Characterization study based on the morphology of various okra [*Abelmoschus esculentus* (L.) Moench.] genotypes

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Abstract

Morphological characterization of any crop's available germplasm based on qualitative traits is an effective tool in identifying their characteristics, which is helpful in the future breeding programme as qualitative traits are relatively more stable than the quantitative ones. This type of study helps in determining distinctiveness, uniformity and stability of a particular genotype under different agroclimatic conditions. The present investigation aims at the morphological characterization of twenty-six selected genotypes of okra including a standard check Arka Anamika for selection of desired cultivars from the evaluated ones. For the external morphological characterization analysis, the selected germplasms were grown in a Randomized Block Design (RBD) experimental design and the data for 22 qualitative traits was taken from 5 plants of each replication. A good amount of variation was observed, among the different traits under study, green leaf colour between veins, yellow flower petal colour and erect fruit position depicted 100% frequency and higher frequencies were also observed for erect plant growth habit (96.15%), green stem colour (96.15%), serration of margin of leaf blade (96.15%), round seed shape (88.46%), narrow acute fruit shape at the apex (84.61%) and medium branching habit (73.07%). The study suggested that genotypes like VL Bhindi-2, Parbhani Kranti, Agri Bahar, Hisar Naveen, Hisar Unnat, Pusa Sawani and Varsha Uphar were the genotypes that exhibited a wide range of variations and after some testing can be exploited for the further breeding programme.

Keywords: Characterization, Distinctiveness, Okra, Qualitative, Stability, and Uniformity.

1. Introduction

Okra/Bhindi [*Abelmoschus esculentus* (L.) Moench 2n = 2x=130] which is also known as Gumbo/Guinea Gumbo/Dherosh and Lady's Finger etc. is an annual herbaceous crop belonging to the family Malvaceae having great economic importance as consumed widely as a cooked vegetable **(Mishra *et. al.*, 2015).** In India, it is cultivated widely from tropical to subtropical parts of the country. Word Okra is derived from an African word and commonly used as it is homeling to Africa's Northern region and regions of Ethiopia and Sudan. Southeast Asia is considered as a centre of diversity because in this region there is an overlapping of cultivated and wild species. **(Kochar, 1986).** Okra was cultivated by the ancient Egyptians by the 12th century and is originated in Ethiopia around the Nile River and its cultivation spread throughout the

Middle East and North Africa **(Reddy *et. al.*, 2012).** It is an amphidiploid (allotetraploid) derived from *Abelmoschus tuberculatus* (2n = 58), a wild species from India, and a species (*Abelmoschus ficulneus*) with 2n = 72 chromosomes **(Singh and Bhatnagar, 1975).** Another edible okra species is *Abelmoschus caillei* (West African Okra) **(Jonah *et. al.*, 2019).** Commonly, green tender fruits of okra are used as a vegetable and marketed mostly as fresh, but it is also canned and dehydrated for further utilizations. Okra fruits contain 89 g water, 2-4 g protein, 0.3 g fat, 7.6 g carbohydrate, 92 mg calcium, 51 mg phosphorus, 0.6 mg iron and 249 mg potassium per 100-gram fresh weight. It is also a rich source of iron and vitamin A, B and C **(Choudhary 2015)**. It has some medicinal values as it cures ulcers and gives relief in case of haemorrhoids **(Adams, 1975).** Along with this, fruits of okra also help in the remedy of Genito-urinary disorder, spermatorrhoea and chronic dysentery **(Martin, 1982 and Bell, 1988)**.

Okra is cultivated around the world in an area of 1.117 million hectares with a production of 8.706 million tonnes having productivity of 7.8 tonnes/hectare. **(Samim *et. al.*, 2018).** It has the largest area and production is in India followed by Nigeria in the world. India ranks first in the world with 72% of the total world production of okra. In India okra is commercially grown in Gujrat, Maharashtra, Andhra Pradesh, Uttar Pradesh, Madhya Pradesh, West Bengal, Assam, Rajasthan, Tamil Nadu, Haryana, Punjab and Karnataka. During 2018 the okra crop had average productivity of 11.97 tonnes/hectare covers an area of 0.509 million hectares with an annual production of 6.095 million tonnes all over India (**Anonymous, 2018**).

Although a great number of commercial cultivars and hybrids of okra are present in the market most of these are not in match with the all the growing regions of the country. Morphological characterization based on qualitative traits of crops is a very crucial and essential first step in any crop improvement and breeding programme **(De Vicente *et. al.*, 2005).** Hence, morphological characterization is a process by which various genotypes, germplasm lines or accessions are identified, differentiated or distinguished according to their characters based on descriptors assigned. Morphological descriptors are the foundation for characterization of plant genotypes based on external/morphological characteristics **(Samim *et. al.*, 2018).** The varietal identification and parental purity assessment are an important parameter for the released cultivars. Cultivars are commonly identified based on morphological differences of seed, seedling and mature plant **(Srivastava *et. al.*, 2001).** Since the introduction of Indian legislation Protection of Plant Varieties and Farmers Rights Act **(PPV and FRA, 2001)**, it is said that the release of new crop varieties is possible only if it is distinct (D) from other varieties, uniform (U) in their characteristics and generally stable (S) over the years (DUS). Therefore, by the enaction of this act farmers and seed growers become assured that they are being supplied with authentic seed material with the known identity of a specific variety and assured quality. Keeping this in view the present investigation was carried out to differentiate twenty-six okra cultivars based on morphological characters for identification of superior genotypes that can be used in cultivation and further breeding program.

2. Materials and Methods

2.1 Experimental site

The current experiment was conducted under natural field conditions at Department of Horticulture, Horticultural Research Centre (H.R.C), Hemvati Nandan Bahuguna Garhwal University, Chauras campus Srinagar (Garhwal), Uttarakhand (India) situated in Alaknanda valley lying between 78°47'30" E longitude and 30°13'0" N latitude, at an elevation 540 meter above MSL, in the mid-hill Himalayan conditions. It is located in a valley zone of 6 km long and 3 to 4 km wide. It is divided into two halves by the holy Alaknanda river, which generally flows in the North-East to South-West direction. The site is located in a sub-tropical condition having extremes in the temperature in both winter and summer seasons. During summer months of May to June, the temperature reaches up to 35-40 °C hence having a dry summer and heavy and continuous rain in the month from April to July. The soil of the site was sandy clay in texture and having p^H 6.4, 0.84% carbon, 95.3 Kg/ha available nitrogen, 3.05 Kg/ha available phosphorus and 135 Kg/ha available potassium.

2.2 Experimental design and Plant material used

Twenty-six genotypes including one check cultivar (Arka Anamika) viz., Agri Bahar, Chanda, Hisar Naveen, Hisar Unnat, Kashi Kranti, Kashi Mohini, Kashi Pragati, Kashi Vibhuti, Kaveri, King Bhindi, LC-1, LC-2, LC-3, LC-4, LC-5, LC-6, Lucky-666, Parbhani Kranti, Punjab-8, Pusa A-4, Pusa Sawni, Super Anamika, VL Bhindi-2, Vandana-241 and Varsha Uphar were evaluated in RCBD (Randomized complete block design) with 3 replications during the Kharif season of 2019 from month June to September.

2.3 Management and cultural practices

The field used in experimentation site was ploughed 3 times followed by harrowing to a fine tilth. Field's area was divided into 7 blocks, each having dimensions 23.05 m x 2.4 m length and width respectively, separated at a distance of 50 cm from each other. Plots with experimental material of size 2.4 m × 1.8 m were prepared to keep 50 cm apart as per the layout plan with the help of a rope, measuring tape and spade. Before seed sowing, seeds were soaked overnight for facilitating faster germination. Seed (2-3) dibbling was done at 2 cm depth and a spacing of 60 cm × 60 cm. FYM was incorporated in the field which is well-decomposed and dried @ 25 tonnes per hectare during the time of field preparation. The inorganic fertilizers were applied as per the recommended dose *i.e.* 150: 60: 50 kg NPK per hectare in the form of urea, single super phosphate and muriate of potash. Half dose of nitrogen and a full dose of phosphorus and potassium were applied in the soil before sowing of seeds. The Remaining half dose of N was applied in two split doses *i.e.* one fourth after 30 days of sowing and one fourth at the time of flowering and fruiting.

2.4 Data Recording

During the fieldwork, various Qualitative traits were recorded by considering ten random plants from each treatment selected and tagged for recording the observations. The data was taken in the form of descriptor codes assigned by **PPV&FRA 2001** and **UPOV 2019** for the crop Okra. Observations were recorded at stages of crop growth when the character under study was fully expressed for example traits related to fruit were recorded when plant reached horticultural maturity and fruit reached an optimum length and girth.

3. Result and Discussion

3.1 Morphological characterization

All the data regarding morphological characterization is furnished in Tables 1 and 2. Erect plant growth habit was found dominant (96.15%) while medium (3.84%) The branching habit was found as weak (19.23%), medium (73.07%) and strong (7.69%) which indicates a high yield potential in majority of genotypes as erect plant height and medium and strong branching leads to higher yields **(Ogwu *et. al.*, 2018).** Green stem colour was observed in 96.15% while red stem colour was observed in 3.84% cultivars. Medium intensity of the green colour of the stem was dominant (96.15%) while that of light intensity of the green colour of the stem was found to be recessive (3.84%) However, these results were contradictory to the findings of **Osawaru *et. al.*, (2013) and Binalfew *et. al.*, (2016)**.

Strong serration of margin of leaf blade was observed in 96.15% cultivars while that was medium for 3.84% cultivars. Deep lobing was found in most of the cultivars (46.15%), medium (42.30%) and shallow in very fewer cultivars (11.53%). All the cultivars had a green colour between veins. The intensity of colour between veins was found light (7.69%), medium (38.46%) and dark (53.84%). The dark green colour of leaves is generally due to presence of high chlorophyll content in the leaves which ultimately leads to increased yield hence, it becomes a good criterion for selection of elite cultivars **Pachiyappan *et. al.*, (2016)**. Genotypes with red colour between mid-rib were 69.23% and those with light green were 30.76%. Cultivars having linear-shaped epicalyx segments were 96.15% and lanceolate epicalyx segments 3.84%. Partially persistent epicalyx segments were 61.15% while that of Non-persistent (30.76%) and persistent (7.69%) in lower frequencies Similar findings with these regards was also observed by **Binalfew *et. al.*, (2016)**. All the cultivars were found having yellow petal colour which is a desirable trait as it helps in attracting pollinators during the pollination process **Rajesh *et. al.*, (2018).** Purple petal base colour was found in equal frequencies i.e. purple base colour only inside (50%) and both side purple base colour (50%). Variation in the above-mentioned traits shows that there is a considerable amount of morphological variation even within a species. Similar results were also reported by **Ogwu *et. al.*, (2018) and Amiteye *et. al.*, (2019).**

Light green fruit colour was found to be dominant (65.38%) and green colour (34.61%) Similar findings were also observed by **Samim *et. al.*, (2018) and Binalfew *et. al.*, (2016)**. Fruit pubescence was observed slightly rough in 69.23% cultivars and prickly in 30.76%. However, these results were contradictory to the findings of **Samim *et. al.*, (2018) and Binalfew *et. al.*, (2016)**. Attractive fruit colour, lesser fruit pubescence and smooth fruit texture are the factors which determine consumer acceptability of the product hence, these traits become a good selection criterion for a breeder. Dark green colour coupled with a smooth texture is desirable for okra cultivars **(Samim *et. al.*, 2018).** Cultivars having a flat surface between ridges were 65.38% and with the concave surface between ridges (34.61%). However, this result was opposite that of result observed by **Binalfew *et. al.*, (2016) and Deepanshu *et. al.*, (2017).** Ridges in fruits is a feature that aids to the seed dispersal and facilitates the removal of seeds during thrashing **(Ogwu *et. al.*, 2018).** Strong constriction of the basal part was reported in 53.84% cultivars and weak constriction was reported 46.15%. Narrow acute apex shape of fruit was found to be 84.61%, acute 11.53% and blunt 3.84%. All the genotypes

were found fruits with the erect position Moreover, the nature of *A. esculentus* allows for easy and continuous harvesting of the fruit, whereas an erect nature allows for maximum and uniform exposure of all leaves and other vegetative parts to better sunlight and would also result in an increase in dry matter production and an increase in yield **Ogwu *et. al.*, (2018)**. Seeds having green coloured seeds were 61.53% and with brown coloured seeds 38.46%. Seed hairiness was found to be present in 53.84% and absent in 46.15%. Seed shape was found round in 88.46% genotypes while it was reniform in 11.53% cultivars Similar results were also observed by **Osawaru *et. al.*, (2013) and Amiteye *et. al.*, (2019)**.

From the above information, it is clear that there exists a considerable scope in the parent material studied for identifying desirable genotypes since significant differences and variations were observed among the genotypes for all the traits studied which can be exploited for the further breeding programme. Also, all the characteristics of the genotypes under study were following the characteristics confirmed by **PPV&FRA 2001** except for the cultivar Kashi Vibhuti which shows a different characteristic that of mentioned by PPV&FRA which might be due to some undesirable pollination that has led to the change in the genotype of the cultivar.

4. Conclusion

Based on Morphological Characterization analysis, morphological features of all the cultivars were observed. Majority of the genotypes showed green leaf colour between veins, yellow flower petal colour, erect fruit position, erect plant growth habit, green stem colour, serration of margin of the leaf blade, linear shape of epicalyx segments and narrow acute shape at the apex. However, traits like medium plant growth habit, red stem colour, the light intensity of green stem colour, medium serration of leaf margin, the lanceolate shape of epicalyx segments and blunt apex fruit shape were observed in very fewer cultivars. The study suggested that genotypes like VL Bhindi-2, Parbhani Kranti, Agri Bahar, Hisar Naveen, Hisar Unnat, Pusa Sawani and Varsha Uphar were the genotypes that exhibited a wide range of variations and genotypes need further testing and to be released as a substitute of already existing okra varieties or they can be involved in the further breeding programme for the development of superior varieties or hybrids for yield and quality improvement of okra.

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Table:1. Characterization of okra germplasms following descriptor based qualitative traits

	Character	Type	Descriptor Code	Number of Genotypes	Frequency (%)
Plant Growth Characteristics	Plant Growth Habit	Erect	1	25	96.15
		Medium	2	1	3.84
	Branching Habit	Weak	3	5	19.23
		Medium	5	19	73.07
		Strong	7	2	7.69
	Stem Colour	Green	1	25	96.15
		Red	2	1	3.84
	Stem: Intensity of green colour	Light	3	1	3.84
		Medium	5	25	96.15
Leaf Characteristics	Leaf-blade: Serration of margin	Medium	5	1	3.84
		Strong	7	25	96.15
	Leaf-blade: Depth of lobing	Shallow	3	3	11.53
		Medium	5	11	42.30
		Deep	7	12	46.15
	Leaf-blade: Colour between veins	Green	1	26	100
	Leaf-blade: Intensity of colour between veins	Light	3	2	7.69
		Medium	5	10	38.46
		Dark	7	14	53.84
	Colour of the midrib	Light green	1	8	30.76
		Red	2	18	69.23
	The shape of epicalyx segments	Linear	1	25	96.15
		Lanceolate	2	1	3.84
	Persistence of epicalyx segments	Non-persistence	1	8	30.76
		Partially persistence	2	16	61.15
		Persistence	3	2	7.69
	Flower: Petal colour	Yellow	2	26	100

Contd…

Flower Characteristics	**Flower: Petal base colour purple**	Inside only	1	13	50
		Both side	2	13	50
Fruit Characteristics	**Fruit colour**	Light Green	1	17	65.38
		Green	2	9	34.61
	Fruit: Surface between ridges	Concave	3	9	34.61
		Flat	5	17	65.38
	Fruit pubescence	Slightly rough	5	18	69.23
		Prickly	7	8	30.76
	Fruit: Constriction at the basal part	Weak	3	12	46.15
		Strong	7	14	53.84
	Fruit: Shape at the apex	Narrow acute	1	22	84.61
		Acute	2	3	11.53
		Blunt	3	1	3.84
	Fruit position	Erect	1	26	100
Seed Characteristics	**Seed colour**	Green	1	16	61.53
		Brown	2	10	38.46
	Seed hairiness	Absent	1	12	46.15
		Present	9	14	53.84
	Seed shape	Round	1	23	88.46
		Reniform	9	3	11.53

Table: 2. Morphological Characterization of Okra genotypes based on Qualitative traits

Genotypes	Plant growth characteristics				Leaf characteristics							Flower characteristics		Fruit characteristics						Seed characteristics		
	Plant growth habit	Branching habit	Stem colour	Stem: Intensity of green colour	Leaf-blade: Serration of margin	Leaf-blade: Depth of lobing	Leaf-blade: Colour between veins	Leaf-blade: Intensity of colour between veins	Colour of the midrib	The shape of epicalyx segments	Persistence of epicalyx segments	Flower: Petal Colour	Flower: Petal base colour purple	Fruit colour	Fruit surfaces between ridges	Fruit pubescence	Fruit: constriction at the basal part	Fruit: shape at apex	Fruit position	Seed colour	Seed hairiness	Seed shape
Agri Bahar	1	3	1	5	7	7	1	7	1	1	1	2	2	2	3	5	3	1	1	2	9	1
Chanda	1	5	1	5	7	5	1	7	2	1	2	2	1	2	5	5	3	2	1	2	1	1
Hisar Naveen	1	5	1	5	7	7	1	5	2	1	2	2	2	1	5	7	3	1	1	1	1	2
Hisar Unnat	1	5	1	5	7	5	1	7	2	1	2	2	1	1	5	5	7	1	1	2	9	1
Kashi Kranti	1	5	1	5	7	5	1	5	2	1	2	2	2	1	5	7	7	1	1	1	9	1
Kashi Mohini	1	5	2	3	7	5	1	7	2	1	2	2	1	1	5	7	7	1	1	1	1	1
Kashi Pragati	1	5	1	5	7	7	1	5	2	1	2	2	2	1	5	5	3	1	1	2	1	1
Kashi Vibhuti	1	5	1	5	7	3	1	7	2	1	1	2	2	2	3	7	7	2	1	2	1	1
Kaveri	1	5	1	5	7	7	1	7	1	1	2	2	1	2	5	5	3	1	1	1	9	1
King Bhindi	1	5	1	5	7	5	1	7	2	1	2	2	1	1	3	7	7	1	1	1	9	1
LC-1	1	7	1	5	7	3	1	5	2	1	1	2	2	1	5	5	7	3	1	2	1	2
LC-2	1	5	1	5	7	3	1	5	2	1	1	2	1	1	5	5	7	2	1	1	1	1
LC-3	1	5	1	5	7	5	1	7	1	1	3	2	2	2	5	5	3	1	1	1	1	1
LC-4	1	5	1	5	7	7	1	5	2	1	1	2	2	1	5	7	3	1	1	2	9	1
LC-5	1	5	1	5	7	5	1	5	2	1	1	2	2	2	5	5	3	1	1	2	9	1
LC-6	1	5	1	5	7	7	1	7	1	1	2	2	1	1	3	5	7	1	1	2	9	1
Lucky-666	1	3	1	5	7	7	1	7	1	1	2	2	1	2	5	5	3	1	1	1	9	1
Parbhani Kranti	1	5	1	5	7	5	1	3	2	1	2	2	2	1	3	5	7	1	1	1	1	1
Punjab-8	1	7	1	5	7	5	1	5	2	1	2	2	1	1	3	5	7	1	1	1	9	1
Pusa A-4	1	3	1	5	7	7	1	7	2	1	2	2	2	1	5	7	3	1	1	1	9	2
Pusa Sawni	1	5	1	5	5	5	1	3	2	1	2	2	1	1	3	5	7	1	1	1	1	1
Super Anamika	1	3	1	5	7	7	1	5	1	1	1	2	1	2	5	5	3	1	1	1	9	1
VL Bhindi-2	2	5	1	5	7	7	1	5	1	1	2	2	1	1	3	5	7	1	1	1	1	1
Vandana-241	1	5	1	5	7	7	1	7	1	2	2	2	1	2	5	5	3	1	1	1	9	1
Varsha Uphar	1	3	1	5	7	7	1	7	2	1	1	2	2	1	5	7	7	1	1	2	1	1
Arka Anamika*	1	5	1	5	7	5	1	7	2	1	3	2	2	1	3	5	7	1	1	1	9	1
Status of Characteristics according to minimal descriptors of Vegetable Crops	1. Erect 2. Medium	3.Weak 5. Medium7. Strong	1.Green 2Red	3.Light 5. Medium	5.Medium 7. Strong	3.Shallow 5. Medium7. Deep	1.Green	3.Light 5. Medium7. Dark	1.Light Green 2. Red	1.Linear 2. Lanceolate	1.Non-persistence 2. Partially persistence 3. Persistence	2.Yellow	1.Inside only 2. Both side	1.Light Green 2. Green	3.Concave 5. Flat	5.Slightly Rough 7. Prickly	3.Weak 7. Strong	1.Narrow Acute 2. Acute3. Blunt	1.Erect	1.Green 2. Brown	1.Absent 9. Present	1.Round 2. Reniform