recorded with SWGHT1R2 in first year (6.26cm), second year (6.55cm), and pooled data (6.42cm). Fruit width also recorded highest with WGHT1R2 with the value 10.42cm, 10.57cm and 10.50cm (for first year, second year and pooled data respectively). The highest number of fruits per plant was recorded with SWGHT1R3 i.e. 883.33, 842.33 and 866.33 and the lowest number of fruits was recorded in SGHHT2R2 viz. 323, 440.00 and 381.50 for first year, second year and pooled data respectively. The maximum peel thickness (15.48mm, 15.50mm and 15.49mm) was recorded for WGHT1R2 and the lowest (10.41mm, 10.26mm and 10.34mm) was recorded for WGHT2R1 in first year, second year and pooled data respectively. Difference in all fruit parameters were observed among *Citrus macroptera* collected from different location which is in agreement with other studies where variation was observed in studies done from different location [2], [3], [4] [5].

As we observed in table (5) number of seed per segment recorded maximum (1.37, 1.35 and 1.36) for SWGHT1R2 and minimum number of seed per segment (2.29, 2.22, and 2.26) in first year, second year and pooled data respectively. SGHT2R2 (17.78) recorded longest in seed length in the first year. Also in the second year SGHT2R2 (17.66) recorded longest in seed length. SGHT2R2 (17.72) recorded longest in seed length in pooled data. Lowest in seed length was observed in SGHT1R3 (13.00, 12.96 and 12.98) in the first year, second year and pooled data respectively. Seed width was recorded highest in SGHT2R2 (8.04, 7.86 and 7.95 mm) and lowest was recorded in SGHT1R3 with 5.43mm, 5.42mm and 5.42mm in the first year, second year and pooled data respectively. Difference in seed number, seed length and seed width among accessions was reported in earlier studies [2], [5], [8].

4. Conclusion

The present study showed significant difference in all the character of *Citrus macroptera* collected from different districts of Garo Hills. Variation in qualitative characters may be due to underlying genetic diversity and the influence of environmental factors. However, there was no variation observed among the *Citrus macroptera* collected from different districts for floral characters. Existence of variation will be helpful as primary source and in selection of suitable accessions for improvement programs.

Compliance with ethical standards

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Disclosure of conflict of interest

The authors declare no conflict of interest.

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