Original Research Article

Assessing high-yielding variety Anand Komal for dual-season cultivation of Okra (*Abelmoschus esculentus* L. Moench) in middle Gujarat agro climatic condition

Abstract

India is the top country by the okra production in the world. Due to the principal significance of maximizing agricultural benefits for farmers in the existing context of Gujarat, there was a compelling need for the development of a high-yielding dual-season variety of okra. The genotype has been specifically developed for cultivation during the summer and *kharif* seasons in the central region of Gujarat. Systematic testing was conducted in Preliminary Evaluation Trial II (PET II) from 2016 onwards, spanning various trials across diverse locations within the state from 2017 to 2020, encompassing both *kharif* and summer seasons. As a result of its commendable performance, the genotype designated as Anand Komalwas developed for consideration and endorsement under the specific agro-climatic conditions prevalent in central Gujarat. The new variety excels in middle Gujarat, yielding 125.00 q/ha, surpassing GAO 5, GO 6, and Pusa Sawani by 21.49, 44.82, and 42.05% during *kharif* and summer. It features dark green, tender fruits with strong leaf serration and deep lobbing, tall stature, more nodes, and short internodes. It contains higher phenol (0.13%), soluble sugars (2.50%), and chlorophyll (0.55 mg/g) and shows lower susceptibility to major diseases and pests. ISSR marker "*ISSR-25*" delineated distinct genetic profiles among the okra samples, particularly highlighting the genetic uniqueness of variety AOL-16-01. This variety presents a promising option for middle Gujarat, offering improved yields and enhanced resilience to agricultural challenges.

Key Words: *Abelmoschus esculentus*, Anand Komal, Dual Season, Okra, Yield

Introduction

Okra (*Abelmoschus esculentus* L. Moench), a member of the *Malvaceae* family, represents a multifaceted vegetable prominently investigated for its immature, non-fibrous edible fruits in tropical and subtropical regions (Uppaluriand Rangan, 2023). The nomenclature of okra varies globally, with distinct local names such as "Bhindi" in India, "Gumbo" in the USA, and "Lady's Finger" in England (Makur *et al.*, 2019).

Okra exhibits a low content of saturated fat, cholesterol, and sodium, coupled with a high concentration of dietary fiber, vitamin A, vitamin C, vitamin K, calcium, magnesium, phosphorus, potassium, manganese, iron, zinc, and copper (Elkhalifa*et al.*, 2021). The seeds

of okra, constituting 20% of its composition, represent a notable source of protein and serve as a novel source of vegetable oil, comprising 14%.[11-14] The Average Nutritive Value (ANV) of okra, standing at 3.21%, surpasses that of tomatoes, brinjals, and cucurbitaceous vegetables (Bah and Colley, 2024). Okra has gained prominence among export-oriented vegetable crops owing to its elevated nutritive value and extended shelf life in comparison to other vegetables (Olofsson *et al.*, 2021). Gujarat, with its well-equipped cargo facilities at the International Airports in Ahmedabad and Mumbai, holds a pivotal position for the export potentiality of okra.

India is the top country by the okra production in the world. As of 2022, the okra production in India was 6.87 million tonn that accounts for 61.19% of the world's the okra production (Knoema, 2024). Within the domain of fresh vegetables, okra emerged as a standout, commanding a substantial 60% share of India's export in this category. The cultivation of okra spanned an extensive area of 546 thousand hectares, yielding an annual production of 6700 thousand tonnes and achieving a commendable productivity rate of 12.27tonnes per hectare(PIB, 2021). Noteworthy states in India for okra cultivation include Gujarat, Maharashtra, Andhra Pradesh, Uttar Pradesh, Tamil Nadu, Karnataka, Haryana, and Punjab(APEDA, 2021). The cultivation of okra is undertaken during both the *Kharif* and summer seasons, attesting to its versatility as a crop.

The principal okra cultivation regions in Gujarat encompass Surat, Vadodara, Junagadh, Surendranagar, Gandhinagar, Banaskantha, Kheda, and Anand districts. The crop occupied an aggregate area of 93. 95 thousand hectares, yielding a production output of 1147. 66 thousand metric tons and demonstrating a productivity rate of 12.22 tonnes per hectare during the 2022-23 in the Gujarat state(DOH, 2023).

The cultivars Gujarat Okra 1 (1983), Gujarat Okra Hybrid 1 (1992), Gujarat Okra 2 (1999), Gujarat Okra Hybrid 2 (2009), Gujarat Junagadh Okra 3 (2010), Gujarat Junagadh Okra Hybrid 3 (2011), Gujarat Anand Okra 5 (2011), Gujarat Junagadh Okra Hybrid 4 (2016), Gujarat Okra 6 (2018), and Gujarat Anand Okra 7 (2019) were bred and developed by the Agricultural Universities of the Gujarat State specifically for cultivation during the *kharif* season only. Due to the principal significance of maximizing agricultural benefits for farmers in the existing context of Gujarat, there was a compelling need for the development of a high-yielding dual-season variety of okra. The genotype has been specifically developed for cultivation during the summer and *kharif* seasons in the central region of Gujarat. Systematic testing was conducted in Preliminary Evaluation Trial II (PET II) from 2016 onwards, spanning various trials across diverse locations within the state from 2017 to 2020,

encompassing both *kharif* and summer seasons. Furthermore, the genotype has been actively contributed to the All India Coordinated Research Project (Vegetable Crops) [AICRP (VC)] since 2019 for comprehensive national testing. As a result of its commendable performance, the genotype designated as Anand Komalwasdeveloped for consideration and endorsement under the specific agro-climatic conditions prevalent in central Gujarat.

Material and Methods

Experimental materials and design

The genotype AOL 16-01, alternatively known as Gujarat Anand Okra 8 or Anand Komal, emerged from the controlled crossbreeding program involving GP-OK-292 × AOL 08-5 utilizing the pedigree method of plant breeding at the Main Vegetable Research Station of Anand Agricultural University, Anand, spanning the years 2016 to 2020. The field experiment was executed following a randomized complete block design, comprising three replications, while GAO 5, GO 6, and Pusa Sawani were deployed as check varieties. Each experimental plot encompassed 15 plants, adhering to a spacing pattern of 60 × 30 cm across various years and locations. Planting involved the sowing of three seeds per hole, with subsequent thinning to a singular plant per hole once plants attained the 3–4 leaf stages.

Phenotyping and Statistical analysis

Data were systematically collected encompassing a range of phenology traits, including the duration to flowering and the initiation of first picking, alongside growth and yield-related parameters such as plant height (cm), primary branches per plant, number of nodes per plant, internodes length (cm), petiole length (cm), length of middle leaf node (cm), peduncle length (cm), fruit length (cm), fruit girth (cm), fruit weight (g), fruits per plant, number of seeds/fruit, 100 seed weight (g), and fruit yield. Additionally, biochemical attributes including moisture content (%), phenol content (%), total soluble sugar concentration (%), protein content (%), mucilage content (g/kg), and total chlorophyll content (mg/g) were meticulously recorded following standardized protocols at the Biochemistry Department, A.A.U., Anand. Subsequent statistical analyses were conducted utilizing the INDOSTATE software (IndoStat Inc., Hyderabad, India) within the Statistical Department at A.A.U., Anand.

Genotypic Diversity Analysis

CTAB protocol of Doyle and Doyle (1990) was used to extract the genomic DNA. PCR reaction was performed using ISSR marker and result observe using 3% agarose gel electrophoresis at department of Plant Biotechnology, A.A.U., Anand.

Result and Discussion

Yield Performance

Okra accession Anand Komalwas derived from the segregating population resulting from the cross GP-OK-292 × AOL 08-5. The morphological attributes of Anand Komalalong with checksfor the *kharif* and summer seasons are delineated in Tables 1 and 2, respectively. Anand Komalexhibited higher plant height (148.00 cm), number of nodes per plant (21.70), fruit weight (13.30 g), fruits per plant (22.00), and number of seeds per fruit (52.50), alongside reduced days to flowering (40.60) and internode length (6.80 cm) during the *kharif* season. Conversely, during the summer season, Anand Komaldemonstrated increased plant height (81.80 cm), fruit weight (12.73 g), as well as decreased days to flowering (41.00) and days to first picking (47.50). The proposed genotype showcased a mean fruit yield of 125.00 q/ha, exhibiting 21.49, 44.82, and 42.05% higher fruit yield in middle Gujarat compared to the controls GAO 5, GO 6, and Pusa Sawani, respectively (Table 3) while evaluating under PET, SSVT and LSVT. Based on mean fruit yield data, Anand Komal (129.45 q/ha) exhibited 21.66, 47.31, and 37.25% higher fruit yield at Anand during the *kharif* season compared to the controls GAO 5, GO 6, and Pusa Sawani, respectively (Table 4). Moreover, across five trials at Anand, Anand Komalconsistently ranked within the top non-significant group, attaining a fruit yield of 113.89 q/ha in summer, which represents a 21.00%, 40.36%, and 57.70% increase over the controls GAO 5, GO 6, and Pusa Sawani, respectively (Table 5). Results are in accordance with the finding of the Yadav *et al.*, 2023.Anand Komalemerges as a high-yielding, early-maturing accession with short internodes, rendering it favourable for farmers. The superior performance of Anand Komalacross various locationsand seasons of Gujarat is depicted in Tables 6, 7 and 8.

Morphological characters

Fruits of this variety are dark green colour, tender, smooth, medium long having narrow acute shape of apex (Fig. 1). Tall plant stature with more number of nodes and short internodes (Fig. 2). It has strong serration of leaf blade margin and deep depth of lobbing (Fig. 3). Morphological diversity of the developed variety Anand Komal (AOL 16-01) is described in the table 9 as per the DUS guideline. The NBPGR has assigned the National Identity number as IC 638931.

Nutritional Quality

The variety contains higher phenol (0.13%), total soluble sugars (2.50%) and total chlorophyll (0.55 mg/g) as compared to the checks GAO 5, GO 6 and Pusa Sawani (Table

10). Low mucilage content (30.10 g/kg) make this variety choice of the kitchen due to its cooking advantages.

Biotic stress tolerance

Anandkomal exhibits reduced incidence rates of yellow vein mosaic disease and enation leaf curl disease (%) in contrast to the control varieties GAO 5, GO 6, and PusaSawani at anand(Table 11). Moreover, this genotype manifests diminished shoot borer damage and minimal infestation levels of jassid when juxtaposed with the GAO 5, GO 6, and Pusa Sawani at Anand Location (Table 12).

Molecular Characterisation

The DNA fingerprinting analysis utilizing the ISSR marker "*ISSR-25*" delineated distinct genetic profiles among the okra samples, particularly highlighting the genetic uniqueness of variety AOL-16-01 in comparison to its reference varieties, namely GAO-5, GO-6, and Pusa Sawani. A total of 13 bands were observed, ranging from 197 to 1400 bp. Notably, the absence of the 9^{th} band, which typically appears at 583 bp, in AOL-16-01 underscores its genetic disparity from the aforementioned reference cultivars (Table 13 and Fig. 4). 100 bp plus ladder was used as reference to measure band size.

Conclusion

The new variety excels in middle Gujarat, yielding 125.00 q/ha, surpassing GAO 5, GO 6, and Pusa Sawani by 21.49, 44.82, and 42.05 during *kharif* and summer. It features dark green, tender fruits with strong leaf serration and deep lobbing, tall stature, more nodes, and short internodes. It contains higher phenol (0.13%), soluble sugars (2.50%), and chlorophyll (0.55 mg/g) and shows lower susceptibility to diseases and pests. This variety presents a promising option for middle Gujarat, offering improved yields and enhanced resilience to agricultural challenges.

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1.

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3.

Table 1: Ancillary observations of economic attribute of proposed entry along with checks during *kharif*

Sr. No.	Characters	Anand Komal	GAO 5 (C)	GO 6 (C)	Pusa Sawani (NC)
1	Days to flowering	40.60 (38-42)	43.00 (40-45)	45.40 (42-48)	38.60 (36-40)
2	Days to first picking	45.80 (43-48)	49.40 (47-51)	51.20 (48-53)	43.20 (41-45)
3	Plant height (cm)	148.00 (130-158)	138.00 (125-160)	124.60 (110-138)	128.80 (115-145)
4	Primary branches per plant	2.67 (2-3)	3.33 (3-4)	2.67 (2-3)	2.33 (2-3)
5	Number of nodes per plant	21.70 (20-24)	17.00 (16-19)	16.40 (15-18)	16.80 (16-18)
6	Internodes length (cm)	6.80 (6.5-7.5)	8.20 (7.6-8.4)	7.60 (7.2-8.0)	7.70 (7.0-8.0)
7	Petiole length (cm)	26.80 (26.2-28)	27.67 (26-29)	27.30 (26-28)	27.00 (26-28)
8	Length of middle leaf node (cm)	21.00 (20-22)	21.40 (21-23)	21.50 (21-23)	21.40 (21-23)
9	Peduncle length (cm)	2.80 (2.70-3.10)	2.95 (2.80-3.00)	2.88 (2.76-3.20)	2.90 (2.80-3.30)
10	Fruit length (cm)	13.20 (11.80-15.30)	13.60 (12.0-15.0)	10.40 (9.0-11.6)	10.00 (9.0-11.8)
11	Fruit girth (cm)	5.33	5.30	5.75	5.40

		(4.60-6.50)	(4.50-6.50)	(4.80-6.80)	(4.60-6.30)
12	Fruit weight (g)	13.30 (12.40-15.60)	12.50 (12.00-15.00)	11.70 (10.40-14.80)	11.00 (10-12.60)
13	Fruits per plant	22.00 (18-24)	18.60 (15-21)	17.20 (16-20)	14.60 (13-16)
14	Number of seeds/fruit	52.50 (46-56)	50.33 (45-55)	42.50 (40-45)	36.40 (34-40)
15	100 seed weight (g)	6.80 (6.30-7.20)	7.10 (6.90-7.50)	5.30 (4.90-5.70)	5.10 (4.70-5.40)

Table 2: Ancillary observations of economic attribute of proposed entry along with checks during summer

Sr. No.	Characters	Anand Komal	GAO 5 (C)	GO 6 (C)	Pusa Sawani (NC)
1	Days to flowering	41.00 (40-42)	44.00 (42-46)	43.00 (42-44)	41.50 (41-42)
2	Days to first picking	47.50 (47-48)	50.50 (49-52)	49.00 (48-50)	48.50 (48-49)
3	Plant height (cm)	81.80 (78-85)	75.80 (72-80)	78.60 (73-88)	68.60 (60-76)
4	Primary branches per plant	2.33 (2-3)	2.67 (2-3)	2.00 (1.67-2.33)	1.67 (1.33-2.00)
5	Fruit length (cm)	11.10 (10.70-11.80)	11.30 (10.67-11.67)	10.10 (9.33-11.00)	9.50 (9.33-9.67)
6	Fruit girth (cm)	5.10 (4.80-5.70)	5.33 (5.00-5.67)	5.20 (4.80-6.00)	5.00 (4.70-5.33)
7	Fruit weight (g)	12.73 (12.67-12.78)	11.65 (11.40-11.90)	10.74 (10.67-10.80)	10.60 (10.50-10.80)

Table 3: Yield performance of okra entry Anand Komalin comparison with checks in the middle Gujarat

Year/ Season	Name of trial	Location	Fruit yield (q/ha)				S. Em ±	CD at 5 %	CV %
			AOL 16-01	Checks					
				GAO 5 (a)	GO 6 (b)	Pusa Sawani (c)			
2016/	PET II	Anand	94.62	96.35	-	85.07	7.22	21.13	14.87

Kharif		**% Inc. over the checks**		**-**	**-**	**11.23**			
2017/ *Kharif*	SSVT	Anand	124.65[c]	107.00	-	97.05	8.80	25.82	14.24
		% Inc. over the checks		**16.50**	**-**	**28.44**			
2018/ *Kharif*	SSVT	Anand	137.91[abc]	98.44	101.16	87.62	8.43	24.52	14.13
		% Inc. over the checks		**40.10**	**36.33**	**57.40**			
2019/ Summer	PET	Anand	110.65[abc]	94.79	88.77	60.53	3.00	8.73	12.44
2019/ *Kharif*	LSVT		140.28[abc]	113.08	101.39	100.81	7.01	20.84	11.64
		Mean (2)	**125.47**	**103.94**	**95.08**	**80.67**			
		% Inc. over the checks		**20.71**	**31.96**	**55.54**			
2020/ Summer & 2020/ *Kharif*	LSVT	Anand	117.13[abc]	93.46	73.50	83.91	5.91	17.32	11.96
			149.77[abc]	117.13	87.96	101.04	7.06	20.71	12.02
		Mean (2)	**133.45**	**105.30**	**80.73**	**92.48**			
		% Inc. over the checks		**26.73**	**65.30**	**44.30**			
Over all mean (5)			**131.15**	**-**	**90.56**	**-**			
Over all mean (7)			**125.00**	**102.89**	**-**	**88.00**			
Over all % increase over check				**21.49**	**44.82**	**42.05**			
Frequency in top non-signi. Groups			**7/7**	**1/7**	**0/5**	**1/7**			

Note: - a, b, c indicates the significantly superior than respective check

Table 4: Yield performance of okra varietyAnand Komalin comparison with checks in the middle Gujarat during *kharif*

Year/ Season	Name of trial	Location	Fruit yield (q/ha)				S. Em ±	CD at 5 %	CV %
			AOL 16-01	Checks					
				GAO 5 (a)	GO 6 (b)	Pusa Sawani (c)			
2016/ *Kharif*	PET II	Anand	94.62	96.35	-	85.07	7.22	21.13	14.87
		% Inc. over the checks		**-**	**-**	**11.23**			
2017/ *Kharif*	SSVT	Anand	124.65[c]	107.00	-	97.05	8.80	25.82	14.24
		% Inc. over the checks		**16.50**	**-**	**28.44**			
2018/ *Kharif*	SSVT	Anand	137.91[ab]	98.44	101.16	87.62	8.43	24.52	14.13
		% Inc. over the checks		**40.10**	**36.33**	**57.40**			
2019/ *Kharif*	LSVT	Anand	140.28[ab]	113.08	101.39	100.81	7.01	20.84	11.64
		% Inc. over the checks		**24.05**	**38.36**	**39.15**			
2020/ *Kharif*	LSVT	Anand	149.77[ab]	117.13	87.96	101.04	7.06	20.71	12.02
		% Inc. over the		**27.87**	**70.27**	**48.23**			

		checks							
Over all mean (3)			**142.65**	**-**	**96.84**	**-**			
Over all mean (5)			**129.45**	**106.40**	**-**	**94.32**			
Over all % increase over check				**21.66**	**47.31**	**37.25**			
Frequency in top non-signi. Groups			**5/5**	**1/5**	**0/3**	**1/5**			

Note: - a, b, c indicates the significantly superior than respective check

Table 5: Yield performance of okra varietyAnand Komalin comparison with checks in the middle Gujarat during summer

Year/ Season	Name of trial	Location	Fruit yield (q/ha)				S. Em ±	CD at 5 %	CV %
			AOL 16-01	Checks					
				GAO 5 (a)	GO 6 (b)	Pusa Sawani (c)			
2019/ Summer	PET	Anand	110.65[abc]	94.79	88.77	60.53	3.00	8.73	12.44
		% Inc. over the checks		**16.73**	**24.65**	**82.80**			
2020/ Summer	LSVT	Anand	117.13[abc]	93.46	73.50	83.91	5.91	17.32	11.96
		% Inc. over the checks		**25.33**	**59.36**	**39.59**			
Over all mean (2)			**113.89**	**94.13**	**81.14**	**72.22**			
Over all % increase over check				**21.00**	**40.36**	**57.70**			
Frequency in top non-signi. Groups			**2/2**	**0/2**	**0/2**	**0/2**			

Note: - a, b, c indicates the significantly superior than respective check

Table 6: Yield performance of okra entry Anand Komalin comparison with check varieties in the Gujarat state

Year/ Season	Name of trial	Locations	Fruit yield (q/ha)				S. Em ±	CD at 5 %	CV %
			AOL 16-01	Checks					
				GAO 5 (a)	GO 6 (b)	Pusa Sawani (c)			
2016/ *Kharif*	PET II	Anand	94.62	96.35	-	85.07	7.22	21.13	14.87
		% Inc. over the checks		**-**	**-**	**11.23**			
2017/ *Kharif*	SSVT	Anand	124.65[c]	107.00	-	97.05	8.80	25.82	14.24
		% Inc. over the checks		**16.50**	**-**	**28.44**			
2018/ *Kharif*	SSVT	Anand	137.91[abc]	98.44	101.16	87.62	8.43	24.52	14.13
		% Inc. over the checks		**40.10**	**36.33**	**57.40**			
2019/	LSVT	Anand	140.28[abc]	113.08	101.39	100.81	7.01	20.84	11.64

Kharif		Junagadh	81.60	98.96	103.01	87.96	6.45	19.17	11.24
		Navsari	124.00	123.30	121.20	118.90	4.80	13.70	12.14
		Jagudan[#]	65.51	55.96	105.87	99.48	3.80	11.07	3.72
		Mean (3)	**115.29**	**111.78**	**108.53**	**102.56**			
		% Inc. over the checks		**3.14**	**6.23**	**12.41**			
2020/ *Kharif*	LSVT	Anand	149.77[abc]	117.13	87.96	101.04	7.06	20.71	12.02
		Junagadh	105.03	97.22	100.69	92.01	5.73	16.79	10.36
		Navsari	117.90	117.40	115.47	115.30	5.28	15.49	8.35
		Jagudan[#]	69.99	54.92	109.09	83.83	4.61	11.91	18.79
		Mean (3)	**124.23**	**110.58**	**101.37**	**102.78**			
		% Inc. over the checks		**12.34**	**22.55**	**20.87**			
2019/ Summer	PET	Anand	110.65[abc]	94.79	88.77	60.53	3.00	8.73	12.44
		% Inc. over the checks		**16.73**	**24.65**	**82.80**			
2020/ Summer	LSVT	Anand	117.13[abc]	93.46	73.50	83.91	5.91	17.32	11.96
		Navsari	87.50	98.80	102.87	100.90	5.03	14.74	9.32
		Mean (2)	**102.32**	**96.13**	**88.19**	**92.41**			
		% Inc. over the checks		**6.44**	**16.02**	**10.72**			
Over all mean (10)			**117.18**	**-**	**99.60**	**-**			
Over all mean (12)			**115.92**	**104.66**	**-**	**94.26**			
Over all % increase over check				**10.76**	**17.65**	**22.98**			
Frequency in top non-signi. Groups			**10/12**	**3/12**	**3/10**	**3/12**			

Note:- a, b, c indicates the significantly superior than respective check
#Data was not considered due to below state average yield

Table 7: Yield performance of okra entry Anand Komalin comparison with check varieties in the Gujarat state during *kharif*

Year/ Season	Name of trial	Locations	Fruit yield (q/ha)				S. Em ±	CD at 5 %	CV %
			AOL 16-01	Checks					
				GAO 5 (a)	GO 6 (b)	Pusa Sawani (c)			
2016/ *Kharif*	PET II	Anand	94.62	96.35	-	85.07	7.22	21.13	14.87
		% Inc. over the checks		**-**	**-**	**11.23**			
2017/ *Kharif*	SSVT	Anand	124.65[c]	107.00	-	97.05	8.80	25.82	14.24
		% Inc. over the checks		**16.50**	**-**	**28.44**			
2018/	SSVT	Anand	137.91[abc]	98.44	101.16	87.62	8.43	24.52	14.13

Kharif		**% Inc. over the checks**		**40.10**	**36.33**	**57.40**			
2019/ *Kharif*	LSVT	Anand	140.28[abc]	113.08	101.39	100.81	7.01	20.84	11.64
		Junagadh	81.60	98.96	103.01	87.96	6.45	19.17	11.24
		Navsari	124.00	123.30	121.20	118.90	4.80	13.70	12.14
		Jagudan[#]	65.51	55.96	105.87	99.48	3.80	11.07	3.72
		Mean (3)	**115.29**	**111.78**	**108.53**	**102.56**			
		% Inc. over the checks		**3.14**	**6.23**	**12.41**			
2020/ *Kharif*	LSVT	Anand	149.77[abc]	117.13	87.96	101.04	7.06	20.71	12.02
		Junagadh	105.03	97.22	100.69	92.01	5.73	16.79	10.36
		Navsari	117.90	117.40	115.47	115.30	5.28	15.49	8.35
		Jagudan[#]	69.99	54.92	109.09	83.83	4.61	11.91	18.79
		Mean (3)	**124.23**	**110.58**	**101.37**	**102.78**			
		% Inc. over the checks		**12.34**	**22.55**	**20.87**			
Over all mean (7)			**115.25**	**-**	**104.59**	**-**			
Over all mean (9)			**114.13**	**102.48**	**-**	**98.52**			
Over all % increase over check				**11.37**	**10.19**	**15.84**			
Frequency in top non-signi. Groups			**8/9**	**2/9**	**2/7**	**2/9**			

Note:- a, b, c indicates the significantly superior than respective check
#Data was not considered due to below state average yield

Table 8: Yield performance of okra entry Anand Komal in comparison with check varieties in the Gujarat state during summer

Year/ Season	**Name of trial**	**Locations**	**Fruit yield (q/ha)**				**S. Em ±**	**CD at 5 %**	**CV %**
			AOL 16-01	**Checks**					
				GAO 5 (a)	**GO 6 (b)**	**Pusa Sawani (c)**			
2019/ Summer	PET	Anand	110.65[abc]	94.79	88.77	60.53	3.00	8.73	12.44
		% Inc. over the checks		**16.73**	**24.65**	**82.80**			
2020/ Summer	LSVT	Anand	117.13[abc]	93.46	73.50	83.91	5.91	17.32	11.96
		Navsari	87.50	98.80	102.87	100.90	5.03	14.74	9.32
		Mean (2)	**102.32**	**96.13**	**88.19**	**92.41**			
		% Inc. over the checks		**6.44**	**16.02**	**10.72**			
Over all mean (3)			**105.09**	**95.68**	**88.38**	**81.78**			
Over all % increase over check				**9.84**	**18.91**	**28.51**			
Frequency in top non-signi. Groups			**2/3**	**1/3**	**1/3**	**1/3**			

Note:- a, b, c indicates the significantly superior than respective check

Table 9: Morphological characters of proposed entry along with checks (As per DUS Guidelines)

Sr. No.	Characters	Anand Komal	GAO 5 (C)	GO 6 (C)	Pusa Sawani (NC)
1	Stem colour	Dark Green	Dark Green	Green	Green
2	Stem: Intensity of green colour	Dark	Dark	Light	Light
3	Leaf blade: Depth of lobbing	Deep	Shallow	Shallow	Shallow
4	Stem: Number of nodes at first flowering	Few	Few	Medium	Medium
5	Flowering time	Medium	Medium	Late	Medium
6	Leaf blade: Length	Medium	Medium	Medium	Medium
7	Leaf blade: width	Medium	Medium	Medium	Medium
8	Leaf blade: Serration of margin	Strong	Medium	Medium	Medium
9	Leaf blade: Colour between veins	Green	Green	Green	Green
10	Leaf blade: Intensity of colour between veins	Dark	Medium	Medium	Light
11	Vein : Colour	Light Green	Light Green	Light Green	Light Green
12	Petiole : Length	Medium	Medium	Medium	Medium
13	Flower : Petal colour	Yellowish white	Yellowish white	Yellow	Yellow
14	Flower : Petal base colour (purple)	Both sides	Both sides	Both sides	Both sides
15	Flower : Length	Medium	Medium	Medium	Medium
16	Flower : Diameter (at the top of flower)	Medium	Medium	Medium	Medium
17	Fruit : Colour	Dark Green	Dark Green	Green	Light Green
18	Fruit: length (cm)	Medium	Medium	Medium	Medium
19	Fruit: diameter	Medium	Medium	Medium	Medium
20	Fruit : Surface between ridges	Concave	Concave	Convex	Concave
21	Fruit : pubescence	Medium	Medium	Medium	Weak
22	Fruit : constriction of basal part	Strong	Strong	Weak	Weak
23	Fruit : Shape of apex	Narrow Acute	Acute	Acute	Narrow Acute
24	Fruit : Number of locules	<6	<6	<6	<6
25	Plant : Number of branches	Medium	Medium	Medium	Medium
26	Stem : Diameter (at 10 cm above ground level)	Medium	Medium	Medium	Medium
27	Plant : Height	Tall	Tall	Tall	Tall

28	Fruit : Length of physiologically mature fruit	Long	Long	Long	Long
29	Fruit : Diameter	Small	Small	Small	Small
30	Seed : Colour	Green	Green	Green	Green
31	Seed : Hairiness	Absent	Absent	Absent	Absent

Table 10: Biochemical parameters of proposed entry along with checks

Sr. No.	Characters	Anand Komal	GAO 5 (C)	GO 6 (C)	Pusa Sawani (NC)
1	Moisture (%)	79.59	81.29	82.70	80.90
2	Phenol (%)	0.13	0.12	0.11	0.10
3	Total Soluble Sugars (%)	2.50	2.42	1.95	2.15
4	Protein (%)	0.88	0.95	0.95	0.96
5	Mucilage (g/kg)	30.10	33.78	44.15	44.52
6	Total chlorophyll (mg/g)	0.55	0.54	0.37	0.34

Table 11: Rating of incidence of diseases at Anand centre

Diseases	Year and season	Name of trial	Varieties			
			AOL 16-01	GAO 5 (C)	GO 6 (C)	Pusa Sawani (NC)
Yellow vein mosaic diseases (%)	2016/ *Kharif*	PET II	3.26	5.70	-	8.19
	2017/ *Kharif*	SSVT	3.64	5.24	-	7.14
	2018/ *Kharif*	SSVT	3.68	5.27	6.42	7.14
	2019/ summer	LSVT	0.00	1.04	4.60	5.17
	2019/ *Kharif*	LSVT	1.04	1.04	2.08	2.08
	2020/ summer	LSVT	1.25	3.25	9.38	12.25
	2020/ *Kharif*	LSVT	0.00	0.00	2.48	10.33
	Range		**0.00-3.68**	**0.00-5.70**	**2.08-9.38**	**2.08-12.25**
	Reaction		**HR**	**HR**	**HR**	**R**
Enation leaf curl disease (%)	2019/ *Kharif*	LSVT	0.00	0.00	1.25	1.67
	2020/ summer	LSVT	0.00	0.00	5.33	2.35
	2020/ *Kharif*	LSVT	0.00	3.33	8.00	5.33
	Range		**0.00**	**0.00-3.33**	**1.25-8.00**	**1.67-5.33**
	Reaction		**HR**	**HR**	**HR**	**HR**

*Rating scale of disease reaction is selected as per (Ali *et al.*, 2005)

Table 12: Rating of incidence of insect-pests at Anand centre

Insect-pests	Year and Season	Name of trial	Varieties			
			AOL 16-01	GAO 5 (C)	GO 6 (C)	Pusa Sawani (NC)
Number of jassid per leaf	2019/*Kharif*	LSVT	3.00	2.49	3.53	5.04
	2020/Summer	LSVT	2.00	3.78	4.25	5.84
	2020/*Kharif*	LSVT	1.30	2.06	3.50	4.93
		Range	**1.30-3.00**	**2.06-3.78**	**3.50-4.25**	**4.93-5.84**
Number of Whitefly per leaf	2019/*Kharif*	LSVT	2.60	1.64	2.00	3.18
	2020/Summer	LSVT	1.30	2.56	3.46	5.43
	2020/*Kharif*	LSVT	0.56	1.01	2.49	2.96
		Range	**0.56-2.60**	**1.01-2.56**	**2.00-3.46**	**2.96-5.43**
Okra shoot & fruit borer damage (%) **(Shoot damage %)**	2019/*Kharif*	LSVT	4.17	7.29	3.13	4.17
	2020/Summer	LSVT	4.89	5.05	5.24	5.28
	2020/*Kharif*	LSVT	2.69	3.80	5.74	5.08
		Range	**2.69-4.89**	**3.80-7.29**	**3.13-5.74**	**4.17-5.28**
Okra shoot & fruit borer damage (%) **(Fruit damage %)**	2019/*Kharif*	LSVT	3.77	3.81	6.70	7.54
	2020/Summer	LSVT	4.38	7.16	6.50	10.30
	2020/*Kharif*	LSVT	2.65	3.60	4.34	4.95
		Range	**2.65-4.38**	**3.60-7.16**	**4.34-6.70**	**4.95-10.30**

Table 13: Genetic diversity in band size of the okra entry AOL-16-01

Bands	1	2	3	4
	GAO 5	GO 6	Pusa Sawani	AOL-16-01
1	197	197	197	197
2	234	234	234	234
3	270	270	270	270
4	321	321	321	321
5	370	370	370	370
6	411	411	411	411
7	448	448	448	448
8	481	481	481	481
9	583	583	583	--------
10	707	707	707	707
11	986	986	986	986
12	1155	1155	1155	1155
13	1400	1400	1400	1400

Fig. 1: Narrow acute shape of apex and dark green fruit colour

Fig. 2: Short internode and fruiting characteristics of the Anand Komal

Fig.3: Field view of the Anand Komal

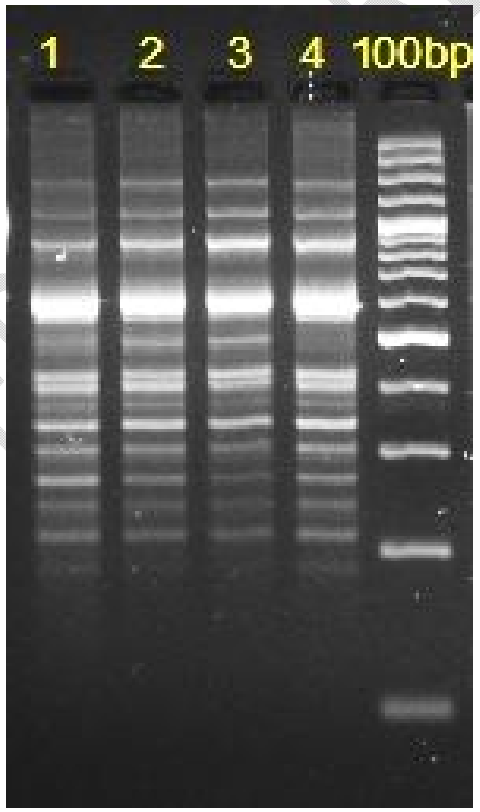

Fig.4: DNA fingerprinting report of okra generated by ISSR marker system. M(Marker): 100 bp plus ladder; ISSR-25

Disclaimer (Artificial intelligence)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts

References

1. APEDA (2021). Agricultural and Processed Food Products Export Development Authority (APEDA), Ministry of Commerce & Industry, Govt. of India. Indian Production of Okra/Ladyfinger. Retrieved from https://agriexchange.apeda.gov.in/India%20Production/India_Productions.aspx?cat=Vegetables&hscode=1079
2. Bah, C., & Colley, A. (2024). Comparative Advantages of Intercropping Okra with Selected Vegetables, Okra and Lettuce, Okra and Tomato, Okra and Eggplant, and Okra Sole Crop. *IRDH International Journal of Technology, Agriculture and Natural Sciences*, *1*(1), 1-9.
3. DOH (2023). Director of Horticulture, Government of Gujarat. Retrieved from https://doh.gujarat.gov.in/Images/directorofhorticulture/pdf/statistics/apy_2023.pdf
4. Doyle, J.J. and Doyle, J.L. (1990). Isolation of plant DNA from fresh tissue. Focus. 12:13–15.
5. Elkhalifa, A. E. O., Alshammari, E., Adnan, M., Alcantara, J. C., Awadelkareem, A. M., Eltoum, N. E., ...& Ashraf, S. A. (2021). Okra (*Abelmoschus esculentus*) as a potential dietary medicine with nutraceutical importance for sustainable health applications. *Molecules*, *26*(3), 696. https://doi.org/10.3390/molecules26030696
6. Knoema. (2024). Agriculture Indicators: Production of Okra. Retrieved from https://knoema.com/data/agriculture-indicators-production+okra
7. Makur, M. M., Duraisamy, R., & Birhanu, T. (2019). Clarifying capacity of eco-friendly nanoCaO and okra (*AbelmoschusEsculentus*) extract on the processing of sugarcane juice: a Review. *Int. Res. J. of Sci. Tech*, *1*(1), 21-30. https://doi.org/10.46378/irjst.2019.010104
8. Olofsson, M., Ros-Tonen, M., Gupta, J., de SteenhuijsenPiters, B., & Van Leynseele, Y. (2021). Rethinking the divide: Exploring the interdependence between global and nested local markets. Journal of Rural Studies, 83, 60-70. https://doi.org/10.1016/j.jrurstud.2021.02.018

9. PIB (2021). Second Advance Estimates (2021-22) of Area and Production of Horticultural Crops released. Retrieved from https://static.pib.gov.in/WriteReadData/specificdocs/documents/2022/jul/doc202271470601.pdf
10. Uppaluri, R. V., & Rangan, L. (Eds.). (2023). Conservation of Biodiversity in the North Eastern States of India: Proceedings of NERC 2022. Springer Nature. https://doi.org/10.1007/978-981-99-0945-2
11. Yadav, S. P. S., Bhandari, S., Ghimire, N. P., Nepal, S., Paudel, P., Bhandari, T., Paudel, P., Shrestha, S., & Yadav, B. (2023). Varietal trials and yield components determining variation among okra varieties (*Abelmoschus esculentus L.*). Journal of Agriculture and Applied Biology, 4(1), 28-38. http://dx.doi.org/10.11594/jaab.04.01.04
12. Meena MK, Suman M. Assessment of Different Okra Varieties for Yield, Quality and, Economical Feasibility Cultivated in the Hadoti Region of South-East Rajasthan, India. J. Exp. Agric. Int. [Internet]. 2024 Feb. 12 [cited 2024 Jun. 26];46(2):147-56. Available from: https://journaljeai.com/index.php/JEAI/article/view/2317
13. Meena MK, Suman M. Evaluation of Okra Varieties under Sub-humid Plains of South-East Rajasthan for Morphological and Phenological Traits. Asian Res. J. Agric. [Internet]. 2024 Feb. 19 [cited 2024 Jun. 26];17(1):49-55. Available from: https://journalarja.com/index.php/ARJA/article/view/409
14. Abd El-Fattah BE, Haridy AG, Abbas HS. Response to planting date, stress tolerance and genetic diversity analysis among okra (Abelmoschusesculentus (L.) Moench.) varieties. Genetic Resources and Crop Evolution. 2020 Apr;67(4):831-51.
15. Mohammed J, Mohammed W, Shiferaw E. Performance and genetic variability of okra (abelmoschusesculentus (L.) Moench) genotypes in Ethiopia for agromorphology and biochemical traits. Advances in Agriculture. 2022;2022(1):5521151.