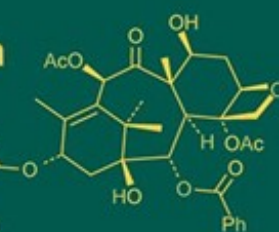
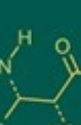
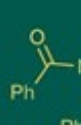
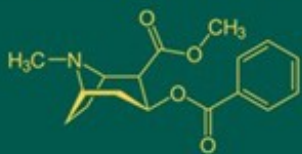


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Evaluation and diversity analysis for growth, yield and quality traits in okra [*Abelmoschus esculentus* (L.) Moench] genotypes

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ABSTRACT

The present investigation was carried out to assess the analysis of variance, mean performance and genetic divergence for growth, flowering, yield and quality traits among twenty-two okra [*Abelmoschus esculentus* (L.) Moench] genotypes, along with two check varieties (Arka Anamika and Arka Abhay), evaluated in a Randomized Complete Block Design with three replications at the Zonal Agricultural and Horticultural Research Station, Shivamogga, during summer 2025-26. Analysis of variance revealed highly significant differences among genotypes for almost all characters studied, confirming an exploitable range of genetic diversity in the germplasm evaluated. At 120 days after sowing, Kashi Chaman recorded the highest plant height (118.24 cm), Green Star Okra the maximum leaf number (29.02) and carbohydrate content (42.10 g/kg), Halu Bende the maximum stem girth (71.82 mm), average fruit weight (20.32 g) and total sugars (3.50 %), Green Star Okra the highest fruit girth (116.29 mm), and Okra Red the highest phenol (50.20 mg GAE) and protein content (3.10 %). Kashi Pragati was earliest to first harvest (41.18 days) and recorded the highest fruits per plant (37.10), fruit yield per plant (483.50 g) and yield per plot (9.67 kg); along with Pusa Bhendi-5 and Selection-1, it emerged as the top three yielding genotypes, recommended for direct cultivation or as parents in future breeding programmes. Genetic divergence assessed through Mahalanobis' D^2 statistic grouped genotypes into five clusters by Tocher's method, Cluster I being the largest with fourteen genotypes, indicating close genetic similarity among these entries. Principal component analysis revealed that the first five components accounted for 80.22 per cent of total variance, with number of fruits per plant contributing predominantly to the first principal component. Maximum inter-cluster distance was recorded between Cluster III and Cluster V (20,636.75), indicating these genotypes were most genetically divergent, and may be effectively utilised as parents in hybridization programmes to generate transgressive segregants for developing high-yielding, quality okra varieties.

Keywords: Okra, Genetic variability, Mean performance, Mahalanobis' D^2 , Genetic divergence

Introduction

Okra (*Abelmoschus esculentus* L. Moench) is an important warm-season vegetable crop belonging to the family Malvaceae. It is a herbaceous annual plant, propagated by seeds, with a chromosome number reported as $2n = 72-144$. It is widely cultivated in tropical and subtropical regions and is valued for its nutritional, medicinal, market and export potential. India is the leading producer of okra globally (Anon., 2022). Despite its importance, okra production is affected by several insect pests and diseases, particularly yellow vein mosaic virus, which reduces yield and fruit quality. Hence, improvement of traits such as earliness, branching, number of fruits per plant, fruit quality, pest and disease resistance and yield is essential. Variation among the available genotypes forms the basic requirement for crop improvement, as it provides the raw material for identifying and selecting genotypes possessing desirable traits. Analysis of variance helps establish whether genuine and exploitable differences exist among genotypes for a given character, while the mean performance of genotypes for growth, flowering, yield and quality traits indicates which genotypes are best suited for direct cultivation or for use as parents in hybridization programmes. However, variability alone is not sufficient to ensure success in a breeding programme, the genetic divergence among genotypes must also be assessed, since hybridization between genetically diverse parents is more likely to produce heterotic combinations and desirable transgressive segregants in the resulting progeny. Multivariate clustering techniques enable genotypes to be grouped on the basis of their overall genetic similarity, allowing breeders to select divergent parents from different clusters rather than relying on geographic origin or phenotypic similarity alone, both of which are often poor indicators of true genetic distance.

Therefore, the present study was undertaken to assess the analysis of variance, mean performance and genetic divergence of twenty-two okra genotypes, along with two check varieties, for growth, flowering, yield and quality traits, with a view to identifying superior genotypes for direct cultivation as well as genetically diverse parents suitable for hybridization and improvement programmes in the region.

2. Material and methods

The present investigation was carried out at the Zonal Agricultural and Horticultural Research Station (ZAHRS), Shivamogga, during summer 2025-26. The experimental site is located between 13° 92' N latitude and 75° 56' E longitude at an elevation of 640 m above mean sea level, in the Southern Transition Zone (Zone-7) of Karnataka, which experiences a tropical monsoon climate with warm summers, moderate winters and high humidity during the rainy season. The soil of the experimental field was red sandy loam in texture, well-drained and moderately fertile.

2.1 Experimental material and design

Twenty-two genotypes of okra, collected from different research institutes and sources across India, were evaluated along with two check varieties (Arka *Anamika* and Arka *Abhay*) in a Randomized Complete Block Design (RCBD) with three replications (Table 1). Each genotype was raised in a plot size of 3 m × 1.8 m at a spacing of 60 cm × 45 cm. The recommended dose of fertilizer was applied as per the package of practices of UHS, Bagalkot (Anon., 2013). The crop was irrigated through drip irrigation to compensate 80 per cent evapotranspiration and was kept weed-free by manual weeding. Need-based plant protection measures were followed against sucking pests (aphids, thrips, leafhoppers, whiteflies) and diseases (powdery mildew, *Cercospora* leaf spot). Five plants were selected randomly from each replication and tagged for recording observations.

2.2 Observations recorded and statistical analysis

Growth parameters, viz., plant height (cm), number of leaves per plant, internodal length (cm), number of nodes per plant and stem girth (mm), were recorded. Yield parameters (days to first harvest, fruit length, fruit girth, average fruit weight, number of fruits per plant, fruit yield per plant and yield per plot) were recorded. Quality parameters, viz., leaf and pod total chlorophyll (Arnon, 1949) [1], total phenol content by the Folin-Ciocalteu method (AOAC, 1990) [2], carbohydrate content by the phenol-sulphuric acid method (Dubois *et al.*, 1956) [3], protein content by Lowry's method (Lowry *et al.*, 1951) [4], total sugars by the anthrone method (Ranganna, 1977) [5], crude fibre (AOAC, 2005) [6] and mucilage content by hot water extraction method, were estimated. The mean data recorded for each character were subjected to analysis of variance as per the RCBD model suggested by Panse *et al.* (1967) [7], and the significance of differences among genotypes was tested using the 'F' test; standard error of mean and critical difference were worked out at 5 per cent probability. Genetic divergence among the genotypes was assessed using the Mahalanobis (1936) [8] D² statistic; genotypes were grouped into clusters following Tocher's method (Rao, 1952) [9], and intra- and inter-cluster distances were computed as per Singh *et al.* (1977) [10].

3. Results and discussion

3.1 Analysis of variance

Analysis of variance carried out for growth, flowering, fruit yield and biochemical quality parameters of the twenty-two okra genotypes revealed highly significant differences among the genotypes for almost every character studied, confirming the presence of an exploitable amount of genetic variability among the genotypes evaluated (Table 2). Highly significant differences among genotypes for growth, flowering, yield and quality traits have similarly been reported in okra by Dhall *et al.* (2001) [11], Singh *et al.* (2008) [12], Sravanthi *et al.* (2021) [13] and Reddy *et al.* (2022) [14], which validates the wide genetic

base that is generally exploited in this crop for selection-based improvement.

3.2 Mean performance of okra genotypes

The mean performance of the twenty-two okra genotypes for growth, flowering, yield and quality traits, along with their standard error of mean (*S. Em*_±) and critical difference (CD) at 5 per cent probability, is discussed. Marked differences were observed among the genotypes for plant height at 120 DAS, values ranging from 96.11 to 118.24 cm with an overall mean of 106.99 cm (Table 3). Kashi Chaman recorded the highest plant height (118.24 cm), followed by Green Star Okra (116.35 cm) and Arka *Anamika* (116.10 cm), while Kashi Pragati recorded the lowest (96.11 cm); this superior performance of Kashi Chaman throughout the growth period may be attributed to its genetic potential for vigorous vegetative growth and greater internodal elongation, and similar genotypic differences in plant height among okra genotypes were reported by Jaiprakashnarayan *et al.* (2006) [15] and Awasthi *et al.* (2022) [16]. Number of leaves per plant at 90 DAS varied from 20.11 to 29.02 with average mean of 25.95 the maximum value was recorded in Green Star Okra (29.02), followed by Purna Kranti (Go-10) (24.90) and Purna Rakshak (Gno-1) (27.22), while Nol-303+ (Julie) recorded the minimum (20.11) (Table 3), a trend of genotypic variation in leaf production also reported by Jaiprakashnarayan *et al.* (2006) [15]. Internodal length at 120 DAS ranged from 5.39 cm to 8.78 cm with average mean of

Table 1. List of okra genotypes and check varieties used for the study

Sl. No.	Genotype	Source
1	Sri Okra	Sahaja Seeds, Sahaja Samrudha Organic Producer Company Ltd.
2	Green Star Okra	Sahaja Seeds, Sahaja Samrudha Organic Producer Company Ltd.
3	Okra Double Colour	Sahaja Seeds, Sahaja Samrudha Organic Producer Company Ltd.
4	Okra Green Long	Sahaja Seeds, Sahaja Samrudha Organic Producer Company Ltd.
5	Okra Tree	Sahaja Seeds, Sahaja Samrudha Organic Producer Company Ltd.
6	Nol-303+ (Julie)	Nirmal Seeds
7	Purna Kranti (Go-10)	Navsari Agricultural University, Gujarat
8	Purna Rakshak (Gno-1)	Navsari Agricultural University, Gujarat
9	Indo US Sungreen	Indo US Bio-Tech Ltd.
10	Kashi Lalima	ICAR-IIVR, Varanasi
11	Kashi Kranti	ICAR-IIVR, Varanasi
12	Kashi Chaman	ICAR-IIVR, Varanasi
13	Kashi Pragati	ICAR-IIVR, Varanasi
14	Kashi Parakram	ICAR-IIVR, Varanasi
15	Pusa Sawani	ICAR-IARI, New Delhi
16	Selection-1	Shikaripur local
17	Pusa Bhendi-5	ICAR-IARI, New Delhi
18	Prabhani Kranti	VNMKV, Parbhani
19	Okra Red	UHS, Bagalkot
20	Halu Bende	Bramavara local
21	Arka <i>Anamika</i> (Check)	ICAR-IIHR, Bengaluru

(continued on next page)

Sl. No.	Genotype	Source
22	Arka Abhay (Check)	ICAR-IIHR, Bengaluru

7.04 cm, the highest internodal length recorded in *Pusa Sawani* (8.78 cm), followed by *Okra Green Long* (8.39 cm) and *Halu Bende* (8.10 cm), and the minimum in *Kashi Kranti* (5.39 cm) (Table 3), similar variation in internodal length among okra genotypes was reported by *Awasthi et al. (2022)* [16]. Number of nodes at 120 DAS varied from 13.91 to 21.99 with average mean of 17.09, *Kashi Pragati* recorded the highest (21.99), followed by *Indo US Sungreen* (19.96) and *Green Star Okra* (18.63), whereas *Pusa Sawani* recorded the lowest (13.91) (Table 3), a similar genotypic variation in number of nodes in okra have been reported by *Das et al. (2012)* [17]. Stem girth at 120 DAS differed significantly among the genotypes, ranging from 47.66 to 71.82 mm with an average mean of 54.21 mm, the maximum stem girth was recorded in *Halu Bende* (71.82 mm), followed by *Okra Tree* (69.59 mm) and *Prabhani Kranti* (58.21 mm), while the minimum was observed in *Kashi Kranti* (47.66 mm) (Table 3), similar variation in stem girth among okra genotypes have been reported by *Jaiprakashnarayan et al. (2006)* [15]. The considerable genotypic variation observed for all the growth attributes at 120 DAS indicates good scope for selecting genotypes with vigorous vegetative growth in future okra improvement programmes. Days to 50 per cent flowering ranged from 40.40 to 54.50 days with a mean of 44.59 days (Table 3), where *Kashi Chaman* (40.40 days) attained 50 per cent flowering earliest, whereas *Okra Tree* (54.50 days) took the longest, a similar variability among okra genotypes have been reported by *Samim et al. (2018)* [18]. The considerable variation observed among the genotypes for this trait reflects the presence of genetic diversity and offers good scope for selection of early maturing genotypes.

Days to first harvest varied from 41.18 to 58.73 days with average mean of 48.07 days (Table 4), *Kashi Pragati* (41.18 days) recorded earliest first harvest, whereas *Okra Tree* (58.73 days) took the maximum number of days, followed by *Indo US Sungreen* (54.74 days) and *Arka Abhay* (52.71 days), similar variation in days to first harvest have been reported by *Verma et al. (2007)* [19] and *Adiger et al. (2011)* [20]. Average fruit weight ranged from 9.80 g to 20.32 g with average mean of 13.76 g, whereas *Halu Bende* (20.32 g) recorded the highest fruit weight, followed by *Okra Green Long* (18.90 g) and *Okra Tree* (17.10 g), while *Purna Rakshak* (Gno1) recorded the lowest (9.80 g), similar variation in average fruit weight among okra genotypes have been reported by *Das et al. (2012)* [17]. Fruit girth varied from 44.94 mm to 116.29 mm with a mean of 60.34 mm, *Green Star Okra* (116.29 mm) recorded the maximum, followed by *Okra Double Colour* (110.00 mm) and *Halu Bende* (97.43 mm), while *Nol-303+ (Julie)* recorded the minimum (44.94 mm), a similar variation in fruit girth having been reported by *Duggi et al. (2013)*. Fruit length ranged from 9.47 to 19.20 cm with an average mean of 13.27 cm (Table 4), *Halu Bende* (19.20 cm) recorded the longest fruits, followed by *Okra Green Long* (17.24 cm), while *Kashi Pragati* produced the shortest fruits (9.47 cm). Number of fruits per plant ranged from 13.20 to 37.10 with a mean of 24.35 (Table 4), *Kashi Pragati* (37.10) recorded the maximum, followed by *Pusa Bhendi-5* (33.60) and *Green Star Okra* (29.80), while *Halu Bende* recorded the minimum (13.20), similar variation having been reported by *Das et al. (2012)* [17] and *Duggi et al. (2013)*. Fruit yield per plant varied from 272.50 g to 483.50 g with a mean of 362.88 g; *Kashi Pragati* (483.50 g) recorded the highest, followed by *Pusa Bhendi-5* (459.50 g) and *Selection-1* (445.50 g), while *Pusa Sawani* recorded the lowest (272.50 g). Yield per plot ranged from 5.45 kg to 9.67 kg with a mean of 7.26 kg; *Kashi Pragati* recorded the highest yield per plot (9.67 kg), followed by *Pusa Bhendi-5* (9.19 kg) and *Selection-1* (8.91 kg), while *Pusa Sawani* recorded the lowest values (5.45 kg), similar variation in fruit yield among okra genotypes having been reported by *Das et al. (2012)* [17] and *Karadi et al. (2018)* [21]. The wide variability recorded for yield and its component traits indicates substantial scope for iden-

tifying high-yielding genotypes for direct use or as parents in hybridization.

Leaf total chlorophyll content which varied from 1.94 to 3.02 mg g⁻¹, while pod total chlorophyll content ranged from 1.44 to 2.28 mg g⁻¹ (Table 5), *Purna Rakshak* (Gno-1) recorded the highest values for both leaf and pod chlorophyll content, followed by *Purna Kranti* (Go-10) and *Nol-303+ (Julie)*, whereas the lowest chlorophyll content were consistently recorded in *Okra Red*. Total sugars varied from 1.50 to 3.50 per cent with average mean of 2.35 per cent (Table 5), *Halu Bende* (3.50 %) recorded the highest, followed by *Selection-1* (3.25 %) and *Pusa Sawani* (3.20 %), while *Okra Red* recorded the lowest (1.50 %).

Carbohydrate content ranged from 22.40 to 42.10 g kg⁻¹ with a mean of 34.27 g kg⁻¹; *Okra Tree* (42.10 g kg⁻¹) recorded the highest, followed by *Kashi Parakram* (40.20 g kg⁻¹) and *Indo US Sungreen* (39.50 g kg⁻¹), while *Okra Red* recorded the lowest. Phenol content ranged from 35.80 to 50.20 mg GAE with a mean of 40.71 mg GAE; *Okra Red* (50.20 mg GAE) recorded the highest, followed by *Kashi Lalima* (45.56 mg GAE), while *Pusa Sawani* recorded the lowest (35.80 mg GAE). Protein content varied from 1.77 to 3.10 per cent with a mean of 2.48 per cent; *Okra Red* (3.10 %) recorded the highest, followed by *Kashi Lalima* (2.98 %), while *Halu Bende* recorded the lowest (1.77 %). Crude fibre content ranged from 8.87 to 14.31 g 100 g⁻¹ with a mean of 10.87 g 100 g⁻¹; *Kashi Parakram* (14.31 g 100 g⁻¹) recorded the highest and *Okra Red* the lowest (8.87 g 100 g⁻¹), a similar variation for chlorophyll content, total sugars, carbohydrate content, phenol content, protein content and crude fibre content have been reported by *Mohammed et al. (2022)* [22]. Mucilage content ranged from 11.33 to 32.21 g kg⁻¹ with a mean of 20.89 g kg⁻¹; *Halu Bende* (32.21 g kg⁻¹) recorded the highest, followed by *Arka Anamika* (30.10 g kg⁻¹) and *Arka Abhay* (29.30 g kg⁻¹), while *Kashi Lalima* recorded the lowest (11.33 g kg⁻¹), similar variation in mucilage content having been reported by *Duggi et al. (2013)*. The reciprocal trend noted between phenol/protein content and sugar/chlorophyll content across genotypes such as *Okra Red* and *Purna Rakshak* (Gno-1) points to differential partitioning of biochemical constituents among the genotypes.

3.3 Genetic divergence

Genetic divergence among the twenty-two okra genotypes was assessed using the Mahalanobis D² statistic. The genotypes were grouped into five distinct clusters by Tocher's method, Cluster I being the largest with fourteen genotypes, indicating a high degree of genetic similarity among these entries, while the smaller clusters comprised comparatively more diverse genotypes that could be effectively utilised in hybridization programmes (Table 6), this pattern, wherein a majority of genotypes fall into one major cluster while the rest are distributed into smaller, more divergent groups, has similarly been reported in okra by *Akotkar et al. (2010)* [23], *Pradip et al. (2010)* [24], *Shaikh et al. (2013)* [25] and *Narkhede et al. (2015)* [26], and the predominance of Cluster I suggests a common breeding history among these genotypes, whereas a similar lack of correspondence between genetic divergence and geographic origin was reported by *Das et al. (2012)* [17]. Principal component analysis revealed that the first five components together accounted for 80.22 per cent of the total variance, with number of fruits per plant contributing predominantly to the first principal component.

The maximum intra-cluster distance was recorded in Cluster I (5,705.41), followed by Cluster IV (5,487.87) and Cluster V (4,612.16), while Cluster III, comprising a single genotype, recorded zero intra-cluster distance. Among the inter-cluster distances, the maximum divergence was observed between Cluster III and Cluster V (20,636.75), followed by Cluster II and Cluster V (18,774.02), indicating that genotypes placed in these clusters were the most genetically divergent, while the minimum inter-cluster distance (8,090.03) was recorded between Cluster I and Cluster II, suggesting a comparatively closer genetic relationship (Table 7), similarly wide inter-cluster divergence has been reported in okra by *Prakash et al. (2010)* [27],

Prakash *et al.* (2011) [28], Reddy *et al.* (2012) [29] and Balai *et al.* (2015) [30].

Kashi pragati Pusa Bhendi-5 Selection -1

Table 2. Analysis of variance for different growth, flowering, yield and quality parameters in okra genotypes

Sl. No.	Source Degrees of freedom	Replication 3	Treatment 22	Error 42	S. Em $\pm$	CD at 5%
1.	Plant height (cm)	31.732	136.620*	66.756	4.72	13.46
2.	Number of leaves	1.761	9.548**	3.945	1.15	3.27
3.	Internodal length (cm)	0.140	1.589**	0.283	0.31	0.88
4.	Number of nodes per plant	0.827	10.227**	1.814	0.78	2.22
5.	Stem girth(mm)	7.302	107.408**	17.355	2.41	6.86
6.	Days to 50 % flowering	4.331	31.204**	11.957	2.00	5.70
7.	Days to 1st harvest	5.0149	54.1218**	13.9561	2.15	6.15
8.	Fruit length (cm)	0.412	16.222**	1.050	0.59	1.69
9.	Fruit yield per plant(g)	836.218	9847.8371**	769.8124	16.02	45.72
10.	Yield per plot (kg)	0.136	3.939**	0.317	0.33	0.93
11.	Number of fruits per plant	1.221	117.231**	3.848	1.13	3.23
12.	Average fruit weight (g)	0.685	20.809**	1.116	0.61	1.74
13.	Fruit girth (mm)	5.619	1375.903**	25.595	2.92	8.34
14.	Leaf total chlorophyll (mg/g)	0.015	0.213**	0.043	0.12	0.34
15.	Fruit total chlorophyll (mg/g)	0.008	0.125**	0.024	0.09	0.26
16.	Total sugars (%)	0.020	0.930**	0.031	0.10	0.29
17.	Carbohydrate content (g/kg)	2.510	73.581**	7.351	1.57	4.47
18.	Phenol content (mg GAE)	3.804	35.467**	9.970	1.82	5.20
19.	Protein content (%)	0.014	0.385**	0.038	0.11	0.32
20.	Crude fiber (g/100g)	0.272	6.025**	0.699	0.48	1.38
21.	Mucilage content	1.041	96.385**	2.676	0.94	2.70
22.	Phenol content (mg GAE)	3.804	35.467**	9.970	1.82	5.20
23.	Protein content (%)	0.014	0.385**	0.038	0.11	0.32
24.	Crude fiber (g/100g)	0.272	6.025**	0.699	0.48	1.38

Table 3. Mean performance of different okra genotypes for growth and flowering parameter

Genotypes	PH	NL	IL	NN	SG	D50F
Sri okra	104.56	25.10	6.89	17.27	48.63	43.20
Green star okra	116.35	29.02	6.67	18.63	51.99	44.10
Okra double color	101.80	25.80	7.35	16.03	52.84	46.80
Okra green long	113.40	27.03	8.39	13.95	55.54	43.80
Okra tree	105.33	25.09	6.71	17.8	69.59	54.50
Nol-303+(Julie)	97.86	20.11	6.74	17.85	50.30	44.60
Purna Kranti (Go-10)	100.60	24.90	6.68	17.80	54.07	47.80
Purna Rakshak (Gno-1)	98.26	27.22	7.04	16.40	52.43	45.90
Indo US Sungreen	112.10	25.11	7.10	19.96	56.11	48.10
Kashi Lalima	109.13	26.30	7.00	16.88	48.03	41.20
Kashi Kranti	99.97	27.01	5.39	17.39	47.66	42.30
Kashi Chaman	118.24	28.01	6.05	17.81	51.33	40.40
Kashi Pragati	96.11	23.80	6.42	21.99	52.37	40.90
Kashi Parakram	102.89	26.05	7.39	15.86	55.10	43.50
Pusa Sawani	113.11	25.21	8.78	13.91	56.55	44.57
Selection-1	111.58	26.43	6.96	17.16	50.52	42.80
Pusa Bhendi-5	106.71	27.90	6.71	17.30	51.90	41.80
Prabhani Kranti	107.68	26.02	7.45	15.75	58.21	45.50
Okra Red	100.10	26.42	7.15	16.86	53.00	41.80
Halu bende	107.10	26.02	8.10	14.15	71.82	42.60
Arka Anamika	116.10	27.20	6.81	18.13	51.65	47.10
Arka Abhay	114.76	25.09	7.08	17.16	53.03	47.63
S.Em $\pm$	4.72	1.15	0.31	0.78	2.40	2.00

(continued on next page)

Genotypes	PH	NL	IL	NN	SG	D50F
CD @ 5%	13.46	3.27	0.88	2.22	6.87	5.70

DAS: Days after sowing **PH:** Plant height (cm) at 120 DAS **NL:** Number of leaves at 90

DAS IL: Internodal length at 120 DAS **NN:** Number of nodes at 120 DAS

DAS D50F: Days to 50% flowering **SG:** Stem girth (mm) at 120

Table 4. Mean performance of different okra genotypes for yield parameters.

Genotypes	Yield parameters						YPP
	DFH	FL	FG	AFW	NPP	FYPP	
Sri okra	47.28	14.80	49.97	15.80	16.20	291.50	5.83
Green star okra	48.41	12.02	116.29	12.40	29.80	418.50	8.37
Okra double color	51.36	10.78	110.00	13.20	21.80	326.50	6.53
Okra green long	46.84	17.24	54.06	18.90	15.10	283.50	5.67
Okra tree	58.73	15.20	88.31	17.10	17.20	334.50	6.69
Nol-303+(Julie)	48.52	14.30	44.94	13.98	18.90	300.00	6.00
Purna Kranti (Go-10)	52.11	13.22	55.31	10.40	29.10	343.00	6.86
Purna Rakshak (Gno-1)	49.83	12.10	47.77	9.80	28.90	320.00	6.40
Indo US Sungreen	54.74	13.50	46.20	13.80	23.80	370.00	7.40
Kashi Lalima	43.58	14.42	50.91	11.80	28.50	378.50	7.57
Kashi Kranti	45.02	9.60	56.89	10.90	29.70	364.50	7.29
Kashi Chaman	41.92	13.01	46.83	14.50	24.90	407.50	8.15
Kashi Pragati	41.18	9.47	51.54	11.50	37.10	483.50	9.67
Kashi Parakram	46.96	13.31	54.69	14.90	22.90	386.00	7.72
Pusa Sawani	48.47	11.70	57.83	12.90	18.60	272.50	5.45
Selection-1	45.28	11.42	49.03	13.90	28.30	445.50	8.91
Pusa Bhendi-5	44.11	11.30	45.57	12.10	33.60	459.50	9.19
Prabhani Kranti	49.37	12.30	48.09	13.50	23.10	353.50	7.07
Okra Red	44.71	13.50	52.80	11.21	29.80	375.50	7.51
Halu bende	45.63	19.20	97.43	20.32	13.20	308.00	6.16
Arka Anamika	50.89	13.98	52.80	15.01	23.40	397.00	7.94
Arka Abhay	52.71	15.67	50.29	14.80	21.80	364.50	7.29
S.Em ±	2.15	0.59	2.92	1.13	1.28	16.02	0.33
CD @ 5%	6.15	1.69	8.34	3.23	3.65	45.72	0.93

DFH: Days to first harvest **FL:** Fruit length (cm) **FG:** Fruit girth (mm) **AFW:** Average fruit weight (g) **NFP:** Number of fruits per plant **FYPP:** Fruit yield per plant (kg) **YPP:** Yield per plot (kg) (%) **CC:** Carbohydrate content (g/kg) **PC:** Phenol content (mg GAE) **PRC:** Protein content (%)

Table 5. Mean performance of different okra genotypes for quality parameters

Genotypes	LTC	FTC	TS	CF	MC	CC	PC	PRC
Sri okra	2.67	2.01	2.75	11.57	23.80	31.20	38.20	2.12
Green star okra	2.48	1.86	2.30	11.16	22.60	36.80	39.50	2.28
Okra double color	2.54	1.91	1.75	9.32	13.50	33.50	44.80	2.73
Okra green long	2.63	1.97	2.58	12.67	23.50	34.20	37.00	2.16
Okra tree	2.84	2.13	1.89	12.26	22.87	42.10	44.31	2.54
Nol-303+(Julie)	2.90	2.18	2.03	9.55	17.86	32.80	40.20	2.38
Purna Kranti (Go-10)	2.97	2.24	1.84	10.45	28.70	37.40	41.60	2.62
Purna Rakshak (Gno-1)	3.02	2.28	1.95	12.17	23.20	38.20	42.80	2.61
Indo US Sungreen	2.78	2.10	2.27	10.50	16.92	39.50	43.20	2.59
Kashi Lalima	2.09	1.58	1.61	9.65	11.33	24.60	45.56	2.98
Kashi Kranti	2.70	2.04	1.72	9.05	19.20	34.80	41.23	2.80
Kashi Chaman	2.75	2.08	3.05	12.27	17.80	35.60	37.40	2.24
Kashi Pragati	2.85	2.15	2.40	10.07	18.91	38.80	39.80	2.44
Kashi Parakram	2.81	2.12	2.43	14.31	16.20	40.20	41.01	2.85
Pusa Sawani	2.51	1.89	3.20	12.67	20.91	29.50	35.80	1.84

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Genotypes	LTC	FTC	TS	CF	MC	CC	PC	PRC
Selection-1	2.81	2.10	3.25	9.44	18.01	37.90	37.76	2.08
Pusa Bhendi-5	2.57	1.92	2.65	10.63	18.40	31.80	38.90	2.30
Prabhani Kranti	2.61	1.98	2.10	11.46	22.12	33.20	40.50	2.50
Okra Red	1.94	1.44	1.50	8.87	12.10	22.40	50.20	3.10
Halu bende	2.27	1.71	3.50	10.39	32.21	27.80	36.10	1.77
Arka Anamika	2.66	2.00	2.49	9.81	30.10	35.20	40.50	2.78
Arka Abhay	2.72	2.07	2.39	10.87	29.30	36.40	39.20	2.89
S.Em ±	0.12	0.09	0.10	0.48	0.94	1.57	1.82	0.11
CD @ 5%	0.34	0.26	0.29	1.38	2.70	4.47	5.20	0.32

LTC: leaf total chlorophyll (mg/g) FTC: Fruit total chlorophyll (mg/g) CF: Crude fiber (g/kg) MC: Mucilage content (g/kg) TS: Total sugars



Figure 1. Clustering of okra genotypes based on Mahalanobis D^2 distance using Tocher's method.

Table 6. Classification of okra genotypes into cluster based on D^2 analysis

Cluster	Number of Genotypes	Genotypes
I	14	Arka Anamika, Arka Abhay, Green Star Okra, Indo US Sungreen, Kashi Chaman, Kashi Kranti, Kashi Lalima, Kashi Parakram, Nol303+(Julie), Okra Double Color, Okra Tree, Purna Kranti (Go-10), Purna Rakshak (Gno-1), Sri Okra

Cluster	Number of Genotypes	Genotypes
II	2	Pusa Bhendi-5, Selection-1
III	1	Pusa Sawani
IV	3	Kashi Pragati, Okra Red, Prabhani Kranti
V	2	Halu Bende, Okra Green Long

4. Conclusion

The study revealed highly significant differences among the twenty-two okra genotypes for nearly all growth, flowering, yield and quality traits assessed, indicating substantial and exploitable genetic variability within the germplasm evaluated at ZAHRS, Shivamogga. No single genotype was found to be superior across all traits; rather, distinct genotypes excelled for specific characters - Kashi Chaman for plant height, Okra Tree for leaf number and carbohydrate content, Halu Bende for fruit weight and total sugars, Green Star Okra for fruit girth, and Okra Red for phenol and protein content. With respect to fruit yield per plant and yield per plot — the traits of greatest economic significance to growers- Kashi Pragati, Pusa Bhendi-5 and Selection-1 consistently emerged as the top three performers. These genotypes can be recommended for cultivation in the Southern Transition Zone of Karnataka, as well as for use as parental lines in future okra breeding and hybridization programmes. Cluster analysis based on genetic divergence classified the genotypes into five distinct clusters. Genotypes belonging to the most divergent clusters, namely Clusters II, III and V, are recommended for use as parents in hybridization programmes, as crosses between genetically diverse genotypes are more likely to produce desirable transgressive segregants, thereby facilitating the development of high-yielding, quality okra varieties.

Table 7. Average inter and intra-cluster distance values of okra genotypes for yield and yield related traits.

	Cluster-I	Cluster-II	Cluster-III	Cluster-IV	Cluster-V
Cluster-I	5,705.41	8,090.03	10,296.33	9,305.43	16,091.35
Cluster-II	8,090.03	3,676.73	11,753.95	10,711.79	18,774.02
Cluster-III	10,296.33	11,753.95	0.00	12,327.91	20,636.75
Cluster-IV	9,305.43	10,711.79	12,327.91	5,487.87	17,808.86
Cluster-V	16,091.35	18,774.02	20,636.75	17,808.86	4,612.16

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Plate 1. Best performing genotypes

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