Biological Forum – An International Journal 13(4): 1020-1032(2021)

ISSN No. (Print): 0975-1130
ISSN No. (Online): 2249-3239

Morphological Studies of Acid Lime (*Citrus aurantifolia* Swingle) Genotypes of North Western Regions of India

***Shilpy Kumari*[1*]*, Akash Sharma*[2]*, Romesh Salgotra*[3]*, Manish Sharma*[4]* and Prabhdeep Singh*[1]**

[1]*Research Scholar, Division of Fruit Science,*
Sher-e- Kashmir University of Agricultural Sciences and Technology of Jammu- 180009, India.
[2]*Advanced Centre for Horticulture Research, Udheywalla,*
Sher-e- Kashmir University of Agricultural Sciences and Technology of Jammu- 180018, India.
[3]*School of Biotechnology,*
Sher-e- Kashmir University of Agricultural Sciences and Technology of Jammu- 180009, India.
[4] *Division of Statistics and Computer Sciences,*
Sher-e- Kashmir University of Agricultural Sciences and Technology of Jammu- 180009, India.

(Corresponding author: Shilpy Kumari)*
(Received 27 September 2021, Accepted 20 November, 2021)
(Published by Research Trend, Website: www.researchtrend.net)

ABSTRACT: Acid lime is an important cultivated fruit species with high morphological variability. This variability has been used by breeders and common people to practically distinguish different lime genotypes. Despite such well known variation, so far there is no published study specifically addressed the extent of phenotypic variability in Jammu region. Hence the present study was carried out to identify acid lime (*Citrus aurantifolia* Swingle) accessions using morphological characteristics. Seventy accessions were selected. A total of 34 characters were evaluated from the trees, leaves, flowers, fruits, pulp and seeds from each plant. Morphological characters of acid lime were recorded according to citrus descriptors where qualitative characteristics showed little variation among different acid lime genotypes. However, differences were recorded for quantitative characters. The mean leaf lamina length (89.60 mm) was recorded maximum in JMU-Chet(46) and minimum in JMU-Gura(24). Maximum mean leaf lamina width (53.26 mm) was recorded in JMU-Godd(55). Maximum mean leaf lamina length and width ratio (2.83) was recorded in JMU-Kat(16) whereas minimum (1.33) in JMU-Log(9). The mean leaf thickness was observed maximum (0.59 mm) in genotypes JMU-Bar(11). Maximum number of days (174 days) required for bearing cycle was recorded in JMU-Sum(59) and JMU-Sum(60) whereas, minimum number of days (162 days) was recorded in JMU-Uttar(20). Average number of seeds per fruit was observed 5-9 in 29 genotypes and 10-19 in 41 genotypes of acid lime. Maximum seed length (10.98 mm) was recorded in JMU-Sum(57). Maximum seed width (4.99 mm) was recorded in JMU-Log(4) whereas, minimum seed width (2.18 mm) was in JMU-Gura(22). Maximum seed weight (1.87 g) was found in genotype JMU-Chet(47) and minimum in JMU-Chet(45). The variation in qualitative characters was less while, the quantitative characters differed significantly. Results showed that the detected variations can be utilized in a breeding programme for improvement of acid lime.

Keywords: Morphology, Acid lime accessions, Diversity, Germplasm, Characterization.

INTRODUCTION

Citrus belongs to the family, Rutaceae and is one of the most important cash crops in the world (Swingle and Reece, 1967). The origin of Citrus cannot be determined but reports suggest that it originated from the south and southeast tropical regions of Asia (Moore, 2001; Sharma *et al.*, 2004; Ladaniya, 2008; Singh *et al.*, 2010). The best fruit quality is achieved under sub-tropical conditions and the highest acreage concentrated between 40° North and South of equator due to its wide adaptability to the tropical and sub-tropical conditions (Patil *et al.*, 2012). Among all the citrus fruits acid lime (*Citrus aurantifolia* Swingle) is one of the most important fruits grown in the country, and is traditionally cultivated in union territory of Jammu and Kashmir that covers an area of 4.97 thousand ha with the production of 12.74 thousand MT (Anon., 2018) in Jammu region.

Acid lime fruit have great medicinal value being acidic. Lime is appetizer, stomachic, antiscorbutic, antihelmintic and it checks biliousness (Thirugnanavel *et al.*, 2007). Lime is used in making candy, chocolate, ice-cream, pasteries and 100 gram fruit juice content 80 percent of water, (26 IU carotene), 20 mg Vitamin B1, 0.1 mg Riboflavin, 63 mg Vitamin C, 1.83 mg iron (Fe), 0.16 mg copper (cu), 0.30% oxalo-acetic acid, 8.2% malic acid and alkaline salt therefore, is an essential for human health. Acid lime fruit is a cheap source of vitamin C, organic acid, minerals and other nutritive substances which are essential for human. It is marketed as fresh fruits and also used in ancillary industries for preparation of juice, squashes, cordial, cosmetic etc. The peel is used for extracting lime oil, citrus acid etc. Though, there is huge diversity of lime in Jammu region but phylogeny and taxonomy of citrus fruit are complex, confusing and controversial due to the genetic heterogeneity of the genus, as well as its polyembryonic nature and the long generation time needed to carry out selection and recombination (Nicolosi *et al.,* 2000). Therefore, analysis of the genetic diversity of lime fruit is crucial. Morphological characterization is a way for the description and classification of germplasm and flower colour, growth habits are routinally used morphological characters include both qualitative and quantitative characteristics, which are the strongest determinants of the agronomic value and systematic classification of fruit crop and is considered as an initial step for cultivar identification and diversity assessment. Several authors have investigated and morphologically characterized different selections of Citrus plants, in order to increase the number of genotypes with potential to be used in breeding programs or to be released as new varieties (Koehler-Santos *et al.*, 2003). Morphological properties have been the main character used for recognition and description of plant taxa (Duminil and Michele, 2009; Dwari and Mondal, 2011). The important role of morphology is attributable to its advantageous properties such as ease of examination, has high variation, has an established descriptive terminology and its accessibility to herbarium specimens (Szczepaniak and Cieslak, 2011). Moreover, morphology is applicable to all levels in taxonomic hierarchy. Morphology has always been the first taxonomic evidence for the recognition and delimitation of infraspecific categories. The key role of morphology in defining infraspecific taxa is shown by the fact that no formal taxonomic status would be assigned when there is no morphological differences among populations of particular plant species (Cires *et al.,* 2009; Lohwasser *et al.,* 2010). Many molecular techniques have been developed in studying the genetic diversity (Susandarini *et al.,* 2013) emphasized the practical importance of morphological characters in horticultural plant species as well as in plant systematic for cultivars identification. At present, the morphological study is still considered important and has been deployed as an initial step for cultivar identification and diversity assessment at field level (Elameen *et al.,* 2010). Different genotypes of lime are grown in Jammu region and none of them has been characterized. This adds to the weakness of breeding programmes of commercial genotype selection for foothills of north western regions. Although it is one of the most important citrus fruit grown in Jammu region, production as well as yield is very low due to lack of high yielding and good quality variety. Therefore, Selection of superior genotype from the collected accessions will help in increasing production of acid lime in this country because, variability in the population is a prerequisite for crop improvement and is considered as a boon to a plant breeder in Jammu province. Therefore, the study was initiated to characterize the germplasm based on different morphological traits and to identify the seedling lime genotype in the foothills of Jammu region that may enrich lime germplasm for north west zone of the country.

MATERIALS AND METHODS

A. Survey coverage

Still there is an immense potential of locating superior clones for collection, evaluation, conservation and utilization for the future crop improvement works. Hence, the present investigation was carried through survey in major lime growing districts viz., Jammu, Samba, Kathua, Udhampur and Reasi of Jammu province during 2017 and 2018 to select promising accession among the diverse acid lime (seedling) genotypes and assess variability in their morphological characteristics. A total of seventy superior seedling origin lime genotypes with divergent characters were selected. Codes were allotted to each selection on the basis of their location and geo tagging was done on selected plants and the research work was carried out at Division of Fruit Science, Sher-e-Kashmir University of Agricultural Sciences and technology of Jammu, Chatha, Jammu. **Samples of trees, leaves, flowers, fruit, pulp and seeds were collected randomly from each accession. A total of 34 characters were evaluated from the trees, leaves, flowers, fruits, pulp and seeds from each plant.** Details of genotypes collection sites are presented in Table 1.

Morphological characters were observed with reference to standards issued by the International Plant Genetic Resources Institute (IPGRI) Descriptors of Citrus (IPGRI, 1999). Observations were recorded during the years 2017 and 2018 on the seedling lime trees for different vegetative characters for their growth and development stages. Vegetative characters were studied under different sub headings *viz.* tree characters, leaf characters, flower characters, fruit and seed characters.

Tree characters: The tree morphology was observed for spine density on adult tree (not on suckers) (absent, low, medium and high), spine length on adult tree (mm), spine shape (curved and straight), Shoot tip colour (Green and Purple) and Shoot tip surface (glabrous and pubescent).

Leaf characters: The leaf characteristic were recorded for lamina length (mm), lamina width (mm), ratio of leaf lamina length/ width, leaf thickness (mm), petiole length (mm), leaf apex (Attenuate, acuminate obtuse, rounded and emarginated), petiole wing width (narrow, medium and wide), petiole wing shape (obcordate, obdeltate and obovate), Colour of leaf upper/lower surface (same, lighter and darker), Nerves on leaf upper surface (Protuberant and flat), angle of leaf bases (acute and obtuse), angle of leaf apex (acute and obtuse), and petiole attachment to twigs (straight and curved).

Flower characters: Flower description was based on colour of anther (white, pale yellow and yellow), number of stamens (< 4 per petal, 4 per petal and > 4 per petal), arrangements of flower (solitary, inflorescence and both) and Flower/inflorescence position (axillary, terminal and both).

Fruit characters: Fruit characteristics were studied for fruit axis (solid, semi-hollow and hollow), fruit surface texture (smooth, rough, papillate, pitted, bumpy and grooved), adherence of albedo (mesocarp) to pulp (endocarp) (weak, medium and strong), albedo colour (greenish, white, yellow, pink, orange and reddish), absence /presence of areola (present and absent), Bearing cycle (recorded by counting the number of days from the date of start of flowering to the date of harvesting), pulp colour (white, green, yellow, orange, pink, light red, orange-red, red and purple) and pulp texture (crispy, fibrous and fleshy).

Seed characters: Seed description was based on average number of seeds per fruit (to determine number of seeds per fruit, seed weight (g), seed length (mm) and seed width (mm) and the data recorded during the investigation was statistically analyzed.

B. Data analysis

The data on the quantitative variables from the leaves, flowers and fruit of each accession were statistically analyzed with the help of INDOSTAT statistical package.

Table 1: Details of sample collection sites of acid lime genotypes.

District	Below 600 m asl Altitude (M)	No. of genotypes	District	Below 800 m asl Altitude (M)	No. of genotypes
Jammu	327	14	Udhampur	755	14
Samba	300	13			
Kathua	307	13			
Reasi	466	16			

RESULTS AND DISCUSSION

A. Tree characters

In the present study, it is evident from Table 2 that spine density was found to be variable in the existing genotypes and out of seventy acid lime genotypes medium spine density was observed in twenty five genotypes whereas, high spine density on adult tree was recorded in fourty five genotypes of acid lime. Since spine is a characteristic of juvenility, all the plants have spines. The differences are in the intensity, structure and size of the spines in plants. Thorns have generally been considered a symptom of citrus juvenility. All parts of the citrus tree do not pass through the juvenile stage at the same time. Frost (1943) observed that the trunk of a thorny seedling and the proximal portion of its main branches retain for a long time the ability to produce thorny shoots. On the other hand, the shoots from the uppermost branches showed a tendency toward progressive reduction in thorniness and increase in flowering. At the same time as they mature, the upward and outward shoots from the trunk gradually lose the thorny condition. This same phenomenon was reported by Chase, (1947) with honey locust (*Gleditsia triacanthos* L.). None of the genotypes was having absent and low spine density on adult tree. Our results are in close conformity with the results of Singh, (2013) who reported the high spine density in different strains of rough lemon, trifoliate orange and rangpur lime. Bhusal *et al.,* (2002) also reported numerous spine densities in rough lemon rootstocks. Spine length is one of the factors cited as indices of juvenility for citrus and other woody plant species (Cameron and Frost, 1968). Spine length of 6 - 15 mm was recorded in fourty four genotypes and 16 - 40 mm of spine length was found in twenty six acid lime genotypes. No variation was noticed in spine shape, shoot tip colour and shoot tip surface in all the acid lime genotypes. Spine shape was found to be straight, Shoot tip was green and shoot tip surface was glabrous in all the genotypes. These results are in agreement with the results of Singh, (2013) who recorded glabrous shoot tip surface in rough lemon and trifoliate orange, while it was recorded uneven among different strains of rangpur lime.

B. Leaf characters

Leaves are a major part with absolute existence in plants beside roots and stems. Thus to identify a plant, leaf morphology is one of the characters that can be used to characterize it. On the basis of the results of leaf evaluations of acid lime genotypes (Table 3) observations showed that out of seventy genotypes leaf apex was found acute in fifty four genotypes whereas it was observed obtuse in sixteen genotypes. Similar results were obtained by Khan *et al.,* (2008) who reported acute leaf apex in Kinnow Mandarin while it was obtuse in Feutell’s Early. Little variability was observed with respect to petiole wing width and out of seventy genotypes majority of genotypes sixty six genotypes of acid lime had narrow petiole wing width while only four genotypes were having medium petiole wing width. No variation was observed in petiole wing shape, colour of leaf upper/lower surface and nerves on leaf upper surface among all the acid lime genotypes. Shape of petiole wing was obdeltate, colour of leaf upper/lower surface was dark and flat nerves on leaf upper surface was found in all the genotypes.

Table 2: Variability for growth characters of indigenous lime (*Citrus aurantifolia* Swingle) genotypes of Jammu region.

Sr. No.	Genotypes	Spine density on adult tree (not on suckers)	Spine length on adult tree (not on suckers)	Spine shape	Shoot tip colour	Shoot tip surface
1.	JMU-Log(1)	Medium	16-40 mm	Straight	Green	Glabrous
2.	JMU-Log(2)	Medium	6-15 mm	Straight	Green	Glabrous
3.	JMU-Log(3)	High	16-40 mm	Straight	Green	Glabrous
4.	JMU-Log(4)	High	6-15 mm	Straight	Green	Glabrous
5.	JMU-Log(5)	Medium	16-40 mm	Straight	Green	Glabrous
6.	JMU-Log(6)	Medium	16-40 mm	Straight	Green	Glabrous
7.	JMU-Log(7)	High	16-40 mm	Straight	Green	Glabrous
8.	JMU-Log(8)	High	16-40 mm	Straight	Green	Glabrous
9.	JMU-Log(9)	High	16-40 mm	Straight	Green	Glabrous
10.	JMU-Bar(10)	High	6-15 mm	Straight	Green	Glabrous
11.	JMU-Bar(11)	High	6-15 mm	Straight	Green	Glabrous
12.	JMU-Bar(12)	High	16-40 mm	Straight	Green	Glabrous
13.	JMU-Bar(13)	High	16-40 mm	Straight	Green	Glabrous
14.	JMU-Kat(14)	Medium	6-15 mm	Straight	Green	Glabrous
15.	JMU-Kat(15)	Medium	6-15 mm	Straight	Green	Glabrous
16.	JMU-Kat(16)	Medium	6-15 mm	Straight	Green	Glabrous
17.	JMU-Kat(17)	Medium	6-15 mm	Straight	Green	Glabrous
18.	JMU-Uttar(18)	Medium	6-15 mm	Straight	Green	Glabrous
19.	JMU-Uttar(19)	High	6-15 mm	Straight	Green	Glabrous
20.	JMU-Uttar(20)	High	16-40 mm	Straight	Green	Glabrous
21.	JMU-Uttar(21)	High	16-40 mm	Straight	Green	Glabrous
22.	JMU-Gura(22)	High	16-40 mm	Straight	Green	Glabrous
23.	JMU-Gura(23)	Medium	16-40 mm	Straight	Green	Glabrous
24.	JMU-Gura(24)	Medium	16-40 mm	Straight	Green	Glabrous
25.	JMU-Gura(25)	Medium	16-40 mm	Straight	Green	Glabrous
26.	JMU-Taror(26)	Medium	16-40 mm	Straight	Green	Glabrous
27.	JMU-Balli(27)	Medium	6-15 mm	Straight	Green	Glabrous
28.	JMU-Balli(28)	Medium	6-15 mm	Straight	Green	Glabrous
29.	JMU-Balli(29)	Medium	6-15 mm	Straight	Green	Glabrous
30.	JMU-Balli(30)	High	16-40 mm	Straight	Green	Glabrous
31.	JMU-Neeli(31)	High	6-15 mm	Straight	Green	Glabrous
32.	JMU-Neeli(32)	Medium	6-15 mm	Straight	Green	Glabrous
33.	JMU-Neeli(33)	Medium	6-15 mm	Straight	Green	Glabrous
34.	JMU-Jib(34)	High	16-40 mm	Straight	Green	Glabrous
35.	JMU-Jib(35)	High	6-15 mm	Straight	Green	Glabrous
36.	JMU-Jib(36)	Medium	6-15 mm	Straight	Green	Glabrous
37.	JMU-Jib(37)	High	6-15 mm	Straight	Green	Glabrous
38.	JMU-Jib(38)	High	6-15 mm	Straight	Green	Glabrous
39.	JMU-Tikri(39)	High	6-15 mm	Straight	Green	Glabrous
40.	JMU-Tikri(40)	High	6-15 mm	Straight	Green	Glabrous
41.	JMU-Pana(41)	High	16-40 mm	Straight	Green	Glabrous
42.	JMU-Pana(42)	High	16-40 mm	Straight	Green	Glabrous
43.	JMU-Pana(43)	High	6-15 mm	Straight	Green	Glabrous
44.	JMU-Pana(44)	High	6-15 mm	Straight	Green	Glabrous
45.	JMU-Chet(45)	High	6-15 mm	Straight	Green	Glabrous
46.	JMU-Chet(46)	High	6-15 mm	Straight	Green	Glabrous
47.	JMU-Chet(47)	High	6-15 mm	Straight	Green	Glabrous
48.	JMU-Chet(48)	High	6-15 mm	Straight	Green	Glabrous
49.	JMU-Duggi(49)	High	6-15 mm	Straight	Green	Glabrous
50.	JMU-Lait(50)	High	6-15 mm	Straight	Green	Glabrous
51.	JMU-Lait(51)	High	6-15 mm	Straight	Green	Glabrous
52.	JMU-Godd(52)	High	6-15 mm	Straight	Green	Glabrous
53.	JMU-Godd(53)	High	6-15 mm	Straight	Green	Glabrous
54.	JMU-Godd(54)	High	16-40 mm	Straight	Green	Glabrous
55.	JMU-Godd(55)	High	6-15 mm	Straight	Green	Glabrous
56.	JMU-Godd(56)	High	6-15 mm	Straight	Green	Glabrous
57.	JMU-Sum(57)	Medium	6-15 mm	Straight	Green	Glabrous
58.	JMU-Sum(58)	Medium	6-15 mm	Straight	Green	Glabrous
59.	JMU-Sum(59)	Medium	6-15 mm	Straight	Green	Glabrous
60.	JMU-Sum(60)	High	16-40 mm	Straight	Green	Glabrous
61.	JMU-Sun(61)	High	16-40 mm	Straight	Green	Glabrous
62.	JMU-Sun(62)	High	16-40 mm	Straight	Green	Glabrous
63.	JMU-Sun(63)	Medium	6-15 mm	Straight	Green	Glabrous
64.	JMU-Sun(64)	High	6-15 mm	Straight	Green	Glabrous
65.	JMU-Nag(65)	High	6-15 mm	Straight	Green	Glabrous
66.	JMU-Nag(66)	High	6-15 mm	Straight	Green	Glabrous
67.	JMU-Nag(67)	High	16-40 mm	Straight	Green	Glabrous
68.	JMU-Nag(68)	High	16-40 mm	Straight	Green	Glabrous
69.	JMU-Nag(69)	Medium	6-15 mm	Straight	Green	Glabrous
70.	JMU-Nag(70)	Medium	6-15 mm	Straight	Green	Glabrous

Significant variation in leaf morphology was confirmed by (Dass *et al.,* 1998). Susandarini *et al.,* (2013) also reported significant variability in leaf characters while assessing the taxonomic relationship of pummelo accessions using morphological characters. Width of petiole wing has also been used as a morphological marker for screening of genotypes in citrus (Blanco *et al.,* 1998). Variability was found with respect to angle of leaf bases and angle of leaf apex in all the lime genotypes. Among seventy genotypes acute angle of leaf bases was recorded in thirty three genotypes and obtuse angle in thirty seven genotypes and fifty four genotypes had acute angle of leaf apex and obtuse angle of leaf apex was recorded in sixteen genotypes of acid lime. In acid lime genotypes variability was observed with respect to petiole attachment to twigs and petiole length. Out of seventy genotypes fourty one genotypes had straight petiole attachment to twigs and twenty nine genotypes had recorded curved petiole attachment to twigs and as far as petiole length is concerned twenty nine genotypes were having 0-10 mm, thirty were having 11-15 mm and eleven genotypes were having >15 mm of petiole length. The leaf morphological characteristics also play an important role as classifying citrus species and varieties (Camargo *et al.,* 2006; Du *et al.,* 2007) and as a pre breeding selection criteria.

Significant variation in leaf lamina length, leaf lamina width, ratio leaf lamina length/width, leaf thickness was observed among different acid lime genotypes as shown in Table 4. Maximum mean leaf lamina length (89.60 mm) was recorded in JMU-Chet(46) and it was statistically at par with JMU-Kat(17) (87.05 mm), JMU-Chet(47) (87.20 mm) and JMU-Sun(63) (88.08 mm) while, minimum mean leaf lamina length (50.33 mm) was found in JMU-Gura(24) (50.33 mm). Maximum mean leaf lamina width (53.26 mm) was recorded in JMU-Godd(55) and minimum leaf lamina width was found in JMU-Log(3). Maximum leaf lamina length and width ratio (2.83) was recorded in JMU-Kat(16) and minimum mean leaf lamina length and width ratio (1.33) was found in JMU-Log(9). Leaf thickness among different lime genotypes ranging from 0.31 to 0.59 mm with maximum mean leaf thickness (0.59 mm) was recorded in genotypes JMU-Bar(11) and lowest leaf thickness (0.31 mm) JMU-Neeli(32) genotype. Our results are supported by Singh *et al.,* (2010) they reported maximum leaf lamina length in strain no. 8744, while Texas had the minimum leaf lamina length, maximum leaf lamina length and width ratio was recorded in Noreo, while marmalade had the minimum leaf lamina length and width ratio in six rangpur lime strains. These variations were exhibited due to environment and genotype interaction. The findings are also supported by the observations of the Kinley and Chinawat (2011); Dorji and Yapwattanaphun (2011) who recorded variations in leaf lamina length of mandarin genotypes.

Table 3: Variability for leaf characters of indigenous lime (*Citrus aurantifolia* Swingle) genotypes of Jammu. region.

Sr. No.	Genotypes	Leaf apex	Petiole wing width	Petiole wing shape	Colour of leaf upper/lower surface	Nerves on leaf upper surface	Angle of leaf bases	Angle of leaf apex	Petiole attachment to twigs	Petiole length
1.	JMU-Log(1)	Obtuse	Narrow	Obdeltate	Darker	Flat	Obtuse	Obtuse	Straight	>15 mm
2.	JMU-Log(2)	Acute	Narrow	Obdeltate	Darker	Flat	Obtuse	Acute	Straight	>15 mm
3.	JMU-Log(3)	Acute	Medium	Obdeltate	Darker	Flat	Obtuse	Acute	Straight	>15 mm
4.	JMU-Log(4)	Acute	Narrow	Obdeltate	Darker	Flat	Acute	Acute	Straight	11-15 mm
5.	JMU-Log(5)	Acute	Narrow	Obdeltate	Darker	Flat	Obtuse	Acute	Curved	11-15 mm
6.	JMU-Log(6)	Acute	Narrow	Obdeltate	Darker	Flat	Obtuse	Acute	Straight	11-15 mm
7.	JMU-Log(7)	Acute	Narrow	Obdeltate	Darker	Flat	Acute	Acute	Straight	>15 mm
8.	JMU-Log(8)	Acute	Narrow	Obdeltate	Darker	Flat	Obtuse	Acute	Curved	0-10 mm
9.	JMU-Log(9)	Acute	Medium	Obdeltate	Darker	Flat	Obtuse	Acute	Curved	11-15 mm
10.	JMU-Bar(10)	Acute	Narrow	Obdeltate	Darker	Flat	Obtuse	Acute	Curved	0-10 mm
11.	JMU-Bar(11)	Acute	Narrow	Obdeltate	Darker	Flat	Obtuse	Acute	Curved	11-15 mm
12.	JMU-Bar(12)	Acute	Medium	Obdeltate	Darker	Flat	Obtuse	Acute	Straight	11-15 mm
13.	JMU-Bar(13)	Acute	Narrow	Obdeltate	Darker	Flat	Acute	Acute	Straight	11-15 mm
14.	JMU-Kat (14)	Obtuse	Narrow	Obdeltate	Darker	Flat	Obtuse	Obtuse	Straight	0-10 mm
15.	JMU-Kat(15)	Obtuse	Narrow	Obdeltate	Darker	Flat	Obtuse	Obtuse	Straight	11-15 mm
16.	JMU-Kat(16)	Acute	Narrow	Obdeltate	Darker	Flat	Acute	Acute	Straight	0-10 mm
17.	JMU-Kat(17)	Obtuse	Narrow	Obdeltate	Darker	Flat	Obtuse	Obtuse	Curved	11-15 mm
18.	JMU-Uttar(18)	Acute	Narrow	Obdeltate	Darker	Flat	Acute	Acute	Curved	11-15 mm
19.	JMU-Uttar(19)	Obtuse	Narrow	Obdeltate	Darker	Flat	Obtuse	Obtuse	Straight	0-10 mm
20.	JMU-Uttar(20)	Acute	Narrow	Obdeltate	Darker	Flat	Acute	Acute	Curved	11-15 mm
21.	JMU-Uttar(21)	Acute	Narrow	Obdeltate	Darker	Flat	Acute	Acute	Curved	11-15 mm
22.	JMU-Gura(22)	Acute	Narrow	Obdeltate	Darker	Flat	Acute	Acute	Straight	0-10 mm
23.	JMU-Gura(23)	Acute	Narrow	Obdeltate	Darker	Flat	Acute	Acute	Straight	11-15 mm
24.	JMU-Gura(24)	Acute	Narrow	Obdeltate	Darker	Flat	Acute	Acute	Curved	11-15 mm
25.	JMU-Gura(25)	Acute	Narrow	Obdeltate	Darker	Flat	Acute	Acute	Straight	0-10 mm
26.	JMU-Taror(26)	Acute	Narrow	Obdeltate	Darker	Flat	Acute	Acute	Curved	0-10 mm

27.	JMU-Balli(27)	Acute	Narrow	Obdeltate	Darker	Flat	Acute	Acute	Straight	11-15 mm
28.	JMU-Balli(28)	Acute	Narrow	Obdeltate	Darker	Flat	Obtuse	Acute	Straight	>15 mm
29.	JMU-Balli(29)	Acute	Narrow	Obdeltate	Darker	Flat	Obtuse	Acute	Straight	>15 mm
30.	JMU-Balli(30)	Acute	Narrow	Obdeltate	Darker	Flat	Obtuse	Acute	Straight	0-10 mm
31.	JMU-Neeli(31)	Obtuse	Narrow	Obdeltate	Darker	Flat	Acute	Obtuse	Straight	0-10 mm
32.	JMU-Neeli(32)	Obtuse	Narrow	Obdeltate	Darker	Flat	Obtuse	Obtuse	Curved	11-15 mm
33.	JMU-Neeli(33)	Acute	Narrow	Obdeltate	Darker	Flat	Obtuse	Acute	Straight	0-10 mm
34.	JMU-Jib(34)	Acute	Narrow	Obdeltate	Darker	Flat	Acute	Acute	Straight	11-15 mm
35.	JMU-Jib(35)	Obtuse	Narrow	Obdeltate	Darker	Flat	Obtuse	Obtuse	Straight	0-10 mm
36.	JMU-Jib(36)	Acute	Narrow	Obdeltate	Darker	Flat	Acute	Acute	Straight	0-10 mm
37.	JMU-Jib(37)	Acute	Narrow	Obdeltate	Darker	Flat	Acute	Acute	Curved	11-15 mm
38.	JMU-Jib(38)	Acute	Narrow	Obdeltate	Darker	Flat	Acute	Acute	Straight	0-10 mm
39.	JMU-Tikri(39)	Acute	Narrow	Obdeltate	Darker	Flat	Obtuse	Acute	Straight	0-10 mm
40.	JMU-Tikri(40)	Obtuse	Narrow	Obdeltate	Darker	Flat	Acute	Obtuse	Straight	0-10 mm
41.	JMU-Pana(41)	Acute	Narrow	Obdeltate	Darker	Flat	Acute	Acute	Curved	0-10 mm
42.	JMU-Pana(42)	Acute	Narrow	Obdeltate	Darker	Flat	Obtuse	Acute	Curved	0-10 mm
43.	JMU-Pana(43)	Acute	Narrow	Obdeltate	Darker	Flat	Obtuse	Acute	Curved	11-15 mm
44.	JMU-Pana(44)	Acute	Narrow	Obdeltate	Darker	Flat	Acute	Acute	Curved	0-10 mm
45.	JMU-Chet(45)	Obtuse	Narrow	Obdeltate	Darker	Flat	Obtuse	Obtuse	Curved	0-10 mm
46.	JMU-Chet(46)	Acute	Narrow	Obdeltate	Darker	Flat	Acute	Acute	Curved	11-15 mm
47.	JMU-Chet(47)	Acute	Narrow	Obdeltate	Darker	Flat	Acute	Acute	Straight	0-10 mm
48.	JMU-Chet(48)	Acute	Narrow	Obdeltate	Darker	Flat	Acute	Acute	Straight	0-10 mm
49.	JMU-Duggi(49)	Obtuse	Narrow	Obdeltate	Darker	Flat	Obtuse	Obtuse	Straight	0-10 mm
50.	JMU-Lait(50)	Acute	Narrow	Obdeltate	Darker	Flat	Obtuse	Acute	Curved	11-15 mm
51.	JMU-Lait(51)	Obtuse	Narrow	Obdeltate	Darker	Flat	Obtuse	Obtuse	Curved	11-15 mm
52.	JMU-Godd(52)	Acute	Narrow	Obdeltate	Darker	Flat	Obtuse	Acute	Curved	11-15 mm
53.	JMU-Godd(53)	Obtuse	Narrow	Obdeltate	Darker	Flat	Obtuse	Obtuse	Straight	0-10 mm
54.	JMU-Godd(54)	Acute	Narrow	Obdeltate	Darker	Flat	Obtuse	Acute	Straight	11-15 mm
55.	JMU-Godd(55)	Acute	Narrow	Obdeltate	Darker	Flat	Obtuse	Acute	Straight	11-15 mm
56.	JMU-Godd(56)	Obtuse	Medium	Obdeltate	Darker	Flat	Obtuse	Obtuse	Straight	11-15 mm
57.	JMU-Sum(57)	Obtuse	Narrow	Obdeltate	Darker	Flat	Obtuse	Obtuse	Straight	0-10 mm
58.	JMU-Sum(58)	Acute	Narrow	Obdeltate	Darker	Flat	Acute	Acute	Curved	0-10 mm
59.	JMU-Sum(59)	Acute	Narrow	Obdeltate	Darker	Flat	Acute	Acute	Curved	11-15 mm
60.	JMU-Sum(60)	Acute	Narrow	Obdeltate	Darker	Flat	Obtuse	Acute	Curved	11-15 mm
61.	JMU-Sun(61)	Acute	Narrow	Obdeltate	Darker	Flat	Acute	Acute	Straight	>15 mm
62.	JMU-Sun(62)	Acute	Narrow	Obdeltate	Darker	Flat	Obtuse	Acute	Straight	11-15 mm
63.	JMU-Sun(63)	Acute	Narrow	Obdeltate	Darker	Flat	Acute	Acute	Curved	>15 mm
64.	JMU-Sun(64)	Obtuse	Narrow	Obdeltate	Darker	Flat	Obtuse	Obtuse	Straight	>15 mm
65.	JMU-Nag(65)	Acute	Narrow	Obdeltate	Darker	Flat	Acute	Acute	Straight	0-10 mm
66.	JMU-Nag(66)	Acute	Narrow	Obdeltate	Darker	Flat	Acute	Acute	Straight	>15 mm
67.	JMU-Nag(67)	Acute	Narrow	Obdeltate	Darker	Flat	Acute	Acute	Straight	0-10 mm
68.	JMU-Nag(68)	Acute	Narrow	Obdeltate	Darker	Flat	Acute	Acute	Curved	>15 mm
69.	JMU-Nag(69)	Acute	Narrow	Obdeltate	Darker	Flat	Obtuse	Acute	Curved	0-10 mm
70.	JMU-Nag(70)	Acute	Narrow	Obdeltate	Darker	Flat	Acute	Acute	Curved	11-15 mm

Table 4: Variability for leaf characters of indigenous lime (*Citrus aurantifolia* Swingle) genotypes of Jammu region.

Sr. No.	Genotypes	Leaf lamina length (mm)	Leaf lamina width (mm)	Ratio leaf lamina length/width	Leaf thickness (mm)
1.	JMU-Log(1)	66.23	34.44	1.92	0.56
2.	JMU-Log(2)	63.30	36.24	1.76	0.58
3.	JMU-Log(3)	52.20	21.21	2.47	0.53
4.	JMU-Log(4)	68.60	35.20	1.95	0.47
5.	JMU-Log(5)	62.26	28.60	2.17	0.43
6.	JMU-Log(6)	69.73	38.00	1.84	0.41
7.	JMU-Log(7)	73.41	33.44	2.20	0.47
8.	JMU-Log(8)	74.44	35.80	2.08	0.46
9.	JMU-Log(9)	56.42	42.30	1.33	0.42
10.	JMU-Bar(10)	77.43	46.70	1.65	0.43
11.	JMU-Bar(11)	74.30	45.60	1.63	0.59
12.	JMU-Bar(12)	60.04	31.50	1.92	0.51

13.	JMU-Bar(13)	73.87	40.67	1.82	0.57
14.	JMU-Kat (14)	80.40	38.20	2.10	0.36
15.	JMU-Kat(15)	83.53	37.50	2.23	0.49
16.	JMU-Kat(16)	83.40	29.53	2.83	0.46
17.	JMU-Kat(17)	87.05	42.04	2.07	0.43
18.	JMU-Uttar(18)	83.20	37.60	2.21	0.41
19.	JMU-Uttar(19)	71.38	39.27	1.81	0.53
20.	JMU-Uttar(20)	71.85	38.39	1.61	0.52
21.	JMU-Uttar(21)	56.07	33.00	1.70	0.39
22.	JMU-Gura(22)	72.71	33.90	2.14	0.37
23.	JMU-Gura(23)	63.04	37.07	1.70	0.36
24.	JMU-Gura(24)	50.33	35.99	1.40	0.53
25.	JMU-Gura(25)	67.07	45.16	1.48	0.57
26.	JMU-Taror(26)	86.20	37.20	2.32	0.54
27.	JMU-Balli(27)	57.02	36.00	1.58	0.46
28.	JMU-Balli(28)	60.60	42.00	1.45	0.46
29.	JMU-Balli(29)	58.05	35.08	1.66	0.38
30.	JMU-Balli(30)	53.00	37.11	1.43	0.54
31.	JMU-Neeli(31)	63.09	35.00	1.80	0.55
32.	JMU-Neeli(32)	57.00	30.68	1.86	0.31
33.	JMU-Neeli(33)	60.00	32.73	1.83	0.52
34.	JMU-Jib(34)	74.00	37.40	1.98	0.45
35.	JMU-Jib(35)	68.60	27.20	2.53	0.50
36.	JMU-Jib(36)	83.60	37.44	2.23	0.36
37.	JMU-Jib(37)	71.30	32.00	2.24	0.41
38.	JMU-Jib(38)	65.40	29.40	2.23	0.47
39.	JMU-Tikri(39)	62.31	35.24	1.77	0.53
40.	JMU-Tikri(40)	71.33	31.20	2.29	0.58
41.	JMU-Pana(41)	82.20	31.40	2.63	0.49
42.	JMU-Pana(42)	63.00	33.20	1.90	0.31
43.	JMU-Pana(43)	70.51	33.77	2.10	0.52
44.	JMU-Pana(44)	69.30	28.60	2.42	0.56
45.	JMU-Chet(45)	66.80	27.32	2.45	0.51
46.	JMU-Chet(46)	89.60	44.30	2.03	0.43
47.	JMU-Chet(47)	87.20	41.00	2.13	0.46
48.	JMU-Chet(48)	80.40	38.20	2.11	0.49
49.	JMU-Duggi(49)	66.35	30.42	2.20	0.50
50.	JMU-Lait(50)	83.40	30.26	2.76	0.55
51.	JMU-Lait(51)	71.60	39.02	1.83	0.39
52.	JMU-Godd(52)	55.09	40.43	1.36	0.46
53.	JMU-Godd(53)	73.27	41.26	1.79	0.35
54.	JMU-Godd(54)	74.22	43.14	1.72	0.47
55.	JMU-Godd(55)	79.31	53.26	1.49	0.50
56.	JMU-Godd(56)	67.69	33.09	2.05	0.56
57.	JMU-Sum(57)	72.06	31.58	2.29	0.51
58.	JMU-Sum(58)	79.03	37.69	2.10	0.39
59.	JMU-Sum(59)	80.66	29.44	2.75	0.40
60.	JMU-Sum(60)	86.01	41.33	2.08	0.58
61.	JMU-Sun(61)	58.30	33.60	1.73	0.53
62.	JMU-Sun(62)	71.50	39.26	1.82	0.37
63.	JMU-Sun(63)	88.08	37.20	2.37	0.38
64.	JMU-Sun(64)	74.44	35.50	2.10	0.48
65.	JMU-Nag(65)	73.81	33.32	2.21	0.48
66.	JMU-Nag(66)	69.83	38.18	1.84	0.42
67.	JMU-Nag(67)	52.20	21.57	2.46	0.51
68.	JMU-Nag(68)	63.20	36.60	1.73	0.54
69.	JMU-Nag(69)	66.20	34.17	1.96	0.43
70	JMU-Nag(70)	82.27	43.74	1.88	0.46
	General mean	70.45	35.93	1.99	0.472
	±SE (m)	1.17	0.89	0.06	0.03
	CV (%)	2.88	4.30	5.29	9.48
	CD at 5%	3.28	2.49	0.17	0.07

C. Floral characters

Floral characters are also important traits used in characterization and variability studies of genotypes. Based on flowering characters no variation was recorded in colour of anther among all acid lime genotypes during the period of investigation. Numbers of stamens per petal were recorded 4 per petal in thirteen genotypes and > 4 per petal in fifty seven genotypes. out of seventy genotypes studied fourty four genotypes had inflorescence arrangement of flowers and twenty six genotypes had both (solitary and inflorescence) arrangement of flowers. Axillary flower/ inflorescence position was found in all the genotypes (Table 5).

Table 5: Variability for floral characters of indigenous lime (*Citrus aurantifolia* Swingle) genotypes of Jammu region.

Sr. No.	Genotypes	Colour of anthers	Number of stamens	Arrangement of flowers	Flower/inflorescence position
1.	JMU-Log(1)	Pale yellow	> 4 per petal	Inflorescence	Axillary
2.	JMU-Log(2)	Pale yellow	> 4 per petal	Inflorescence	Axillary
3.	JMU-Log(3)	Pale yellow	4 per petal	Both	Axillary
4.	JMU-Log(4)	Pale yellow	> 4 per petal	Inflorescence	Axillary
5.	JMU-Log(5)	Pale yellow	> 4 per petal	Inflorescence	Axillary
6.	JMU-Log(6)	Pale yellow	> 4 per petal	Inflorescence	Axillary
7.	JMU-Log(7)	Pale yellow	> 4 per petal	Both	Axillary
8.	JMU-Log(8)	Pale yellow	> 4 per petal	Both	Axillary
9.	JMU-Log(9)	Pale yellow	> 4 per petal	Inflorescence	Axillary
10.	JMU-Bar(10)	Pale yellow	> 4 per petal	Both	Axillary
11.	JMU-Bar(11)	Pale yellow	> 4 per petal	Inflorescence	Axillary
12.	JMU-Bar(12)	Pale yellow	4 per petal	Both	Axillary
13.	JMU-Bar(13)	Pale yellow	4 per petal	Inflorescence	Axillary
14.	JMU-Kat (14)	Pale yellow	> 4 per petal	Inflorescence	Axillary
15.	JMU-Kat(15)	Pale yellow	> 4 per petal	Inflorescence	Axillary
16.	JMU-Kat(16)	Pale yellow	> 4 per petal	Inflorescence	Axillary
17.	JMU-Kat(17)	Pale yellow	> 4 per petal	Inflorescence	Axillary
18.	JMU-Uttar(18)	Pale yellow	> 4 per petal	Inflorescence	Axillary
19.	JMU-Uttar(19)	Pale yellow	> 4 per petal	Inflorescence	Axillary
20.	JMU-Uttar(20)	Pale yellow	> 4 per petal	Inflorescence	Axillary
21.	JMU-Uttar(21)	Pale yellow	> 4 per petal	Both	Axillary
22.	JMU-Gura(22)	Pale yellow	4 per petal	Inflorescence	Axillary
23.	JMU-Gura(23)	Pale yellow	> 4 per petal	Inflorescence	Axillary
24.	JMU-Gura(24)	Pale yellow	> 4 per petal	Both	Axillary
25.	JMU-Gura(25)	Pale yellow	> 4 per petal	Inflorescence	Axillary
26.	JMU-Taror(26)	Pale yellow	> 4 per petal	Both	Axillary
27.	JMU-Balli(27)	Pale yellow	> 4 per petal	Both	Axillary
28.	JMU-Balli(28)	Pale yellow	> 4 per petal	Inflorescence	Axillary
29.	JMU-Balli(29)	Pale yellow	> 4 per petal	Inflorescence	Axillary
30.	JMU-Balli(30)	Pale yellow	> 4 per petal	Both	Axillary
31.	JMU-Neeli(31)	Pale yellow	4 per petal	Both	Axillary
32.	JMU-Neeli(32)	Pale yellow	> 4 per petal	Inflorescence	Axillary
33.	JMU-Neeli(33)	Pale yellow	> 4 per petal	Both	Axillary
34.	JMU-Jib(34)	Pale yellow	> 4 per petal	Inflorescence	Axillary
35.	JMU-Jib(35)	Pale yellow	> 4 per petal	Inflorescence	Axillary
36.	JMU-Jib(36)	Pale yellow	4 per petal	Both	Axillary
37.	JMU-Jib(37)	Pale yellow	> 4 per petal	Inflorescence	Axillary
38.	JMU-Jib(38)	Pale yellow	> 4 per petal	Inflorescence	Axillary
39.	JMU-Tikri(39)	Pale yellow	> 4 per petal	Both	Axillary
40.	JMU-Tikri(40)	Pale yellow	4 per petal	Inflorescence	Axillary
41.	JMU-Pana(41)	Pale yellow	> 4 per petal	Both	Axillary
42.	JMU-Pana(42)	Pale yellow	> 4 per petal	Both	Axillary
43.	JMU-Pana(43)	Pale yellow	> 4 per petal	Both	Axillary
44.	JMU-Pana(44)	Pale yellow	> 4 per petal	Both	Axillary
45.	JMU-Chet(45)	Pale yellow	4 per petal	Inflorescence	Axillary
46.	JMU-Chet(46)	Pale yellow	> 4 per petal	Inflorescence	Axillary

47.	JMU-Chet(47)	Pale yellow	> 4 per petal	Inflorescence	Axillary
48.	JMU-Chet(48)	Pale yellow	> 4 per petal	Inflorescence	Axillary
49.	JMU-Duggi(49)	Pale yellow	> 4 per petal	Inflorescence	Axillary
50.	JMU-Lait(50)	Pale yellow	4 per petal	Both	Axillary
51.	JMU-Lait(51)	Pale yellow	> 4 per petal	Both	Axillary
52.	JMU-Godd(52)	Pale yellow	> 4 per petal	Inflorescence	Axillary
53.	JMU-Godd(53)	Pale yellow	> 4 per petal	Both	Axillary
54.	JMU-Godd(54)	Pale yellow	4 per petal	Both	Axillary
55.	JMU-Godd(55)	Pale yellow	> 4 per petal	Inflorescence	Axillary
56.	JMU-Godd(56)	Pale yellow	> 4 per petal	Inflorescence	Axillary
57.	JMU-Sum(57)	Pale yellow	> 4 per petal	Inflorescence	Axillary
58.	JMU-Sum(58)	Pale yellow	4 per petal	Both	Axillary
59.	JMU-Sum(59)	Pale yellow	> 4 per petal	Inflorescence	Axillary
60.	JMU-Sum(60)	Pale yellow	> 4 per petal	Inflorescence	Axillary
61.	JMU-Sun(61)	Pale yellow	> 4 per petal	Inflorescence	Axillary
62.	JMU-Sun(62)	Pale yellow	4 per petal	Inflorescence	Axillary
63.	JMU-Sun(63)	Pale yellow	> 4 per petal	Inflorescence	Axillary
64.	JMU-Sun(64)	Pale yellow	> 4 per petal	Inflorescence	Axillary
65.	JMU-Nag(65)	Pale yellow	> 4 per petal	Both	Axillary
66.	JMU-Nag(66)	Pale yellow	4 per petal	Inflorescence	Axillary
67.	JMU-Nag(67)	Pale yellow	> 4 per petal	Both	Axillary
68.	JMU-Nag(68)	Pale yellow	> 4 per petal	Inflorescence	Axillary
69.	JMU-Nag(69)	Pale yellow	> 4 per petal	Inflorescence	Axillary
70	JMU-Nag(70)	Pale yellow	> 4 per petal	Both	Axillary

D. Fruit characters

Fruit character is the primary basis in genotype selection. Study of fruit diversity is of utmost importance to select the elite acid lime genotypes for breeding and variety development program. The fruit's external quality is determined by physical characteristics such as rind colour, fruit size, shape and any visible defects. Characters related to fruit size and fruit morphology are the main traits that account towards phenotypic diversity in citrus and citrus relatives (Kahn *et al*., 2008). Variability was not observed in fruit axis, fruit surface texture, adherence of albedo to pulp, albedo colour, and presence/absence of aerola among all the lime genotypes during the study period. Fruit axis was found solid, Adherence of albedo to pulp was strong, white colour of albedo and areola was present in all the acid lime genotypes, and smooth surface texture was noted in fifty four genotypes and rough in sixteen genotypes (Table 6). A wide variation in fruit surface texture has been reported by (Yadlod *et al.*, 2018) in lime and (Singh *et al.*, 2009) in lemon. The magnitude of the adherence of albedo to pulp is an important character from transportation and storage point of view (Santos *et al.,* 2003). Maximum number of days (174 days) required for bearing cycle was recorded in JMU-Sum(59) and JMU-Sum(60) followed by 173 days in JMU-Sun(62) and JMU-Sun(61) whereas, minimum number of days (162 days) was recorded in JMU-Uttar(20).

Table 6: Variability for fruit characters of indigenous lime (*Citrus aurantifolia* Swingle) genotypes of Jammu region.

Sr. No.	Genotypes	Fruit axis	Fruit surface texture	Adherence of albedo to pulp	Albedo colour	Absence/presence of areola	Bearing cycle (days)
1.	JMU-Log(1)	Solid	Smooth	Strong	White	Present	169
2.	JMU-Log(2)	Solid	Smooth	Strong	White	Present	169
3.	JMU-Log(3)	Solid	Smooth	Strong	White	Present	173
4.	JMU-Log(4)	Solid	Smooth	Strong	White	Present	173
5.	JMU-Log(5)	Solid	Smooth	Strong	White	Present	172
6.	JMU-Log(6)	Solid	Smooth	Strong	White	Present	168
7.	JMU-Log(7)	Solid	Smooth	Strong	White	Present	170
8.	JMU-Log(8)	Solid	Smooth	Strong	White	Present	170
9.	JMU-Log(9)	Solid	Smooth	Strong	White	Present	168
10.	JMU-Bar(10)	Solid	Rough	Strong	White	Present	169
11.	JMU-Bar(11)	Solid	Rough	Strong	White	Present	169
12.	JMU-Bar(12)	Solid	Rough	Strong	White	Present	168
13.	JMU-Bar(13)	Solid	Rough	Strong	White	Present	168
14.	JMU-Kat (14)	Solid	Smooth	Strong	White	Present	170

15.	JMU-Kat(15)	Solid	Smooth	Strong	White	Present	169
16.	JMU-Kat(16)	Solid	Smooth	Strong	White	Present	169
17.	JMU-Kat(17)	Solid	Smooth	Strong	White	Present	169
18.	JMU-Uttar(18)	Solid	Smooth	Strong	White	Present	169
19.	JMU-Uttar(19)	Solid	Rough	Strong	White	Present	162
20.	JMU-Uttar(20)	Solid	Smooth	Strong	White	Present	163
21.	JMU-Uttar(21)	Solid	Smooth	Strong	White	Present	163
22.	JMU-Gura(22)	Solid	Smooth	Strong	White	Present	164
23.	JMU-Gura(23)	Solid	Smooth	Strong	White	Present	166
24.	JMU-Gura(24)	Solid	Smooth	Strong	White	Present	166
25.	JMU-Gura(25)	Solid	Rough	Strong	White	Present	167
26.	JMU-Taror(26)	Solid	Smooth	Strong	White	Present	168
27.	JMU-Balli(27)	Solid	Smooth	Strong	White	Present	167
28.	JMU-Balli(28)	Solid	Smooth	Strong	White	Present	167
29.	JMU-Balli(29)	Solid	Smooth	Strong	White	Present	169
30.	JMU-Balli(30)	Solid	Smooth	Strong	White	Present	169
31.	JMU-Neeli(31)	Solid	Rough	Strong	White	Present	168
32.	JMU-Neeli(32)	Solid	Rough	Strong	White	Present	167
33.	JMU-Neeli(33)	Solid	Rough	Strong	White	Present	168
34.	JMU-Jib(34)	Solid	Rough	Strong	White	Present	169
35.	JMU-Jib(35)	Solid	Smooth	Strong	White	Present	169
36.	JMU-Jib(36)	Solid	Smooth	Strong	White	Present	169
37.	JMU-Jib(37)	Solid	Smooth	Strong	White	Present	168
38.	JMU-Jib(38)	Solid	Rough	Strong	White	Present	169
39.	JMU-Tikri(39)	Solid	Rough	Strong	White	Present	169
40.	JMU-Tikri(40)	Solid	Smooth	Strong	White	Present	170
41.	JMU-Pana(41)	Solid	Smooth	Strong	White	Present	167
42.	JMU-Pana(42)	Solid	Smooth	Strong	White	Present	167
43.	JMU-Pana(43)	Solid	Rough	Strong	White	Present	167
44.	JMU-Pana(44)	Solid	Smooth	Strong	White	Present	170
45.	JMU-Chet(45)	Solid	Smooth	Strong	White	Present	168
46.	JMU-Chet(46)	Solid	Smooth	Strong	White	Present	170
47.	JMU-Chet(47)	Solid	Smooth	Strong	White	Present	169
48.	JMU-Chet(48)	Solid	Smooth	Strong	White	Present	169
49.	JMU-Duggi(49)	Solid	Smooth	Strong	White	Present	169
50.	JMU-Lait(50)	Solid	Rough	Strong	White	Present	167
51.	JMU-Lait(51)	Solid	Smooth	Strong	White	Present	167
52.	JMU-Godd(52)	Solid	Smooth	Strong	White	Present	168
53.	JMU-Godd(53)	Solid	Smooth	Strong	White	Present	165
54.	JMU-Godd(54)	Solid	Smooth	Strong	White	Present	166
55.	JMU-Godd(55)	Solid	Smooth	Strong	White	Present	168
56.	JMU-Godd(56)	Solid	Smooth	Strong	White	Present	170
57.	JMU-Sum(57)	Solid	Smooth	Strong	White	Present	169
58.	JMU-Sum(58)	Solid	Rough	Strong	White	Present	173
59.	JMU-Sum(59)	Solid	Smooth	Strong	White	Present	174
60.	JMU-Sum(60)	Solid	Rough	Strong	White	Present	174
61.	JMU-Sun(61)	Solid	Smooth	Strong	White	Present	173
62.	JMU-Sun(62)	Solid	Smooth	Strong	White	Present	173
63.	JMU-Sun(63)	Solid	Smooth	Strong	White	Present	166
64.	JMU-Sun(64)	Solid	Smooth	Strong	White	Present	166
65.	JMU-Nag(65)	Solid	Smooth	Strong	White	Present	166
66.	JMU-Nag(66)	Solid	Smooth	Strong	White	Present	169
67.	JMU-Nag(67)	Solid	Smooth	Strong	White	Present	169
68.	JMU-Nag(68)	Solid	Smooth	Strong	White	Present	169
69.	JMU-Nag(69)	Solid	Smooth	Strong	White	Present	166
70	JMU-Nag(70)	Solid	Smooth	Strong	White	Present	169

E. Pulp and seed characters

Juice colour in citrus is an essential character for fresh as well for processing purpose. Results of the present study showed a marked variation in pulp colour among the studied citrus genotypes. Data mentioned in Table 7 depicted that distinct variability was found in pulp colour of acid lime genotypes. White pulp colour was observed in thirteen acid lime genotypes, green in twenty six, and yellow pulp colour was observed in thirty one genotypes of acid lime. No variation was observed in pulp texture among all the acid lime genotypes. Pulp texture was found fleshy in all the acid lime fruits under investigation. The greater variability in pulp colour confirms the highly heterozygous nature of the genotypes under study. Less number of seeds per fruit is a desirable character in lime. Seedlessness is one of the breeding objectives in citrus (Liu and Deng, 2007; JinPing *et al.*, 2009). Normally the fruits with less number of seeds may contain more edible part in the fruit. Results from the present study reveals that in most of the genotypes i.e fourty one were having 10-19 number of seeds and twenty nine genotypes were having 5-9 seeds. Maximum seed length (10.98 mm) was recorded in JMU-Sum(57) and minimum mean seed length (6.31 mm) in genotype JMU-Gura(22). Maximum seed width (4.99 mm) was recorded in JMU-Sum(57) whereas, minimum mean seed width (3.92 mm) was recorded in genotype JMU-Gura(22). Genotype JMU-Chet(47) had maximum seed weight (1.87 g) and JMU-Chet(45) had recorded minimum mean seed weight (0.80 g) (Table 8). These results are in conformity with the findings of Shinde *et al.,* (2004) who found the maximum number of seeds per fruit in Promalini. Likewise, Khan *et al.*, (2005) observed that seed content in sweet orange cultivars ranges from 1-28. The chance of selecting seedless citrus varieties from existing seeded types is low (Fatima, 2004). However, relatively low seed numbers in accessions from Trongsa may be of interest to breeders for further investigation.

Table 7: Variability for pulp and seed characters of indigenous lime (*Citrus aurantifolia* Swingle) genotypes of Jammu region.

Sr. No.	Genotypes	Pulp colour	Pulp texture	Average no. of seeds per fruit	Seed length (mm)	Seed width (mm)	Seed weight (g)
1.	JMU-Log(1)	Green	Fleshy	5-9	7.81	3.53	1.52
2.	JMU-Log(2)	Green	Fleshy	10-19	10.22	4.35	1.07
3.	JMU-Log(3)	Yellow	Fleshy	5-9	9.52	3.70	1.62
4.	JMU-Log(4)	Green	Fleshy	10-19	10.16	4.99	1.14
5.	JMU-Log(5)	Yellow	Fleshy	10-19	7.72	3.96	1.85
6.	JMU-Log(6)	White	Fleshy	5-9	7.86	3.99	0.98
7.	JMU-Log(7)	Green	Fleshy	10-19	8.10	3.47	1.26
8.	JMU-Log(8)	Yellow	Fleshy	5-9	8.72	3.28	0.95
9.	JMU-Log(9)	Yellow	Fleshy	5-9	10.02	4.26	1.19
10.	JMU-Bar(10)	Yellow	Fleshy	10-19	10.13	4.42	1.38
11.	JMU-Bar(11)	Yellow	Fleshy	10-19	9.97	4.10	1.46
12.	JMU-Bar(12)	Yellow	Fleshy	5-9	7.90	3.42	0.85
13.	JMU-Bar(13)	Yellow	Fleshy	10-19	8.02	3.11	1.24
14.	JMU-Kat (14)	Yellow	Fleshy	5-9	8.41	3.36	1.17
15.	JMU-Kat(15)	White	Fleshy	5-9	7.83	4.54	1.15
16.	JMU-Kat(16)	White	Fleshy	10-19	7.86	4.40	1.19
17.	JMU-Kat(17)	Yellow	Fleshy	10-19	7.92	4.06	1.22
18.	JMU-Uttar(18)	Yellow	Fleshy	10-19	6.92	3.21	1.23
19.	JMU-Uttar(19)	Green	Fleshy	5-9	6.81	3.39	1.19
20.	JMU-Uttar(20)	White	Fleshy	10-19	6.86	3.43	1.32
21.	JMU-Uttar(21)	Green	Fleshy	5-9	7.52	3.52	0.96
22.	JMU-Gura(22)	Yellow	Fleshy	10-19	6.31	2.18	0.86
23.	JMU-Gura(23)	Yellow	Fleshy	10-19	6.59	2.24	1.77
24.	JMU-Gura(24)	Yellow	Fleshy	5-9	7.27	4.89	0.87
25.	JMU-Gura(25)	Green	Fleshy	10-19	7.30	3.90	1.11
26.	JMU-Taror(26)	Yellow	Fleshy	5-9	7.29	3.81	1.12
27.	JMU-Balli(27)	White	Fleshy	10-19	7.31	3.91	1.32
28.	JMU-Balli(28)	White	Fleshy	10-19	7.39	3.86	1.09
29.	JMU-Balli(29)	White	Fleshy	10-19	7.33	3.79	1.36
30.	JMU-Balli(30)	White	Fleshy	5-9	8.30	4.40	0.96
31.	JMU-Neeli(31)	White	Fleshy	10-19	7.68	4.92	1.05
32.	JMU-Neeli(32)	White	Fleshy	10-19	7.28	3.89	1.18
33.	JMU-Neeli(33)	Green	Fleshy	5-9	10.02	4.23	1.19
34.	JMU-Jib(34)	Yellow	Fleshy	10-19	9.32	3.41	1.39
35.	JMU-Jib(35)	Green	Fleshy	5-9	10.27	3.27	1.10
36.	JMU-Jib(36)	Yellow	Fleshy	5-9	9.89	4.43	1.22
37.	JMU-Jib(37)	Yellow	Fleshy	10-19	10.72	4.41	1.12
38.	JMU-Jib(38)	Yellow	Fleshy	10-19	8.29	3.26	1.19
39.	JMU-Tikri(39)	White	Fleshy	5-9	9.48	3.36	1.21
40.	JMU-Tikri(40)	Green	Fleshy	10-19	8.36	3.86	1.15
41.	JMU-Pana(41)	Yellow	Fleshy	5-9	6.48	2.63	1.20
42.	JMU-Pana(42)	Yellow	Fleshy	5-9	7.29	4.11	0.97
43.	JMU-Pana(43)	Yellow	Fleshy	5-9	7.62	4.28	1.16
44.	JMU-Pana(44)	Yellow	Fleshy	10-19	7.73	4.43	1.09

45.	JMU-Chet(45)	Yellow	Fleshy	5-9	6.98	3.39	0.80
46.	JMU-Chet(46)	White	Fleshy	10-19	7.40	3.86	1.20
47.	JMU-Chet(47)	Green	Fleshy	10-19	7.31	4.00	1.87
48.	JMU-Chet(48)	Green	Fleshy	10-19	7.29	3.28	1.18
49.	JMU-Duggi(49)	Green	Fleshy	10-19	7.33	4.41	1.03
50.	JMU-Lait(50)	Yellow	Fleshy	5-9	9.97	4.19	1.66
51.	JMU-Lait(51)	Green	Fleshy	10-19	10.25	4.29	0.99
52.	JMU-Godd(52)	Green	Fleshy	10-19	8.90	3.43	1.15
53.	JMU-Godd(53)	Green	Fleshy	10-19	9.70	4.19	1.19
54.	JMU-Godd(54)	Yellow	Fleshy	5-9	8.45	4.32	1.12
55.	JMU-Godd(55)	Yellow	Fleshy	10-19	10.29	4.38	1.13
56.	JMU-Godd(56)	Green	Fleshy	10-19	7.36	4.34	1.30
57.	JMU-Sum(57)	Green	Fleshy	5-9	10.98	4.86	1.09
58.	JMU-Sum(58)	Green	Fleshy	10-19	8.56	4.28	1.25
59.	JMU-Sum(59)	Green	Fleshy	10-19	10.33	4.27	1.32
60.	JMU-Sum(60)	Green	Fleshy	10-19	7.84	3.10	1.28
61.	JMU-Sun(61)	Green	Fleshy	5-9	9.80	4.76	0.97
62.	JMU-Sun(62)	Green	Fleshy	10-19	9.73	4.37	1.42
63.	JMU-Sun(63)	Yellow	Fleshy	10-19	10.62	4.01	1.10
64.	JMU-Sun(64)	Yellow	Fleshy	5-9	9.00	4.66	1.07
65.	JMU-Nag(65)	Green	Fleshy	5-9	9.33	4.23	1.25
66.	JMU-Nag(66)	Yellow	Fleshy	10-19	9.80	3.96	1.21
67.	JMU-Nag(67)	Green	Fleshy	10-19	9.23	2.69	1.32
68.	JMU-Nag(68)	Green	Fleshy	10-19	8.30	3.66	1.76
69.	JMU-Nag(69)	White	Fleshy	5-9	7.02	4.40	1.16
70.	JMU-Nag(70)	Yellow	Fleshy	5-9	8.09	4.87	1.36
	General mean				8.45	3.92	1.21
	±SE (m)				0.39	0.21	0.04
	CV (%)				8.03	9.56	6.37
	CD at 5%				1.09	0.60	0.12

CONCLUSION

From our study it can be concluded that be concluded that despite having lower variations in qualitative traits significant morphological variations were existed among the acid lime accessions with respect to quantitative characters indicating the diversity of the analyzed accessions. This could be due to action of diverse evolutionary forces. All the observations made in this study showed that acid lime from Jammu Province does not consist of a single variety when morphologically assessed and identified and will provide valuable evidence for decision making in characterization of acid lime germplasm and its management. However, this study will form an important basis for selection of variability and to be used in future crop improvement of these species.

Conflict of Interest. None.

REFERENCES

IPGRI (International Plant Genetic Resource Institute, Rome, Italy). (1999). Descriptors of Citrus. International Plant Genetic Resource Institute, Rome, Italy. (available from http:/www.cgiar.org/ipgri/).

Anonymous (2018). District-Wise/Kind-Wise estimated Area under Major Horticulture Crops J&K, Department of Horticulture, Jammu and Kashmir.

Bhusal, R. C., Fusao, M. and Kipkoriony, L. R. (2002). Selection of rootstocks for flooding and drought tolerance in Citrus species. *Pakistan Journal of Biological Sciences, 5*(5): 509-512.

Blanco, A. S., Foguet, J. L., Gonzalez, J. L. and Fouguet, L. (1998). Polyembryony and seed number in hybrid citrus progenies used as rootstock. *Revista Industrial y Agricola de Tucuman, 75*: 41-44.

Camargo, N. J., Meyer, G. E., Jones, D. D. and Samal, A. K. (2006). Plant species identification using elliptic Fourier leaf shape analysis. *Computers and Electronics in Agriculture, 50*: 121-134.

Cameron, S. W. and Frost, H. B. (1968). Genetics, breeding, and nucellar embryony. In: Reuther, W., Batchelor, L.D. and Webber, H.J. (eds.) The Citrus Industry, vol. 2, University of California, USA, pp. 325-389.

Chase, S. B. (1947). Propagation of thornless honey locust. *Journal of Forestry*, *45*: 715-722.

Cires, E., Cuesta, C., Peredo, E. L., Revilla, M. A. and Prieto, J. A. F. (2009). Genome size variation and morphological differentiation within *Ranunculus parnassifolius* group (Ranunculaceae) from calcareous screes in the Northwest of Spain. *Journal of Systematics and Evolution, 281*: 193-208.

Dass, H. C., Singh, A., Vijayakumari, N. and Singh, A. (1998). Rootstock breeding - variation for leaf morphology in citrus rootstock hybrid progeny. *Indian Journal of Horticulture, 55*: 16-19.

Dwari, S. and Mondal, A. K. (2011). Systematic studies (morphology, anatomy and palynology) of economically viable grass *Brachiaria mutica* (Forsskil) Stapf in Eastern India, *African Journal of Plant Science, 5*: 296-304.

Dorji, K. and Yapwattanaphun, C. (2011). Assessment of morphological diversity for local mandarin (*Citrus reticulata* Blanco.) accessions in Bhutan. *Journal of Agriculture, Science and Technology, 7*: 485-495.

Du, J. X., Wang, X. F. and Zhang, G. J. (2007). Leaf shape based plant species recognition. *Journal of Computational and Applied Mathematics, 185*: 883-893.

Duminil, J. and Michele, M. D. (2009). Plant species delimitation: A comparison of morphological and molecular markers. *Plant Biosystem, 143*: 528-542.

Elameen, A., Larsen, A., Sonja, S. K., Fjellheium, S., Msolla, S. and Masumba, E. (2010). Phenotypic diversity of plant morphological and root descriptor characters within a sweet potato, *Ipomoea batatas* (L.) Lam., germplasm collection from Tanzania. *Genetic Resources and Crop Evolution, 58*: 397-407.

Frost, H. B. (1943). Genetic and breeding. In: Webber, H.J. and Batchelor, L.D. (eds.) The Citrus Industry, vol. 1, University of California Press, Berkely, pp: 817-913.

JinPing, X., LiGeng, C., Ming, B., HaiLin, L. and WeiQi, Y. (2009). Identification of AFLP fragments linked to seedlessness in Ponkan mandarin (*Citrus reticulata* Blanco) and conversion to SCAR markers. *Scientia Horticulturae, 121*: 505–510

Khan, A., Hussain, S. A., Nabi, G. and Asghar, H. (2005). Screening of sweet orange varieties on physico-chemical characters. *Sarhad Journal of Agriculture, 21*(2): 205-208.

Khan, M. M., Mumtaz, S., Ahmad, S., Abbas, M. and Khan, I. A. (2008). Some studies on the morphology of Kinnow mandarin and Feutrell's early. *Pakistan journal of agricultural sciences, 45*(4): 424-431.

Kinley, D. and Chinawat. Y. (2011). Morphological identification of mandarin (*Citrus reticulata* Blanco) in Bhutan. *Kasetsart Journal - Natural Science, 45*: 793-802.

Koehler-Santos, P., Dornelles, A. L. C. and Freitas, L. Bd. (2003). Characterization of mandarin Citrus germplasm from Southern Brazil by morphological and molecular analyses. *Pesquisa Agropecuaria Brasileira, 38*: 797-806.

Ladaniya, M. S. (2008). Fruit Biochemistry. In: Ladaniya MS 9ed.) Citrus Fruit: Biology, Technology and Evaluation. San Diego: Academic Press. pp. 125-190.

Liu, Y. Z. and Deng, X. X. (2007). Citrus breeding and genetics in China. Asian Australas. *Journal of Plant Science and Biotechnology,* 1: 23–28.

Lohwasser, U., Dittbrenner, A., Budahn, H., Marthe, F. and Borner, A. (2010). Taxonomy of plant genetic resources-use of morphological, molecular and phytochemical data in order to verify existing classifi cations. *Agriculturae conspectus scientificus, 75*: 175-178.

Moore, G. A. (2001). Orange and lemons: clues to taxonomy of Citrus from molecular marker. *Trends in genetics, 17(*9): 536 – 1166.

Nicolosi, E., Deng, Z. N., Gentile, A., La Malfa Continella, S. G. and Tribulato, E. (2000). Citrus phylogeny and genetic origin of important species as investigated by molecular markers. *Theoretical and Applied Genetics*, *100*: 1155-1166.

Patil, S. R., Sonkamble, A. M. and Waskar, D. P. (2012). Effect of growth regulators and chemicals on germination and seedling growth of Rangpur lime under laboratory conditions. *International journal of agricultural sciences,* 8: 494-497.

Santos, P. K., Dornelles, A. L. C. and Freitas, L. B. D. (2003). Characterization of mandarin citrus germplasm from southern Brazil by morphological and molecular analysis. *Pesquisa Agropecuaria Brasileira, 38*: 797-806.

Sharma, B. D., Hore, D.K. and Gupta, S. G. (2004). Genetic resources of Citrus of north-eastern India and their potential use. *Genetic Resources and Crop Evolution, 51*: 411-418.

Shinde N. N., Jature S. D., Patil M. B. and Shinde V. N. (2004). Seedless lime a promising mutant of acid lime. *Journal of Maharashtra Agricultural University, 29*(2): 227-228.

Singh, H. (2013). *Morphological characters of citrus rootstock*. Thesis M.Sc PAU Ludhiana pp. 1-93.

Singh, H., Rattanpal, H. S., Sidhu, G. S. and Chahal, T. S. (2010). Study on physio-morphological characteristics among six Rangpur lime (*Citrus limonia* Osbeck.) strains. *Journal of Tree Science, 29*: 48-56.

Singh, N. P., Gill, P. S., Jawandha, S. K. and Kaur, H. (2009). Genetic variability in Hill lemon strains (*Citrus pseudolimon* Tanaka) under Punjab conditions. *Notulae Botanicae Horti Agrobotanici Cluj-Napoca, 37*(1): 238-243.

Susandarini, R., Subandiyah, S., Rugayah, B., Daryono, S. and Nugroho, L. H. (2013). Taxonomic affinity assesment of Indonesian pummelo [*Citrus maxima* (Burm.) Merr.] based on morphological character. *American Journal of Agricultural and Biological Sciences, 8*: 182-190.

Susandarini, R., Subandiyah, S., Rugayah., Daryono, B. S. and Nugroho, L. H. (2013). Assessment of taxonomic affinity of Indonesian pummelo (*Citrus maxima* (burm.) Merr.) based on morphological characters. *American Journal of Agricultural and Biological Sciences, 8*: 182-90.

Swingle, W. T. and Reece, P. C. (1967). The Botany of citrus and its wild relatives. In: Reuther W, Webber HJ, Batchelor LD (ed.) The Citrus Industry, Vol. 1 (rev). University of California Press, Berkley, California, pp. 190-430.

Szczepaniak, M. and Cieslak, E. (2011). Genetic and morphological differentiation between *Melica ciliata* L. and *M. transsilvanica Schur* (Poaceae) in Europe reveals the non-presence of *M. ciliata* in the Polish flora. Acta *Societatis Botanicorum Poloniae, 80*: 301-313.

Thirugnanavel, A., Amutha, R., Baby Rani, W., Indira, K., Mareeswari, S., Muthulaksmi, S. and Parthiban, S. (2007). Studies on regulation of flowering in acid lime (*Citrus aurantifolia* Swingle). *Research Journal of Agriculture and Biological Sciences, 3*(4): 239-241.

Yadlod, S. S., Bhalerao, R. V. and Pingle, S. N. (2018). Variability Studies of Strains of Kagzi Lime (*Citrus aurantifolia* Swingle) in Latur District of Maharashtra. *Research Journal of Agricultural Science, 38*: 48-51.

How to cite this article: Kumari, S.; Sharma, A.; Salgotra, R.; Sharma, M. and Singh, P. (2021). Morphological Studies of Acid Lime (*Citrus aurantifolia* Swingle) Genotypes of North Western Regions of India. *Biological Forum – An International Journal, 13*(4): 1020-1032.