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Morphological Characterization of Local Cucumber (*Cucumis sativus* L.) Genotypes for Fruit Quality Traits

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Abstract

The cucumber *(Cucumis sativus* L.*)* is an important vegetable crop grown worldwide for its tender fruit as salad. In the present study, the morphological characterization of 30 local genotypes was carried out for fruit, seed and plant characters. Genotypes collected from Dharwad region had long, slender, dark green fruits with thin flesh (9.55 mm) and core thickness, whereas genotypes collected from Shivamogga and Puttur region had bigger fruits with thicker flesh (41.44 mm). For quantitative characters, the PCV was higher than GCV for all the characters. The higher PCV and GCV values were recorded for fruit length, fruit diameter, fruit weight, flesh thickness and number of spines (>30%). High heritability with high genetic advance was observed for fruit length, fruit diameter, fruit weight, core thickness, flesh thickness, epidermal thickness, vine length, seed length, number of fruits per plant and number of spines per fruit except seed diameter. D^2 statistics analysis grouped 30 cucumber local genotypes into five different clusters. The highest inter-cluster distance (1289.29) was observed between cluster VI and V. The intra cluster divergence was maximum in cluster I (116.52) and minimum in clusters II, III, VI and V (0.00). Variability found among the genotypes exhibited huge potential to use these plant materials in breeding programs for different fruit quality traits in cucumber. Abbreviations: LBS: Leaf blade shape, FSC: Fruit Spine color NL: Number of locules, FPC: Fruit peel color, FSSE: Fruit shape at stem end, Abbreviations: FL: Fruit length (cm), FD: Fruit diameter (cm) FW: Fruit weight (g), CT: Core thickness (mm), FT: Flesh thickness (cm), NFPP: Number of fruits per plant.

Keywords : Cucumber local genotypes, Cluster distance, Quality traits

Cucumber (*Cucumis sativus* L.) is one of the commercially important and widely cultivated cucurbitaceous vegetables grown throughout the world mainly in subtropical and tropical countries for salad and pickling purpose. The fruits are also used as an astringent and antipyretic. The tender fruits are good for people suffering from constipation, jaundice and indigestion (Patidar *et al.,* 2017). In India, it is cultivated mainly in commercial lands and riverbeds. The total area and production of cucumber in India is 105 ha and 1673 metric tonnes respectively (Anonymous, 2020). Karnataka ranks 2nd in cucumber production after Haryana.

Cucumber is indigenous to India and varies in terms of morphological characters such as growth habit, fruit size, fruit shape, flesh thickness, number of spines, tenderness and fruit color. As a result of continuous selection, a large number of landraces and local forms with restricted distribution have been accumulated in different growing areas. Although there is substantial variation in the morphology of cucumbers, little is known about the genetic diversity of local genotypes in India (Lv *et al.,* 2012). Cucumber is native to the foothills of the Himalayas of Nepal, where the wild, bitter-fruited form, *C. sativus* var. *Hardwickii,* can be found. They are the direct seed sown vegetables having hard seed coat, which need more time for germination and sometime exhibit uneven germination (Devi *et al.,* 2013).

Diversity is the foundation of novel genes for countering pressure to agricultural production rising due to various biotic or abiotic factors. Cucumbers survive in varying climatic conditions and also act as a very important food source in difficult times. These fascinating properties make cucumber an interesting

crop for a detailed and widespread characterization of its germplasm (Cristina *et al.,* 2020).

Cucumber showed a narrow genetic base despite of considerable morphological variability, which limits development of new cucumber cultivars by cross - breeding. Being a largely consumed vegetable, cucumber has great opportunity to improve the production and productivity to meet the requirement by the adoption of improved varieties/ hybrids (Singh *et al*., 2016 and Pandey *et al*., 2016).

Market value of cucumber is mainly related to some of the qualitative and quantitative traits. Fruit skin traits including colour of spines, fruit warts, intensity and uniform colour are some of the most important external quality traits together with the shape and size that determine the commercial types (Hanqiang *et al.,* 2015).

Apart from the commercial scale production, many high quality local genotypes still exist, which have been cultivated by farmers for self-consumption from centuries and to be sold in local markets. These local genotypes constitute a valuable resource for cucumber breeders to increase the variability concerning quantitative and qualitatively inherited characters and adaptation to specific growing conditions. Thus, these germplasms can be used as a source of genes to develop new cucumber varieties. The assessment of genetic variability for fruit quality traits at morphological level is absolutely essential before planning an appropriate breeding strategy for genetic improvement in this crop. Until date, very limited information is available on genetic diversity based on morphological traits and its relationship with molecular markers. Keeping in view the above facts, present study was undertaken to evaluate genetic diversity in local cucumber genotypes grown in Karnataka.

TABLE 1

Analysis of variance (ANOVA) for quantitative characters in local cucumber genotypes

Source of variation	DF	MSS	Cal F
Replication	(r-1)	RMSS	
Genotype	(g-1)	TMSS	TMSS/EMSS
Error	(r-1) (g-1)	EMSS	
Total	(rg- 1)		

MATERIAL AND METHODS

The plant materials used in the study consists of 30 local genotypes of cucumber collected from several places in Karnataka, which has specific fruit quality traits. Cucumber local genotypes analyzed in this study are listed in Table 2. The experiment was laid out in a randomized complete block design with three replications at the Department of Plant Biotechnology, GKVK, University of Agricultural Science, Bangalore, during *rabi* season of 2019-20. Cucumber genotypes were evaluated for morphological characters under field conditions. Pits measuring 0.50 were prepared and filled with 2 kg FYM, half kg each Neem and pongamia cake, three seeds were sown in triangle passion within the pit. The pits were spaced at 2 m between plants 1.5 m

TABLE 2

List of local Cucumber genotypes evaluated in the study

T. No	Geno type	Place of collection	T. No	Geno type	Place of collection
T1	CSGLD	Dharwad	T16	CGLB	Bengaluru
T2	VLD	Dharwad	T17	CSK	North Karnataka
T3	DGLM	Dharwad	T18	CSBWL	Bengaluru
T4	CGM	Dharwad	T19	CSWL	Bengaluru
T5	DGM	Dharwad	T20	CSHLH	Holenarsipur
T6	CSBL-1	Belagavi	T21	CSBL-3	Belagavi
T7	CSSL	Shiralakoppa	T22	CSP	Belagavi
T8	CSU	Bengaluru	T23	CSHL-2	Hassan
T9	CSHL-1	Hassan	T24	CSHLA	Arakalagudu
T10	CSG-1	Golithadka	T25	CSHLC 1	Chanaraya patna
T11	CSG- 2	Golithadka	T26	CSHLC 2	Chanaraya patna
T12	CSG- 3	Golithadka	T27	CSBLS 4	Belagavi
T13	CSLG	Bengaluru	T28	CSJ 1	Jamakandi
T14	CSLW	Bengaluru	T29	CSJ 2	Jamakandi
T15	SCSGL	Tumkur	T30	CSEC	Bengaluru

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between rows. The observations on three randomly selected plants from each replication were recorded. Recommended cultural practices were adopted for proper growth and stand of the crop. The recommended NPK fertilizer doses (150:75:75) were applied in two split application, one as basal dose and another during flower initiation stage. Cultural practices along with plant protection measures were followed as per the package of practices. The fruits were harvested at marketable tender stage.

Observations on various qualitative traits such as Fruit shape, Fruit shape at stem end, Fruit spine color, Fruit peel color and Leaf blade shape was recorded in all the genotypes. Quantitative traits for fruit and plant characters such as, Fruit length (cm), Fruit diameter (cm), Length of vine (cm) was measured using scale, Individual fruit weight (g) was recorded using weighing balance. Epidermal thickness (mm), Core thickness (mm), Flesh thickness (cm), Length of seed (mm) and Diameter of seed (mm) were recorded with Vernier calipers at the marketable tender stage.

Data Analysis

Analysis of Variance (ANOVA) : The field performance data obtained from cucumber genotypes for the various qualitative and quantitative characters was tested for significance using analysis of variance (ANOVA) for randomized complete block design (Snedecor and Cochran, 1967) using the OPSTAT (14.139.232.166) software. The variances were analyzed following the standard procedure applicable to randomized complete block design.

The significant difference among the genotypes was determined by F test using the error variance by comparing calculated F value with table F value at 5 per cent probability levels.

The mean values of genotypes in each replication were used for analysis of variance. The analysis of variance and covariance for individual character and for the character pairs, respectively, were carried out using the mean values of each plot following the method given by Panse and Sukhatme (1954).

Where,

r = number of replications

g = number of treatments (genotypes)

The standard error was calculated as $S.Em = \frac{\sqrt{EMSS}}{r}$

After testing for significance of the differences among the mean of different genotypes for each character, further computations was done as detailed below.

Phenotypic and Genotypic Coefficient of Variation: Computation of Phenotypic Coefficient of Variation (PCV) and Genotypic Coefficient of Variation (GCV). PCV and GCV were classified by method suggested by Sivasubramanian and Menon (1973).

Heritability : Heritability in the broad sense was estimated by following the method..

Genetic Advance : This was computed according to the method suggested by Johnson *et al.* (1955).

Genetic Advances as Percentage of Mean (GAM): The GA as per cent of mean was categorized as per the method of Johnson *et al*. (1995).

Multivariate Analysis using D Statistics : D^2 statistics was used for assessing the genetic divergence between the genotypes as suggested by Mahalanobis (1936). Based on the D^2 values obtained, the entire genotypes were classified into distinct clusters, grouping together the less divergent genotypes according to Tochers method (Rao, 1952).

Results and Discussion

Morphological Characterization of Local Cucumber Genotypes for Qualitative Traits

Qualitative traits of 30 local genotypes were assessed based on plant, fruit and seed characters (Table 2). All the thirty local cucumber genotypes studied exhibited indeterminate growth habit and the duration of crop varied from 130-160 days from date of sowing.

LBS varied among the genotypes studied. Maximum number of genotypes exhibited acute LBS (18), followed by six each in obtuse and round shape.

Thus acute LBS was found to be predominant trait in local cucumber genotypes.

FSC was recorded in all the genotypes. Spine color varied from black to white and it was absent in some genotypes. Spines were absent in ten genotypes with long slender fruits with less flesh thickness compared to the 11 genotypes with white color spine followed by nine genotypes with black color spines. Most of the fruits with spines exhibited bigger fruits with high flesh and core thickness. These genotypes were mostly found growing in malnad region of Karnataka.

Locule number is the indicative of the local genotypes, which are most preferred over the commercial hybrids. It also indicates the diversity of the genotypes. Locule number per fruit ranged from 3 to 5. Maximum number of locules per fruit were observed in the genotype T 23 from Hassan region of Karnataka, followed by 4 locules in 7 genotypes (CSHL-1, CSG-1, CSLG, CSLW, CSWL, CSHLA, CSHLC 2). Whereas, minimum numbers of three locules were observed in the remaining genotypes (Table 3).

FPC is the color of fruit skin at market stage when the fruits had reached desired length in relation to the salad use of the fruit. FPC varied from creamy white, greenish yellow, light green to dark green color. The genotypes collected from Dharwad region exhibited dark green FPC compared to the genotypes collected from Hassan region with creamy white FPC. In contrast to these characters, genotypes collected from Belagavi region of Karnataka exhibited yellowish green FPC. These colors are typical in local cucumber genotypes and these colors are the indicative of the market preference where ever they are grown and sold. For example, Hassan local is preferred very much for its creamy white FPC and tender fruits which fetches premium price in the market (Anjanappa *et al.,* 2012).

FSSE is another typical character of local genotypes which varied from flat, obtuse to acute. Maximum number of genotypes exhibited obtuse

TABLE 3

Morphological characteristics of thirty local cucumber genotypes

	LBS	FSC	NL	FPC	FSSE
T1	Rounded	Absent	3	Dark green	Acute
T2	Rounded	Absent	3	Dark green	Acute
T3	Rounded	Absent	3	Dark green	Acute
T4	Rounded	Absent	3	Dark green	Acute
T5	Rounded	Absent	3	Dark green	Acute
T6	Acute	Black	3	Dark green	Obtuse
T7	Obtuse	White	3	Light green	Obtuse
T8	Rounded	Absent	3	Light green	Flat
T9	Acute	White	4	Light green	Obtuse
T10	Acute	Black	4	Dark green	Flat
T11	Acute	Black	3	Light green	Obtuse
T12	Acute	Black	3	Light green	Obtuse
T13	Acute	White	4	Yellowish green	Flat
T14	Acute	Black	4	Creamy white	Obtuse
T15	Acute	White	3	Dark green	Flat
T16	Acute	White	3	Dark green	Obtuse
T17	Rounded	Absent	3	Light green	Flat
T18	Acute	Black	3	Creamy white	Obtuse
T19	Acute	White	4	Creamy white	Obtuse
T20	Acute	Black	3	Light green	Flat
T21	Obtuse	White	3	Yellowish green	Obtuse
T22	Obtuse	White	3	Yellow green	Acute
T23	Acute	Black	5	Light green	Obtuse
T24	Acute	White	4	Light green	Obtuse
T25	Acute	White	3	Dark green	Obtuse
T26	Acute	White	4	Light green	Obtuse
T27	Acute	Black	3	Dark green	Obtuse
T28	Rounded	Absent	3	Dark green	Acute
T29	Rounded	Absent	3	Dark green	Acute
T30	Acute	Absent	3	Dark green	Obtuse

FSSE followed by acute FSSE. The flat FSSE character was found only in five genotypes collected from Holenarsipur region of Hassan, Bangalore regions of Karnataka and the characteristics found to be primitive.

Similar studies have been reported by Zhang *et al.* (2021) in *Cucumis sativus* and *Cucumis melo*. 23 qualitative characteristics had been measured such as leaf shape, leaf margin, leaf color, plant growth and fruit shape in which fruit weight ranged from

1390 g to 210 g and fruit length varied from 46.3 cm to 10.61 cm. The values of fruit weight displayed the biggest divergence among the quantitative traits.

Morphological Characterization of Local Cucumber Genotypes for Quantitative Traits

Fruit Length (cm) : Among the thirty local cucumber genotypes used, fruit length ranged from 7.77 cm to 39.61cm with an average mean of 19.51cm. The longer fruit length (39.61cm) was recorded in T17 which is locally named as Kakdi and grown in northern parts of Karnataka and the shorter fruit length was recorded in T6 (7.77cm) a genotype collected from Belagavi region (Table 4). Similarly, fruit length ranging from 6.06cm to 25.26cm was reported by Ahirwar and Singh (2018).

Fruit Diameter (cm) : Among the thirty local cucumber genotypes evaluated, fruit diameter ranged from 6.83 cm to 29.08 cm with an average mean of 16.06 cm. The higher fruit diameter was recorded in T7 (29.08 cm) a genotype collected from Siralakoppa region of Shivamogga district, which are known for bigger fruit, thick flesh and longer shelf life. These genotypes are normally grown in *kharif* season, which help them to express the full genetic potential. Smaller fruit diameter was recorded in T6 (6.83 cm) a genotype collected from Belgaum region (Table 4). The results are in line with the findings of Ahirwar and Singh (2018) with respect to fruit diameter in cucumber.

Individual Gruit Weight (g) : Among the thirty local cucumber genotypes studied, individual fruit weight ranged from 122.22 g to 522.22 g with an average mean of 309.64 g. The higher individual fruit weight was recorded in T9 (522.22 g), which was collected from Hassan region. Fruit weight was higher in the genotypes collected Arakalagudu, Chanarayapatana regions of Hassan district where as in contrast the smaller fruit weight was recorded in T4 (122.22g) genotype collected from Dharwad region of Karnataka (Table 4). Similar results in cucumber were reported by Anjanappa *et al.* (2012). The maximum fruit weight reported was 349.97g, in Hassan local cucumber genotypes.

Core Thickness (mm) : Among the thirty local cucumber genotypes used, core thickness of the fruit ranged from 9.55mm to 41.44 mm with an average mean of 31.44 mm. The higher core thickness of the fruit was recorded in T10 (41.11 mm) which was

TABLE 4

Per se Performance of local cucumber genotypes for fruit quality traits

Trait Geno type	FL (cm)	FD (cm)	FL (cm)	FL (cm)	FL (cm)	FL (cm)
T1	20.18	12.58	246.66	33.37	0.91	1
T2	16.51	11.58	283	29.22	1.11	1
T3	23.07	13.66	235.55	35.66	0.93	1.04
T4	9.74	11.08	122.22	32.77	0.97	1.15
T5	24.66	11.25	371	32.72	0.99	1.18
T6	7.77	6.83	150.33	27.33	1.01	1.24
T7	17.76	29.08	293.55	33.05	2.43	1.36
T8	22.38	10.58	429.66	31.38	1.20	1.08
T9	14.38	19.83	522.22	39	1.53	1.03
T10	17.55	19.33	341.33	41.44	1.83	1.17
T11	22.55	19.8	391.33	35.55	1.22	1.43
T12	20.6	22.41	477	33.5	1.73	1.47
T13	13.83	17.51	224.22	32.27	0.98	1.1
T14	14.24	15.91	229	32.61	1.04	1.17
T15	17.63	20.01	162.77	34.16	1.21	1.45
T16	22.72	20.33	316.44	33.88	1.30	1.72
T17	39.61	8.96	195.66	9.55	1.11	1.1
T18	14.06	15.4	188.55	32.22	1.23	1.5
T19	24.84	21.13	407.22	34.83	1.27	1
T20	16.31	17.23	285	22.69	1.2	1.46
T21	12.61	8.41	401.33	24.22	1.35	1.14
T22	23.22	10.16	257.55	25.44	1.34	1.18
T23	20.74	20.45	303	34.74	1.47	1.62
T24	20.82	18.16	411.77	33.77	1.19	1.17
T25	22.18	19.3	334.44	35.27	1.23	1.33
T26	21.75	21.56	421.44	38.11	1.35	1.33
T27	19.88	17.75	442.55	32.5	1.27	1.067
T28	21.76	15.58	346.77	30.38	1.21	1
T29	21.16	14.33	362	30.77	1.18	1
T30	20.88	11.66	135.6	20.66	1.074	1
Mean	19.51	16.06	309.64	31.44	1.26	1.22
S.Em	0.99	0.47	19.68	0.44	0.02	0.02
CV	8.83	5.17	11.01	2.43	3.71	3.78
CD 5%	2.81	1.35	55.72	1.25	0.07	0.07
Significant / Nonsignificant	S**	S**	S**	S**	S**	S**

collected from Puttur region of Karnataka and the lower core thickness was recorded in T17 (9.55mm) locally named as Kakdi which has long slender fruits (Table 4). Long slender cucumber genotypes exhibited lower core thickness where as in genotypes with short big fruits, core thickness was higher.

Flesh Thickness (cm) : Among the thirty local cucumber genotypes used, flesh thickness of the fruit ranged from 0.91 cm to 2.43 cm with an average mean of 1.26 cm. The higher flesh thickness of the fruit was recorded in T7 (2.43 cm) which was collected from Shiralakoppa region of Shivamogga region and the lower flesh thickness was recorded in T1 (0.91 cm) collected from Dharwad region of Karnataka (Table 4). Similar flesh thickness had been recorded by Mousavizadeh *et al*. (2010) ranging from 1.35 cm to 0.733 cm in cucumber. Fruit flesh thickness is an important trait for cucumber and also a critical component to determine the fruit size. Genotypes with bigger fruit flesh thickness exhibits big fruit size while genotypes with smaller flesh thickness exhibits small longer slender fruits.

Epidermal Thickness (mm) : Among the thirty local cucumber genotypes used, epidermal thickness of the fruit ranged from 1 mm to 1.72 mm with an average mean of 1.22 mm. The higher epidermal thickness of the fruit was recorded in T16 (1.72 mm) collected from Bengaluru and the lower epidermal thickness was recorded in (1mm) the genotypes collected from Dharwad and Jamakandi regions of Karnataka (Table 4). Similar results had been recorded by Mousavizadeh *et al*., (2010) ranging from 2.11mm to 1.48mm in cucumber. The fruit surface is a unique tissue with multiple roles influencing fruit development, post-harvest storage and quality, and consumer acceptability. Serving as the first line of protection against herbivores, pathogens, and abiotic stress, the surface can vary markedly among species, cultivars within species, and developmental stages.

Number of Spines : Among the thirty local cucumber genotypes used, the number of spines per fruit ranged from 0 to 134.33 with an average mean of 58.36. The higher number of spines was recorded in T23 (134.33) which was collected from Hassan district of Karnataka and the spines were absent in the genotypes collected from Dharwad and Jamakandhi regions of Karnataka (Table 5). Most of the fruits with spines exhibited bigger fruit size with high flesh and core thickness. These genotypes were mostly found growing in malnad region of Karnataka.

Seed Length (mm) : Among the thirty local cucumber genotypes used, the average length of the seed observed was 8.98 mm and it ranged from of 7.27mm to 10.31mm. The higher length of seed was recorded in T7 and T12 collected from Shilarakoppa region of Shivamogga and Golithadka region of Puttur (10.31mm) and the lower length of the seed was recorded in T1 collected from Dharwad region of Karnataka (7.27mm) (Table 5). Length of the seed will mainly influence on the consumer preference of the fruit. Fruits with small seeds are more suitable for tender consumption and large seeds are suitable for cotyledon purpose. The results are in line with the findings of Mirzabe *et al.* (2017) where length of seeds of Rashid variety of cucumber ranged from 6.40 mm to 9.07 mm.

Seed Diameter (mm) : Among the thirty local cucumber genotypes used, the average diameter of seed observed was 3.63 mm and it ranged from of 2.52 mm to 6.66 mm. The higher diameter of seed was recorded in T11 (6.66 mm) which was collected from Golithadka region of Puttur and the lower diameter of the seed was recorded in T4 (2.52 mm) which was collected from Dharwad region of Karnataka (Table 5). Seed length and diameter will influence on core thickness and size of the fruit. Fruits with longer and bigger seeds exhibited bigger fruit size whereas the slender fruit possessed smaller seeds. Similar results has been reported by of Mirzabe *et al.* (2017) in which seed diameter ranged from 2.91 mm to 4.21 mm.

Length of Vine (cm) : Among the thirty local cucumber genotypes used, length of vine ranged from

TABLE 5

Per se Performance of local cucumber genotypes for plant and fruits traits

Trait Geno type	NS	SL (mm)	SD (mm)	VL (cm)	NFPP
T1	0	7.27	4	108.55	11
T2	0	8	3.88	125.11	10.44
T3	0	8.33	3.11	151.33	13
T4	0	7.64	2.52	156.77	15.11
T5	0	8.83	4.27	143.44	10.44
T6	123.88	7.83	4	138.55	7.88
T7	118.77	10.31	3	112.66	10.55
T8	0	8.05	4	123.44	9.55
T9	94.55	8.06	3.96	132.11	9.88
T10	76	10.12	3.98	133.88	13.33
T11	88.44	10.23	6.66	142.55	11.88
T12	114.22	10.27	3.26	154.11	12
T13	52.11	7.31	3.16	200.88	8.55
T14	66.55	7.81	3.16	170.66	8
T15	41.111	9.16	3.11	122.88	12.33
T16	68	9.83	3.97	134.66	15.88
T17	0	9.27	3.98	186.66	6
T18	77.22	10.1	3.05	153	9.22
T19	126.22	9.8	3.16	153.33	12.88
T20	98.44	10.11	3.22	190.33	8.77
T21	74.33	8.16	3.75	145.44	9.11
T22	76.33	9.14	3.66	182.55	7.33
T23	134.33	8.22	3.91	173.88	8.55
T24	122.55	10.25	3.38	134	8.11
T25	87.55	10.17	3.98	139.55	10.55
T26	70.77	10.13	3	144.55	11.22
T27	39.44	8.24	3.11	140.11	8
T28	0	8.66	4	113.11	13.11
T29	0	9.22	3.77	99.44	13.66
T30	0	8.77	3	104.88	4
Mean	58.36	8.98	3.63	143.75	10.34
S.Em	5.01	0.25	0.62	3.92	0.77
CV	14.89	4.9	29.94	4.72	12.98
CD 5%	14.2	0.72	1.78	11.09	2.19
Significant/ Nonsignificant	S**	S**	NS	S**	S**

99.44 cm to 200.88 cm with an average of 143 cm. The higher length of vine was recorded in T13 collected from Bangalore region (200.88 cm) and the lower length of the vine was recorded in T29 collected from Jamakhandi region of north Karnataka (99.44 cm) (Table 5). Shah *et al.* (2018) have also reported similar results earlier in cucumber, where vine length ranged from 143.33 cm to 255.33 cm.

Number of Fruits Per Plant : Among the thirty local cucumber genotypes evaluated, the number of fruits per vine ranged from 4 to 15.88 with an average of 10.34. The higher number of fruits per plant was recorded in T16 collected from Bengaluru region and the lower number of fruits per plant was recorded in T30, which was commonly known as European cucumber (Table 5). Similarly, Praneetha *et al.* (2020) reported 3.67 to 11.20 number of fruits per plant in cucumber.

Mean, Range and Genetic Variability Parameters

Higher the amount of variation present for a character in the breeding materials, greater the scope for its improvement through selection. The genotypic and phenotypic coefficients of variation computed to assess the existing variability in the local cucumber genotypes are presented in Table 6.

Fruit Length (cm) : The fruit length ranged from 7.77 cm to 39.61 cm with an average mean of 19.51cm. The GCV (29.13%) and PCV (30.44%) values were high. The trait showed high heritability (91.58%) with high GAM (57.43%) (Table 6). The results are in accordance with Ahirwar and Singh (2018), who has reported high GCV (27.65%) and PCV (30.20%) values for fruit length.

Fruit Diameter (cm) : The average mean fruit diameter recorded was 16.06 cm with range of 6.833cm to 29.083cm. The GCV (31.45%) and PCV (31.87%) values were high. The trait showed high heritability (97.36%) and higher GAM (63.92%) (Table 6). Similar findings were reported by Ahirwar and Singh (2018) with a GCV (23.07%) and PCV (26.73%) values in the similar range for fruit diameter.

Individual Fruit Weight (g) : The average individual fruit weight observed was 309.64 g and it ranged from of 122.22 to 522.22 g. The trait showed high GCV (33.86 %) and PCV (35.60 %) with very high

heritability (90.43%) with high GAM (66.32 %) (Table 6). Similar studies have been reported by Shah *et al.* (2018) with high GCV (19.47%) and PCV (19.56 %) and high heritability (99%) along with high GAM (39.92 %) for individual fruit weight in cucumber.

Number of Spines : The average individual number of spines observed was 58.36 and it ranged from of 0 to 134.33. The trait showed high GCV (81.63 %) and PCV (82.98 %) with high heritability (96.78%) (Table 6). High heritability is an added advantage as this feature can be used in breeding programmers to identify the populations very easily.

Epidermal Thickness (mm) : The average epidermal thickness observed was 1.22 mm and it ranged from of 1 mm to 1.72 mm. The trait showed moderate GCV (16.61 %) and PCV (17.03 %) with high heritability (95.06%) with high GAM (33.36 %) (Table 6).

Core Thickness (mm) : The average core thickness observed was 31.44 mm and it ranged from of 9.55 mm to 41.44 mm. The trait showed moderate GCV (19.48 %) and PCV (19.63 %) with high heritability (98.46 %) with high GAM (39.82 %) (Table 6).

Flesh Thickness (mm) : The average flesh thickness observed was 1.26 mm and it ranged from of 0.91 mm to 2.43 mm. The trait showed high GCV (24.20%) and PCV (24.48 %) with high heritability (97.69 %) with high GAM (49.27%) (Table 6).

Seed Length (mm) : The average length of the seed observed was 8.98 mm and it ranged from of 7.27 mm to 10.31 mm. The trait showed moderate GCV (10.97 %) and PCV (12.02 %) with high heritability (83.33 %) and GAM (20.63 %) (Table 6). Shah *et al.* (2018) have recorded similar findings for seed length with 7.81 per cent GCV, 8.34 per cent PCV and GAM 15.08 per cent.

Seed Diameter (mm) : The average diameter of seed observed was 3.63 mm and it ranged from of 2.52 mm to 6.66 mm. The trait showed moderate GCV (10.31%) and high PCV (31.671%) with low heritability (10.59%) with low GAM (6.91%) (Table 6). Similar findings have been recorded by Shah *et al.*

TABLE 6

Estimation of components of variance, coefficient of variance, heritability, genetic advance over mean in cucumber local genotypes

Traits	Mean	Range		Co-efficient of variance (%)		H^2	GA	GA
		Range min	Range max	GCV	PCV			
VL (cm)	143.752	99.44	200.88	17.70	18.32	93.35	50.63	35.22
FL (cm)	19.51	7.7778	39.61	29.13	30.44	91.58	11.21	57.43
FW (cm)	16.06	6.833	29.08	31.45	31.87	97.36	10.27	63.92
FW (g)	309.64	122.22	522.22	33.86	35.60	90.43	205.37	66.32
CT (mm)	31.44	9.555	41.44	19.48	19.68	98.46	12.52	39.82
FT (mm)	1.26	0.9133	2.433	24.20	24.48	97.69	0.62	49.27
ET (mm)	1.22	1	1.7	16.61	17.03	95.06	0.41	33.60
NS	58.36	0	134.33	81.63	82.98	96.78	96.55	165.43
SL (mm)	8.98	7.27	10.31	10.97	12.02	83.33	1.85	20.60
SD (mm)	3.63	2.522	6.666	10.31	31.67	10.59	0.25	6.88
NFPP	10.34	4	15.88	24.75	27.95	78.40	4.67	45.14

(2018) with 5.46 per cent GCV, 8.21 per cent PCV and low GAM (7.79) in cucumber for seed diameter.

Length of Vine (cm) : The length of vine ranged from 99.44 to 200.88 with an average of 143.75. The GCV (17.70 %) and PCV (18.32 %) values were moderate. The high heritability (93.35%) with high GAM (35.22 %) was observed for this character (Table 6). Similar studies have been recorded by Shah *et al.* (2018) with moderate values recorded for GCV (17.70 %), PCV (17.87 %) and high heritability (98%) with high GAM (36.12 %) in length of vine.

Number of Fruits Per Plant : The number of fruits per plant ranged from 4 to 15.88 with an average of 10.34. The GCV (24.75 %) and PCV (27.95 %) values were moderate. The high heritability (78.40 %) with high GAM (45.14 %) was observed for this character (Table 6). Similarly, high heritability and high GAM were observed by Veena *et al.* (2012) for number of fruits per plant in cucumber.

PCV and GCV values were higher (>20) for number of spines, fruit length, diameter of the fruit, individual fruit weight, flesh thickness and number of fruits per plant which suggested greater phenotypic and genotypic variability among the local cucumber genotypes, these attributes can be utilized for making further improvement by selection. Moderate PCV and GCV (10-20 %) values were observed for length of vine, seed length, seed diameter and core thickness.

Higher values of heritability (>60) were observed for fruit length (cm), fruit diameter (cm), individual fruit weight (g), number of spines, epidermal thickness (mm), flesh thickness (mm), length of seed (mm), number of fruits per plant and length of vine (cm) whereas, low values of heritability (0-30 %) have been observed for core thickness (mm). High values of heritability for the above traits suggests, that they were least affected by environmental modification and selection based on phenotypic performance would be reliable.

In the present experiment, high heritability was observed for most of the characters. Similar results are also reported by Hanchinamani *et al.* (2011) in cucumber, Arunkumar *et al.* (2011) in cucumber, Rabbani *et al.* (2012) in ridge gourd, Kumar *et al.* (2013) in cucumber and Jat *et al.* (2014) in Kakri. The trait, diameter of seed showed low heritability. Similar results of heritability for diverse traits have also reported by Rabbani *et al,* (2012) in ridge gourd, Jat *et al.* (2014) in cucumber.

Multivariate Analysis (D^2 Analysis)

Multivariate analysis helps in quantification of degree of divergence among the biological populations and assessing the relative contribution of different characters to the total divergence. The D^2 values between each pair of genotypes was estimated for all the characters. The 30 genotypes were grouped according to Tochers method (Rao, 1952) into five clusters depending upon the genetic divergence.

The intra cluster divergence ranged from 0.00 (Cluster II, III, VI, V) to 116.52 (Cluster I). The intra cluster divergence in cluster II, III, VI, V was zero because the clusters had single genotype. The inter cluster distance was maximum between cluster VI and cluster V (1289.29) followed by cluster V and cluster II (1151.1) in Table 7. A perusal of the cluster distances clearly showed that the genotypes did not cluster according to geographical distribution, rather it was based on morphological divergence at species level. This is in agreement with result of Hasan *et al.* (2018) and Kumawat *et al.* (2020). The cluster divergence was proved by the high inter cluster and low intra cluster D^2 values. The cluster comprising of single genotype with specific valuable traits and other genotypes falling in the highly divergent groups will help in broadening the existing genetic base among the local cucumber genotypes and may produce new genotypes with hitherto unknown combinations.

The D^2 values clearly distinguished cluster III and V which were distinct with respect to fruit and plant characters, whereas genotypes in cluster II and IV

TABLE 7

Inter and intra cluster distance (D^2 values) for 5 cluster

	I	II	III	VI	V
I	116.52				
II	230.87	0.00			
III	242.31	614.49	0.00		
VI	411.63	117.92	797.27	0.00	
V	580.90	1151.10	193.53	1289.29	0.00

had similar fruit size, shape, color and thus Genetic divergence value was also low (117.92). Divergence values between cluster I and III was 241.31, which had dark green, small gherkin like fruits. Cluster I and V also exhibited high divergence value (580.91) indicating more diversity in terms of fruit, plant and seed characters. Thus, based on the genetic divergence values parental selection can be made from cluster I with cluster II and V.

Contribution of Plant and Fruit Characters Towards Genetic Divergence in Cucumber

The highest contribution in the manifestation of genetic divergence among local cucumber genotypes (Table 8) was shared by core thickness (27.59 %) followed by flesh thickness (23.22 %), number of spines (19.77 %), epidermal thickness (12.41 %) and vine length (10.34 %). Similar results were also reported by earlier researchers Punitha *et al*. (2012), Ahirwar *et al*. (2017) and Kumawat *et al.* (2020).

From the present study, it is evident that local genotypes studied may offer good source of material for advance breeding program. Therefore, information on the genetic parameters such as genetic correlation coefficient, coefficient of variation, heritability and genetic advance can help the breeder to develop suitable cultivars within a short time. On the basis of results as summarized above, it is concluded that traits like core thickness, flesh thickness, number of spines, epidermal thickness, fruit length, fruit diameter and fruit

TABLE 8

Contribution (%) of plant and fruit characters towards genetic divergence in cucumber

Traits	Contribution %
FL	1.38 %
FD	2.99 %
FW	1.61 %
CT	27.59 %
ET	12.41 %
FT	23.22 %
NS	19.77 %
SL	0.23 %
SD	0.23 %
VL	10.34 %
NFPP	0.23 %

weight can be considered as suitable selection criteria for the improvement of high yielding cucumber varieties.

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