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Morphological Characterization and Shannon-weaver Diversity Index (H') of Okra [*Abelmoschus esculentus* (L.) Moench] Germplasm

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ABSTRACT

Background: The current evaluation centered on phenotypic qualitative traits of okra as per DUS guidelines to assess the novelty and diversity in okra genotypes. Plant breeders may take advantage of these morphological traits to make sustainable use of the okra germplasm.

Methods: This investigation was carried out at the teaching farm, extended campus of BCKV, Burdwan during spring summer and rainy seasons, in 2021 to examine the phenotypic distinctions between 50 open-pollinated okra varieties for 15 morphological traits. These genotypes were gathered from various regions of India.

Result: In the current study out of 50 genotypes, 24 genotypes (48.00%) showed medium depth of leaf blade, 68 % genotypes showed light green stem colour, 68% genotypes were shown light green vein colour, 62% genotypes showed yellow petal colour, petal base colour was both sides (BS) in 72% of the genotypes, fruit pubescence was absent in 4% of the genotypes, fruit surface was concave in 62% of the genotypes, constriction of the fruit basal part was weak in 62% of genotypes, narrow acute fruit shape of the apex in 48% of the genotypes, fruit colour was the green in 60% of the genotypes, fruit locules were less than six and seed colour was green in all genotypes. Shannon Diversity H' value varied from 0 to 1.206. The fruit pubescence character showed highest diversity (1.206) followed by depth of leaf lobbing (1.038), fruit shape of the apex (0.973) and fruit length at marketable stage (0.947). Seed colour, fruit locule number and serration of the leaf blade's margin did not show any diversity among the genotypes.

Key words: Genotypes, Okra, Qualitative traits, Shannon-weaver diversity index (H').

INTRODUCTION

Okra [*Abelmoschus esculentus* (L.) Moench] is a prominent vegetable crop in India, usually called as lady's finger (Maruthi *et al.,* 2023). This vegetable crop is widely grown in tropical and subtropical regions during the summer and rainy seasons (Bagwale *et al.,* 2016). The origin of bhindi is still a controversy, with supporters of South Asian, Ethiopian and West African origins (Ranga *et al.,* 2019). Characteri-zation of germplasm gives details about the attributes held by each genotype, ensuring that end users achieve the best advantage of the germplasm collection (Reddy *et al.,* 2016). Morphological traits are the oldest and most widely used genetic markers and they could continue to be useful for some germplasm management tasks (Bretting and Widrlechner, 1995). According to Arslanoglu *et al.,* (2011), phenotypic evaluation is the foremost step in the descri-ption, categorization and arranging of germplasm collections. Vegetable breeders looking for novel trait genes must morphologically characterize the landraces, germplasms, genotypes and local cultivars (Reddy *et al.,* 2016). Multiple researchers emphasized the possibility of bhindi improvement through the investigation of genetic resources (Oppong-Sekyere *et al.,* 2011).

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The current work seeks to describe, evaluate and com-pare the accurate morphological traits of okra genotypes to discover their variability and uniqueness. The primary goal of the research was to familiarize okra breeders with acceptable morphological descriptor states that may be

employed as prospective breeding features for generating farmer-driven bhindi varieties.

MATERIALS AND METHODS

Overview of research area

The current investigation was carried out at the teaching farm, extended campus of BCKV, Burdwan during spring summer and rainy seasons, in 2021 to examine the phenotypic distinctions among 50 open-pollinated okra varieties.

Materials and designs used in experiments

The study included 50 different bhindi genotypes grown in a randomised block design and had three replications (during spring summer and rainy season, 2021). The plot size was 3.0 m × 2.7 m (8.1 m^2), with rows 60 cm apart and plants 30 cm apart. Ten days following seed germination, the seedlings were thinned to leave one healthy, strong seedling per hill.

Morphological observations to be recorded

As many as 15 qualitative traits *viz.*, leaf blade (depth, serration of margin), stem colour, vein colour, flower (petal colour, petal base colour), fruit (pubescence, surface between ridges, colour, no. of locules, shape of apex, constriction of basal part, fruit length (cm) at tender marketable stages, length (cm) at physiological mature stage) and seed (colour) attributes were noticed in 50 genotypes of okra as per the minimal descriptors based on DUS guidelines (Table 1) of NBPGR (2011) to characterize the present genotypes of bhindi during the course of the investigation. The above characters were noticed at appropriate stage of plant growth. Shannon Waver Diversity Index (H') is a frequently used diversity metric that takes into account both the abundance and evenness of species or traits within a group (Shannon, 1948). The formula below explains it:

$$(H') = - \sum_{i=1}^{s} pi \ln pi$$

Where,

p = Percentage (n/N) of individuals of one specific species discovered.

(n) = Divided by the entire number of individuals identified.

(N), ln = Natural log.

Σ = Sum of the computations and's' is the number of species.

RESULTS AND DISCUSSION

Leaf and stem characters

Out of 50 genotypes, 24 genotypes (48.00%) showed medium depth of leaf blade, 16 genotypes (32.00%) showed deep depth of leaf blade and 10 genotypes (20.00%) showed shallow depth of leaf blade (the leaf characteristic were shown in the (Plate 1). The stem colour of the genotypes varied with 68 % of genotypes light green, 12 % green and 20 % light red. Serration of the margin of the leaf blade was observed in all 50 genotypes. For vein colour among all genotypes, 68 % were shown light green, 28 % showed green vein colour and 4 % genotypes displayed purple colour.

Flower characters

In the case of the petal colour of the flower, 62% of genotypes showed yellow colour and 38% showed light yellow colour. Petal base colour (as shown in Plate 2) was inside (IS) in 28% of the genotypes and both sides (BS) in 72% of the genotypes.

Fruit characters

Fruit pubescence was absent in 4% of genotypes, weak in 30% of genotypes, medium in the 40% of genotypes and strong in 26% of the genotypes. Fruit surface between ridges (as shown in Plate 4) was concave in 62% of the genotypes, flat in 36 % of genotypes and convex in 2 % of the genotypes studied. Constriction of the fruit basal part was absent in 26% of the genotypes, weak in 62% of genotypes and strong in 12% of the genotypes. The fruit shape of the apex (as shown in Plate 3) was narrow acute in 48% of the genotypes, acute in 40% of the genotypes and blunt in 12% of the genotypes. Fruit locules were less than 6 in all the genotypes studied. Colour of the fruit was light green in 40% of the genotypes and green in 60 % of the genotypes. Fruit length (at marketable stage) was small in 28% of the genotypes, medium in 58% of the genotypes and long in 14% of the genotypes. Fruit length (at the physiological mature stage) was medium in 26% of genotypes and long in 74% of the genotypes. The seed colour was green in all the genotypes studied.

The morphological characterization of all 50 genotypes for 15 qualitative traits were shown in the Table 2 to 5.

According to Reddy *et al.,* (2016), it is vital to include qualitative attributes in the characterization, recognition and description of diversity in okra genotypes. Characterization of bhindi genotypes based on qualitative traits was similarly carried out earlier by Islam (2022), Mohammad *et al.,* (2022), Roy (2022) and Pranay (2022).

Morphological characterization data is crucial for detecting diagnostic features in various genotypes. This allows plant breeders to pick suitable genotypes with distinguishing attributes for crop improvement programs (Chavan *et al.,* 2018).

Characterizing genetic resources allows accessions to be chosen, differentiated, or distinguished based on their characteristics. Qualitative feature description offers insights into genetic diversity enabling development of agriculture, utilization of genetic resources from plants and conservation (Reddy *et al.,* 2023).

Shannon-weaver diversity index (H')

The frequency distributions were utilized to assess the H' for every attribute (Hennink and Zeven, 1991). H' of 50 okra genotypes were assessed from 15 phenotypic traits and findings were shown in the Table 5. High H' with an overall mean of 0.659 was acquired, reflecting the prevalence of diversity among the bhindi genotypes.

In this current study, the H' value ranged from 0 to 1.206. The fruit pubescence character showed highest diversity (1.206) followed by depth of leaf lobbing (1.038), fruit shape of the apex (0.973) and fruit length at marketable

Table 1: Okra descriptors (as per DUS guidelines).

Characteristics	States	Type of assessment
Depth of lobing of the Leaf blade	Shallow (S)	VG
	Medium (M)	
	Deep (D)	
Colour of the stem	Light green (LG)	VG
	Green (G)	
	Light red (LR)	
	Red (R)	
	Purple (P)	
Serration of margin of leaf blade	Plane	VS
	Serrated	
Colour of the vein	Purple (P)	VG
	Red (R)	
	Light red (LR)	
	Green (G)	
	Light green (LG)	
Petal colour of the flower	Yellow (Y)	VG
	Light yellow (LY)	
	Whitish (W)	
Base colour of the petal	(BS) Both side	VG
	(IS) Inside	
Fruit pubescence	Strong	VG
	Weak	
	Medium	
	Absent	
Fruit surface between ridges	Concave	VG
	Flat	
	Convex	
Constriction of basal part of the fruit	Strong	VG
	Weak	
	Absent	
Fruit shape of the apex	Acute (A)	VG
	Blunt (B)	
	Narrow acute (NA)	
Fruit number of locules	<6	MS
	7-8	
	>8	
Fruit colour	Purple (P)	VG
	Red (R)	
	Light red (LR)	
	Green (G)	
	Light green (LG)	
Fruit length (at marketable stage)	Small	MS
	Medium	
	Long	
Fruit length (at physiological mature stage)	Small	MS
	Medium	
	Long	
Seed colour	Green	VG
	Black	

VG : Visual evaluation using a single observation of a group of plants or parts of plants.

MS : Measuring a number of individual plant parts.

Table 2: Morphological characterization of 50 bhindi genotypes based on qualitative traits.

Genotypes	Stem colour	Leaf lobe depth	Serration of margin of the leaf blade	Colour of the vein	Flower petal colour
Arka Anamika	G	D	Serrated	P	Y
Arka Abhay	G	D	Serrated	LG	Y
Hisar Unnat	LG	M	Serrated	LG	Y
Pusa Sawani	G	D	Serrated	LG	Y
Pusa Makhmali	LG	D	Serrated	LG	Y
Punjab 8	LG	D	Serrated	LG	Y
Punjab 7	LG	M	Serrated	LG	Y
Hina RCH	G	M	Serrated	LG	LY
Bhindi Selection 51	LG	M	Serrated	G	Y
Hari Pari	LR	M	Serrated	G	LY
MH 310	LG	M	Serrated	G	LY
Rani 792	LG	D	Serrated	LG	LY
Panchwati	LG	D	Serrated	G	Y
Super Lady luck	LG	M	Serrated	LG	Y
Hari Kranti	LG	S	Serrated	LG	Y
Summer Beauty	LG	M	Serrated	G	Y
Chandra IMP	LR	D	Serrated	LG	Y
NRB 208	LG	M	Serrated	LG	Y
Gold 207	LG	M	Serrated	LG	LY
NOL 303+ (JULIE)	LG	M	Serrated	LG	Y
GFS GOLD (V-4)	LG	M	Serrated	LG	Y
NOL 1307 (SILKY)	LR	D	Serrated	G	LY
Dhanvi 66	LR	M	Serrated	LG	Y
Super Champion 55	LG	S	Serrated	G	Y
Ruchi	LG	S	Serrated	LG	Y
Ajeet-121	LG	M	Serrated	LG	LY
Anima	LG	M	Serrated	LG	LY
Harika	LR	M	Serrated	G	LY
Sarala (LS-11)	LG	M	Serrated	LG	Y
Thakath (TS-102)	LG	D	Serrated	LG	LY
Maharani	G	M	Serrated	LG	LY
Annika	G	D	Serrated	P	Y
AKO 107	LG	M	Serrated	LG	Y
Ankur 41	LG	M	Serrated	G	Y
Deepti	LR	S	Serrated	LG	Y
Green Gold	LG	M	Serrated	LG	Y
Mahima Super	LG	S	Serrated	LG	Y
Mahijha No. 25	LG	D	Serrated	G	Y
Mahyco 777	LG	S	Serrated	LG	Y
Suguna A-51	LG	S	Serrated	LG	LY
Research Soniya	LG	S	Serrated	G	Y
Super Anamika	LG	S	Serrated	LG	Y
Rajrani	LG	D	Serrated	G	Y
Raja	LG	D	Serrated	G	LY
Kiran	LR	M	Serrated	LG	LY
Bambeshwari	LR	S	Serrated	LG	LY
Danteshwari	LR	M	Serrated	G	LY
Madurai Local	LR	D	Serrated	LG	LY
Hoshairpur Local	LG	M	Serrated	LG	LY
Chidambaram Local	LG	D	Serrated	LG	LY

Table 3: Morphological characterization of 50 bhindi genotypes based on qualitative traits.

Genotypes	Petal base colour of the flower	Fruit: Pubescence	Number of locules in fruit	Fruit colour	Fruit surface between ridges
Arka Anamika	IS	Very weak	<6	G	Flat
Arka Abhay	BS	Very weak	<6	LG	Concave
Hisar Unnat	IS	Medium	<6	LG	Flat
Pusa Sawani	BS	Medium	<6	G	Concave
Pusa Makhmali	BS	Strong	<6	G	Flat
Punjab 8	BS	Strong	<6	G	Concave
Punjab 7	IS	Weak	<6	G	Concave
Hina RCH	BS	Weak	<6	G	Concave
Bhindi Selection 51	BS	Medium	<6	G	Concave
Hari Pari	BS	Strong	<6	LG	Concave
MH 310	IS	Weak	<6	G	Concave
Rani 792	BS	Medium	<6	G	Concave
Panchwati	BS	Weak	<6	LG	Convex
Super Lady luck	IS	Weak	<6	LG	Concave
Hari Kranti	IS	Medium	<6	LG	Concave
Summer Beauty	BS	Strong	<6	G	Flat
Chandra IMP	BS	Weak	<6	G	Concave
NRB 208	IS	Weak	<6	G	Flat
Gold 207	BS	Medium	<6	G	Concave
NOL 303+ (JULIE)	BS	Medium	<6	G	Flat
GFS GOLD (V-4)	IS	Weak	<6	G	Concave
NOL 1307 (SILKY)	BS	Weak	<6	G	Flat
Dhanvi 66	IS	Weak	<6	LG	Concave
Super Champion 55	BS	Strong	<6	G	Concave
Ruchi	IS	Medium	<6	G	Concave
Ajeet-121	BS	Medium	<6	LG	Concave
Anima	BS	Medium	<6	LG	Concave
Harika	BS	Strong	<6	G	Concave
Sarala (LS-11)	IS	Medium	<6	G	Concave
Thakath (TS-102)	BS	Medium	<6	G	Concave
Maharani	IS	Medium	<6	G	Flat
Annika	BS	Medium	<6	LG	Flat
AKO 107	BS	Medium	<6	LG	Flat
Ankur 41	BS	Strong	<6	LG	Concave
Deepti	BS	Weak	<6	LG	Concave
Green Gold	BS	Weak	<6	LG	Flat
Mahima Super	BS	Strong	<6	LG	Flat
Mahijha No. 25	BS	Medium	<6	LG	Flat
Mahyco 777	BS	Weak	<6	LG	Flat
Suguna A-51	IS	Medium	<6	G	Concave
Research Soniya	BS	Medium	<6	G	Concave
Super Anamika	IS	Medium	<6	G	Flat
Rajrani	BS	Strong	<6	G	Flat
Raja	BS	Strong	<6	G	Concave
Kiran	BS	Strong	<6	G	Concave
Bambeshwari	BS	Strong	<6	LG	Flat
Danteshwari	BS	Strong	<6	LG	Flat
Madurai Local	BS	Weak	<6	G	Concave
Hoshairpur Local	BS	Weak	<6	LG	Concave
Chidambaram Local	BS	Medium	<6	G	Concave

Table 4: Morphological characterization of 50 bhindi genotypes based on qualitative traits.

Genotypes	Fruit: Shape of apex	Fruit: Constriction of	Fruit length at marke table basal part	Fruit length of physiolo -gically mature fruit	Seed colour
Arka Anamika	NA	Weak	L	L	Green
Arka Abhay	NA	Weak	L	L	Green
Hisar Unnat	A	Weak	L	L	Green
Pusa Sawani	A	Weak	M	L	Green
Pusa Makhmali	B	Strong	S	L	Green
Punjab 8	A	Absent	M	L	Green
Punjab 7	A	Weak	M	L	Green
Hina RCH	B	Strong	S	M	Green
Bhindi Selection 51	NA	Strong	M	L	Green
Hari Pari	A	Weak	S	M	Green
MH 310	A	Absent	M	L	Green
Rani 792	A	Absent	M	L	Green
Panchwati	NA	Absent	M	L	Green
Super Lady luck	NA	Absent	M	L	Green
Hari Kranti	A	Weak	M	L	Green
Summer Beauty	NA	Weak	M	L	Green
Chandra IMP	A	Weak	S	M	Green
NRB 208	A	Weak	M	L	Green
Gold 207	A	Weak	S	M	Green
NOL 303+ (JULIE)	NA	Absent	M	L	Green
GFS GOLD (V-4)	B	Weak	S	M	Green
NOL 1307 (SILKY)	A	Weak	M	L	Green
Dhanvi 66	A	Weak	S	L	Green
Super Champion 55	NA	Weak	S	L	Green
Ruchi	B	Weak	S	M	Green
Ajeet-121	A	Weak	L	L	Green
Anima	NA	Weak	M	L	Green
Harika	B	Strong	M	M	Green
Sarala (LS-11)	A	Strong	M	L	Green
Thakath (TS-102)	A	Absent	S	M	Green
Maharani	NA	Weak	M	M	Green
Annika	B	Weak	S	M	Green
AKO 107	A	Absent	L	L	Green
Ankur 41	A	Strong	S	L	Green
Deepti	NA	Weak	M	L	Green
Green Gold	NA	Weak	L	L	Green
Mahima Super	NA	Weak	S	M	Green
Mahijha No. 25	NA	Weak	L	L	Green
Mahyco 777	NA	Weak	M	L	Green
Suguna A-51	NA	Weak	M	L	Green
Research Soniya	NA	Weak	M	L	Green
Super Anamika	NA	Absent	M	L	Green
Rajrani	A	Weak	S	M	Green
Raja	NA	Weak	M	L	Green
Kiran	A	Absent	M	M	Green
Bambeshwari	NA	Weak	M	L	Green
Danteshwari	NA	Absent	M	L	Green
Madurai Local	NA	Absent	M	L	Green
Hoshairpur Local	NA	Absent	M	L	Green
Chidambaram Local	NA	Weak	M	L	Green

Table 5: Frequency distribution for various qualitative traits in 50 Bhindi genotypes.

Characteristics	Specification	No. of genotypes	Percentage of genotypes (%)	H'-index
Depth of lobing of the Leaf blade	Shallow (S)	10	20	1.038
	Medium (M)	24	48	
	Deep (D)	16	32	
Colour of the stem	Light green (LG)	34	68	0.838
	Green (G)	6	12	
	Light red (LR)	10	20	
	Red (R)	0	0	
	Purple (P)	0	0	
Serration of margin of leaf blade	Plane	0	0	0
	Serrated	50	100	
Vein colour	Light green (LG)	34	68	0.747
	Green (G)	14	28	
	Light red (LR)	0	0	
	Red (R)	0	0	
	Purple (P)	2	4	
Flower petal colour	Yellow (Y)	31	62	0.664
	Light yellow (LY)	19	38	
	Whitish (W)	0	0	
Petal base colour	Inside (IS)	14	28	0.592
	Both side (BS)	36	72	
Fruit pubescence	Very weak	2	4	1.206
	Weak	15	30	
	Medium	20	40	
	Strong	13	26	
Fruit surface between ridges	Concave	31	62	0.742
	Flat	18	36	
	Convex	1	2	
Fruit constriction of basal part	Absent	13	26	0.901
	Weak	31	62	
	Strong	6	12	
Fruit shape of the apex	Narrow acute (NA)	24	48	0.973
	Acute (A)	20	40	
	Blunt (B)	6	12	
Fruit number of locules	<6	50	100	0
	7-8	0	0	
	>8	0	0	
Fruit colour	Light green (LG)	20	40	0.673
	Green (G)	30	60	
	Light red (LR)	0	0	
	Red (R)	0	0	
	Purple (P)	0	0	
Fruit length (at marketable stage)	Small	14	28	0.947
	Medium	29	58	
	Long	7	14	
Fruit length (at physiological mature stage)	Small	0	0	0.573
	Medium	13	26	
	Long	37	74	
Seed colour	Green	50	100	0
	Black	0	0	
Overall mean of H'				**0.659**

stage (0.947). Seed colour, fruit locule number and serration of the margin of the leaf blade did not show any diversity among the genotypes.

Crop biodiversity may be summarized by two components: evenness and richness at allelic level. In phenotypic evaluation, the descriptor and descriptor states correspond to the locus and alleles, respectively. In this study, allelic evenness has been evaluated using the H', while allelic richness was obtained by counting the descriptor states for every descriptor without regard to

Plate 1: Variation in the leaf characteristics of some genotypes.

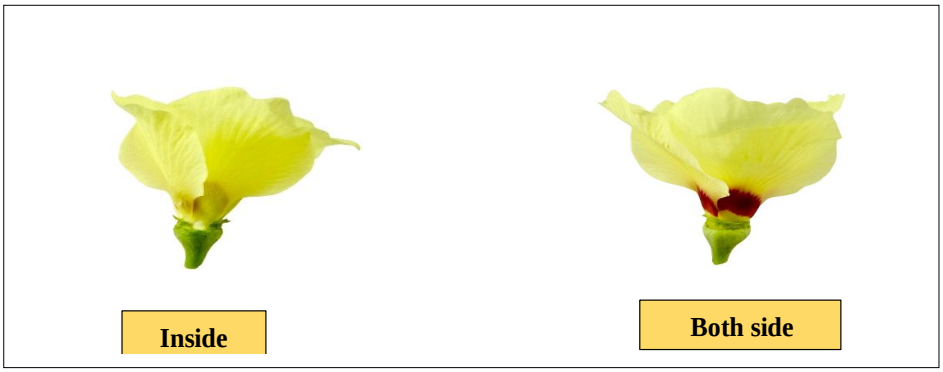

Plate 2: Petal base colour.

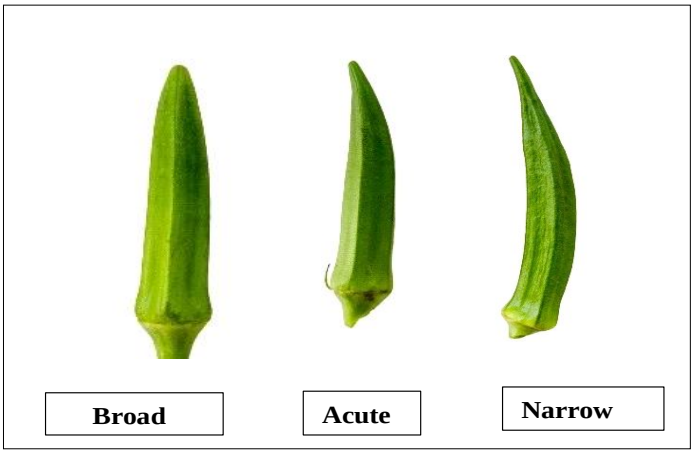

Plate 3: Fruit shape of the apex.

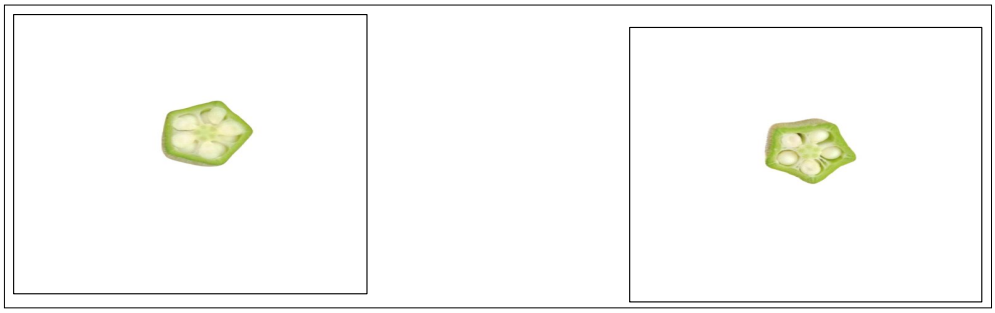

Plate 4: Fruit surface between ridges.

frequency. Richness is the number of genotypes found in a particular region, whereas evenness is the relative abundance of each genotype.

The value of the (H') for all the traits ranged from 0 to 1.206. A high (H') with an overall mean of 65.9% was obtained, which implies the presence of variation among the genotypes. The (H') can vary between 0 to 4.6. A score around 0 suggested that all genotypes in the population were the same, while a value near 4.6 showed that the number of individuals was evenly distributed among the various genotypes. A low (H') indicates a lack of diversity for the parameters and an uneven frequency class. According to Hennink and Zeven (1991), a high H' value suggests that the feature is diverse or variable. Unbalanced frequency class and a lack of variety for the qualities are indicated by values that are lower than the overall mean.

Gangopadhyay *et al.* (2010); Islam (2022); Roy (2022) also investigated the (H') and they observed highly divergent qualitative parameters in bhindi genotypes.

CONCLUSION

The study of angiosperm morphology focusses on the physical characteristics of plants. It plays an important role in plant identification, categorization and description. The main objective of vegetable breeding programs is to produce new cultivars with remarkable combinations of horticulturally pleasing characteristics. Incorporating favorable characteristics from these genotypes into current kinds promotes the development of culture, which can be used for many purposes. Create a customer-driven diversity.

Conflict of interest

The authors have no conflict of interest.

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