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Full Length Article

Characterization of Okra (*Abelmoschus esculentus*) Genotypes for Fruit Firmness, other Horticultural Traits and Heritability Studies

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Abstract

Genetic variability among the genotypes and their characterization are important for improving efficiency of breeding program (s). Genetic variation among 24 okra genotypes was analyzed for various horticultural traits including yield and fruit quality parameters. Heritability parameters including GV, PV, GCV, PCV, broad sense heritability (H^2), genetic advance (GA) and GA as percent of mean were also calculated. Results envisaged significant variation among genotypes for all the studied traits. 'Rama Krishna', 'Line Brand', 'Ikra-02', 'Ikra-04','Durga' and 'Patel' performed better on the basis of measured morphological and yield related traits including plant height, number of leaves plant^{-1}, leaf area, days to flowering, internodal length, fruit length, girth and weight as well as fruit weight plant^{-1}. Moreover, fruit tenderness measured at 6th, 8th, 10th and 12th day after flower opening revealed 'Rama Krishna', 'Line Brand', 'Ikra-02', 'Ikra-04', 'Durga' and 'Patel' were promising genotypes as their fruits remained soft for longer time (12th day) as compared to other genotypes. It is noteworthy that values for PV and PCV were not very high than GV and GCV for all the parameters. Interestingly, GCV values were high for number of leaves plant^{-1}, number of fruits plant^{-1}, fruit weight plant^{-1} and fruit tendernesson 6th, 8th, 10th and 12th day after flowering among the studied traits. High heritability was noticed for all traits except fruit girth and protein contents. Furthermore, high values for GA as percent of mean were noticed for number of leaves plant^{-1}, days to flowering, stem diameter, fruit length, number of fruits plant^{-1}, fruit weight plant^{1}and fruit tenderness at all picking intervals. This study revealed 'Ikra-02'and'Ikra-04'as potential local genotypes having good horticultural traits, especially the fruit tenderness and can be used in developing open pollinated and hybrid varieties of okra. © 2018 Friends Science Publishers

Keywords: Genetic advance; Hybrid; Open pollinated; Promising

Introduction

Vegetables are essential component in the daily diet of people as they provide several nutritional benefits and are generally eaten as fresh or cooked (Kumar *et al*., 2013). Okra (*Abelmoschus esculentus* L. Moench) is known as "bhindi tori" in Pakistan, belongs to family Malvaceae, having its origin in Africa, now found in several countries across Asia and Africa (NRC, 2006). It is an annual, hardy and high-yielding plant, which greatly differs in size, fruit shape, pigmentation, branching habit, fruiting span, fruit yield and fruit firmness (Purquerio *et al*., 2010). Okra fruits contain water (88%), protein (1.52 g), carbohydrates (5.76 g), vitamin C (13.1 mg), Ca (0.4 mg), folic acid (36.5 µg), Mg (46 mg), K (256.6 mg) and dietary fibre (2 g), which help in lowering serum cholesterol, reducing heart disease and cancer, especially colorectal cancer (Aminu *et al*., 2016).

Sufficient information about the genetic variability of a crop is required for the identification of potential genotypes to be used in breeding program as well as germplasm conservation (Bello *et al*., 2014). Study of morphological diversity is mandatory before biochemical and molecular characterization (Bello and Olawuyi, 2015). Selection for breeding depends on the extent of genetic variability in germplasm and the degree to which the desired traits are heritable. Yield is a complex quantitative trait, controlled by several genes that interact with the environment and several traits are associated with it. So, appropriate knowledge of such associations could significantly improve the efficiency of selection for crop improvement (Adekoya *et al*., 2014). Moreover, it would be wise to separate the variability for a trait into heritable as well as non-heritable components with the help of heritability parameters including genotypic and phenotypic variance, genotypic and phenotypic coefficient of variation, broad sense heritability, genetic advance and genetic advance as percent of mean (GV, PV, GCV, PCV, H^2, GA and GA as percent of mean, respectively). These also provide the reliable estimation of phenotype in predicting the breeding value of a trait, which could be transmitted to next generation (Meitei *et al*., 2014). Estimation of genetic

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variability related to yield and yield related components facilitates to find out the influence of environmental conditions on yield and related characteristics (Choudhary *et al*., 2015).

In Pakistan, average yield of okra is too low as compared to other countries like India and Nigeria. It is because okra genotypes include locally adapted landraces which have lost their yield potential because of cultivation for a long period without proper selection. Moreover, these are associated with several challenges such as susceptibility to diseases, abiotic stress and long juvenile periods and short fruiting span. Improved varieties with good yield and quality attract the attention of ultimate consumers in both local and international markets (Ahiakpa *et al*., 2013). Therefore, it is needed to develop high yielding varieties of okra with better adaptability to varying environmental conditions. Keeping in view the significance of exploring the horticultural performance of okra genotypes as well as their heritability patterns, this study was undertaken. This study identified several local and exotic genotypes with high yield and fruit tenderness even under prolonged retention of fruits on the plant.

Materials and Methods

Plant Materials

This study was conducted at Vegetable Research Area, Institute of Horticultural Sciences, University of Agriculture, Faisalabad, Pakistan, (Latitude 31º31 N, Longitude 73º10 E and altitude 213 m). Seeds of okra genotypes *viz.*, 'Arka Anamika', 'Tulsi', 'Anmol', 'Okra-7100', 'Green gold', 'MF-03', 'Anarkali', 'Ikra-02', 'MF-02', 'Prabhani Karanti', 'OH-152', 'Pen Beauty', 'Click-5769', 'Kiran-51', 'Ikra-04' and 'Sabz Pari' were collected from Ayub Agricultural Research Institute, Faisalabad. Seeds of 'Patel', 'Durga', 'Rama Krishna', 'Line Brand', 'Evergreen, 'Greenstar' and 'Super Green' were collected from National Seed Corporation, Gujranwala; while seeds of 'Sudani' were imported from Sudan. All genotypes were grownon March 03 during 2014 and 2015 in randomized complete block design with three replications and each replication comprised of fifteen plants. All cultural practices such as hoeing, weeding, fertilization, irrigation, IPM, etc. were similar for all genotypes during the entire period of study.

Data Collection

Growth related traits: Genotypes were grown on March 03 during 2014 and 2015, till maturity and data were collected using IBPGR (1991) descriptor of okra. Five plants of each genotype were selected in each replication for data collection. Plant height was measured from ground level to top with the help of measuring tape after 60 days of sowing. Same plants were used to count number of leaves plant^{-1}. For the measurement of leaf area, fully expanded leaves were selected and their area was calculated by recording their length and maximum width of leaf blade from the center, which were multiplying with constant factor (0.68) according to the method described by Carleton and Foote (1965). Stem diameter was measured from the base of plant (2 inches above soil surface) using digital caliper. Number of days to flowering was counted from the date of sowing till initiation of first flower. Internodal length was measured as the distance between two consecutive nodes (5th and 6th node). Days from flowering to marketable fruit size was computed by tagging of flowers. Fruiting span was determined by calculating days from first to last picking. Stem color was categorized on the basis of given coding to different shades/colors *i.e.,* green, green + red and purple (1, 2 and 3, respectively). Pubescence on main stem was observed visually and recorded as absent or present (0 and 1). Leaf color was categorized as green or green + red veins (1 and 2) and number of ridges on fruits was counted; while pubescence on fruit was observed visually and rated as absent, slight or abundant (1, 2 and 3, respectively).

Fruit and Quality Related Traits

Fruiting habit was visually observed and categorized as erect, slightly falling, horizontal and drooping (1, 2, 3 and 4, respectively). Green tender fruits of okra were selected randomly from tagged plants and picked for measuring fruit length and girth. Number of fruits plant^{-1} was counted from first to last picking and average fruit weight was recorded. Fruit weight plant^{-1} was determined by summing up weight of all pickings. Protein contents (%) were measured according to the method described by AOAC (2000); while ascorbic acid contents (mg g^{-1}) were measured by the method described by Haddad (1977). For the measurement of fruit tenderness (Newton), texture analyzer (TA.XT. *Plus*, Stable Micro Systems, Agrosta, France) was used at Food and Nutrition Laboratory, National Institute of Food Science and Technology, University of Agriculture, Faisalabad. Fruits were harvested at 6th, 8th, 10th and 12th days after flower opening. These fruits were analyzed for shear force (firmness) using texture analyzer in units "Newton".

Statistical Analysis and Estimation of Heritability Parameters

All data were analyzed statistically by using analysis of variance technique and treatment means were compared using DMRT test at 5% level of significance (Steel *et al*., 1997). Genotypic variance (GV) and phenotypic variance (PV) were calculated by the method described by Burton (1952) and Singh and Narayana (2000). Genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) were estimated by the method described by Sivasubramanian and Menon (1973). Broad sense heritability was calculated as described by Lush (1940). The genetic advance (GA) and genetic advance as percent of

mean (10% selection intensity) was calculated by the formula suggested by Johnson *et al.* (1955). Data were collected for all parameters during both years (2014 and 2015) and mean values are given in this manuscript.

Results

Growth Related Traits

Significant variation was noticed among okra genotypes for growth related traits (Table 1). Tallest plants of okra were recorded for 'Rama Krishna' (127.4 cm), followed by 'Line Brand' (123.6 cm) and 'Ikra-02' (122.0 cm); while shortest statured plants (102.6 cm) were recorded for 'Super Green'. 'Rama Krishna' produced maximum (34.7) number of leaves plant^{-1} followed by 'Patel' (34.1), 'Ikra-02' (34.0), 'Durga' (33.9) and 'Line Brand' (33.7) but the least number of leaves plant^{-1} were recorded in 'Kiran-51' (22.1) and 'Sudani' (22.7). Leaf area was recorded highest for 'Line Brand' (366.7 cm^2), which was statistically at par with 'Rama Krishna' (363.0 cm^2), 'Ikra-02' (362.9 cm^2), 'Ikra-04' (356.5 cm^2) and 'Okra-7100' (356.0 cm^2). However, leaf area was recorded minimum for 'Sudani' (318.0 cm^2) and 'OH-152' (320.9 cm^2) (Table 1). Shortest intermodal length (7.1 cm) was recorded for 'Rama Krishna', 'Tulsi' and 'Ikra-02' but maximum internodal length was noticed in 'Sudani' (10.6 cm), 'Prabhani Karanti' (8.7 cm) and 'Okra-7100' (8.5 cm) (Table 1). Thickest stems with maximum diameter (25.8 cm) were produced by 'Ikra-02', 'Rama Krishna' (25.6 cm) and 'Line Brand' (25.6 cm); while diameter of stems was found least (19.0 cm) for 'MF-03' (Fig. 1A). 'Rama Krishna' and 'Ikra-02' took minimum number of days (31.5 and 32.2 days, respectively) from sowing to start flowering; while 'Sudani' and 'Prabhani Karanti' took longer time (45.8 and 43.5 days, respectively) to initiate flowering (Fig. 1B). 'Sudani' took maximum number of days (9.2 days) from flowering to produce marketable sized fruits but minimum number of days were taken by 'Ikra-02' (6.2 days), 'Ikra-04' (6.3 days), 'Rama Krishna' (6.3 days), 'Patel' (6.3 days) and 'Durga' (6.3 days) to produce marketable fruits from flower opening (Table 1). Most of the genotypes showed slight pubescence on stem and fruit except 'Sudani' which exhibited abundant pubescence. All genotypes produced green coloured stems except 'MF-03', 'Sudani' and 'Super Green', which produced stems of green +red coloured. Most of the genotypes produced leaves of green colour but 'Tulsi', 'Sudani' and 'MF-03' produced leaves with green and red veins. 'Patel', 'Rama Krishna' and 'Greenstar' exhibited erect type of fruiting habit; while the rest of genotypes showed slightly falling fruits. No variation was observed for number of ridges on fruit among all genotypes. 'Rama Krishna' had longest fruiting span (78.8 days) starting from flower initiation till last picking of marketable fruits followed by 'Ikra-02' (77.3 days), 'Line Brand' (76.2 days), 'Ikra-04' (76.1 days) and 'Patel' (74.0 days). Conversely, shortest fruiting span was noticed for 'Sudani' (55.9 days), 'Arka Anamika' (61.6 days) and 'Prabhani Karanti' (61.7 days) (Table 1).

Fruit Related Traits

'Ikra-04' produced longest green fruits (14.8 cm) among all the genotypes followed by 'Patel' (14.8 cm), 'Rama Krishna' (14.4 cm), 'Line Brand' (14.2 cm), 'Ikra-02' (14.1 cm) and 'Durga' (14.2 cm); while smallest sized fruits were produced by 'Click-5769', 'Arka Anamika' and 'Kiran-51' (10.8 cm, 10.8 cm and 10.9 cm, fruit length, respectively) (Table 2). Fruits with maximum girth were produced by 'Ikra-04' (5.8 cm), 'Sudani' (5.8 cm) and 'Okra-7100' (5.8 cm) but 'MF-02' produced fruits with minimum girth (5.0 cm) (Table 2). Number of fruits plant^{-1} was recorded highest for 'Rama Krishna' (25.9) followed by 'Ikra-02' (24.6), 'Line Brand' (23.9), 'Patel' (23.2) and 'Durga' (22.5). 'Sudani'and 'Prabhani Karanti' produced minimum number of fruits plant^{-1} (16.1 and 17.0 fruits, respectively). 'Rama Krishna' superseded all other genotypes for producing highest average fruit weight (14.3 g) followed by 'Ikra-02' (14.0 g), 'Ikra-04' (13.7 g), 'Line Brand' (13.7 g), 'Patel' (13.4 g), 'Sabz Pari' (13.2 g) and 'Durga' (13.1 g). However, 'Sudani' produced fruits with the lowest average fruit weight (10.5 g) followed by 'Prabhani Karanti' (11.0 g) (Table 2). 'Rama Krishna' also exhibited highest fruit weight plant^{-1} (369.5 g plant^{-1}) followed by 'Ikra-02' (361.3 g plant^{-1}) and 'Line Brand' (351.4 g plant^{-1}); while 'Prabhani Karanti' and 'Sudani' exhibited minimum fruit weight plant^{-1} (201.9 g and 209.0 g plant^{-1}, respectively) (Fig. 1C).

Quality Related Traits

Maximum protein contents were found in the fruits of 'Line Brand' (14.7%) followed by 'Rama Krishna' (14.7%), 'Patel' (14.7%) and 'Durga' (14.0%); while the lowest protein contents (11.7%) were found in the fruits of 'Sudani'. Similarly, highest ascorbic acid contents were recorded in the fruits of'Rama Krishna' (0.30 mg g^{-1}), 'Line Brand' (0.29 mg g^{-1}), 'Durga' (0.28 mg g^{-1}) and'Ikra-02' (0.28 mg g^{-1}) but the lowest ascorbic acid contents were found in fruits of 'Sudani' (0.21 mg g^{-1}) (Table 2). Fruits were harvested after six days of flower opening at two days interval *i.e.* 6th, 8th, 10th and 12th days and analyzed for fruit tenderness, which exhibited highly significant variations among okra genotypes. Harvested fruits of all genotypes at 6th day from flower opening remained tender except for fruits of 'Sudani' and 'Prabhani Karanti', which produced comparatively firm fruits (3.9 Newton and 2.8 Newton fruit firmness, respectively). On 8th day from flower opening, fruits of all genotypes sustained their tenderness except for 'Sudani', 'MF-03', 'Prabhani Karanti', 'Super Green', 'Kiran-51' and 'Pen Beauty'. Fruit tenderness of 'Rama Krishna', 'Patel', 'Durga', 'Line Brand', 'Ikra-02' and 'Ikra-04' was highest even when harvesting of fruits was

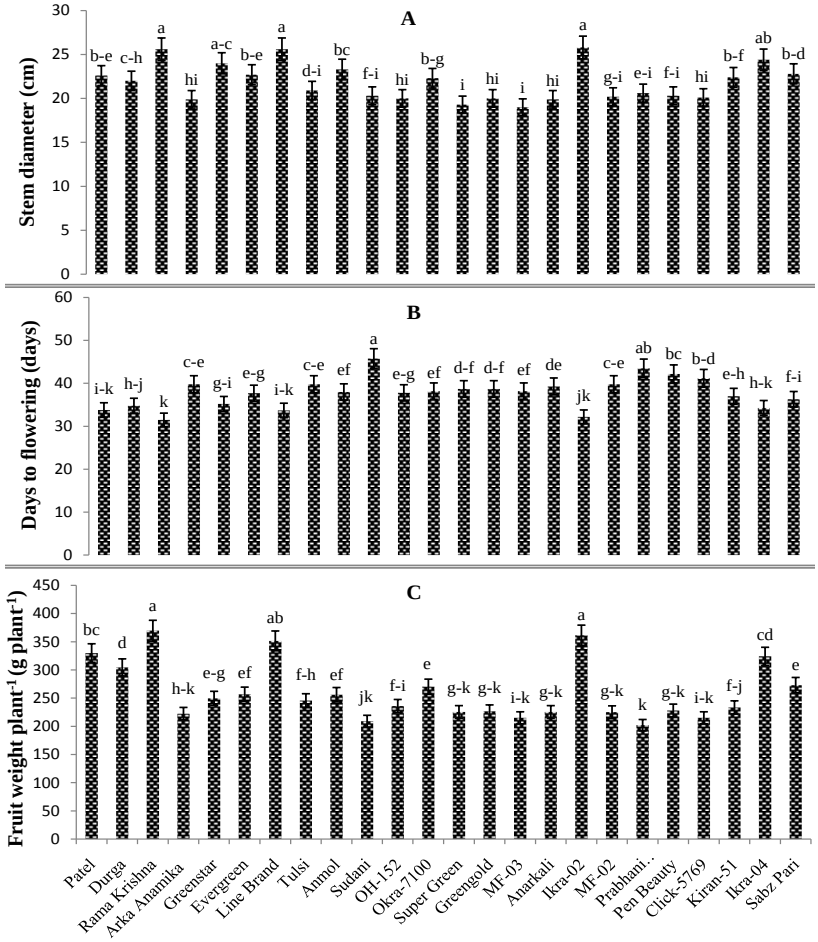

Fig. 1: Comparison of okra genotypes for stem diameter (A), days to flowering (B) and fruit weight plant^{-1} (C). (Figure represents the means of three replications of two separate experiments conducted during the years 2014 and 2015. Means having different letters are significantly different at $P \leq 0.05$ according to DMRT Test)

delayed till 10th and 12th day from flower opening; while fruits of 'Sudani' and 'Pen Beauty' exhibited minimum tenderness, which were firm when harvested (Table 3).

Heritability Parameters of Studied Traits

Phenotypic variance (PV) and phenotypic coefficient of variation (PCV) were higher than genotypic variance (GV) and genotypic coefficient of variation (GCV) for all the traits (Table 4). High GV and PV were noted for plant height (53.90, 60.27), number of leaves plant^{-1} (17.19, 18.67), leaf area (147.46, 179.53), fruit weight plant^{-1} (2518.2, 2879.6) and fruiting span (28.00, 34.55); while lowest values of GV and PV were recorded for all other traits (Table 4). High values of GCV and PCV were recorded for fruit weight plant^{-1} (19.27%, 20.60%) and fruit firmness at 12th day from flower initiation (18.19%, 19.25%); while moderate values were recorded for number of leaves plant^{-1} (14.70%, 15.32%), number of fruits plant^{-1} (12.61%, 13.81%), fruit length (10.25%, 11.35%) and fruit firmness at 6th, 8th, and 10th day from flower opening. High heritability (H^2) was recorded for all the parameters except fruit girth and days taken to marketable fruit size, for which moderate heritability (57.4% and 65.5%, respectively) was recorded. Moderate to low genetic advance (GA) was noticed for all parameters except plant height, leaf area and fruit weight plant^{-1}, where high values for GA (14.23, 22.68 and 96.67, respectively) were recorded. Moreover, highest values for GA as percent of mean were recorded for all traits except leaf area, fruit girth and protein contents which exhibited moderate to low values (6.58%, 6.72% and 8.99%, respectively) (Table 4).

Discussion

Significant variations were observed in the performance of okra genotypes for almost all traits. Tested genotypes showed wide variation in recorded morphological, yield and quality related traits.

Table 1: Comparison of okra genotypes for plant height, leaves plant^{-1}, leaf area, Internodal length, days to marketable fruit and fruiting span

Genotypes	Plant height (cm)	Leaves plant^{-1} (No.)	Leaf area (cm^2)	Internodal length (cm)	Days to marketable fruit(days)	Fruiting span (days)
Patel	119.6 bc	34.1 ab	354.1 bc	7.6 e-g	6.3 fg	74.0 b-e
Durga	118.3 b-d	33.9 ab	351.0 c-e	7.7 e-g	6.3 fg	71.7 c-f
Rama Krishna	127.4 a	34.7 a	363.0 ab	7.1 g	6.3 fg	78.8 a
ArkaAnamika	106.5 ef	26.7 de	343.2 d-h	7.8 d-f	7.3 b-e	61.6 j
Greenstar	114.0 cd	30.1 c	340.0 f-h	8.0 c-f	6.5 e-g	66.7 g-i
Evergreen	112.4 de	28.9 cd	340.6 e-h	8.4 b-d	7.5 b-d	66.4 h-j
Line Brand	123.6 ab	33.7 ab	366.7 a	7.7 d-g	6.3 fg	76.2 a-c
Tulsi	107.0 ef	30.0 c	345.7 c-g	7.1 g	7.5 b-d	69.3 f-h
Anmol	113.6 cd	28.4 cd	336.2 g-i	7.8 d-f	7.3 b-e	66.9 f-i
Sudani	107.6 ef	22.7 gh	318.0 j	10.6 a	9.2 a	55.9 k
OH-152	105.7 f	24.0 f-h	320.9 j	7.8 d-g	7.8 b	66.6 g-i
Okra-7100	103.9 f	28.0 cd	356.0 bc	8.5 bc	6.8 c-g	70.3 e-h
Super Green	102.6 f	23.9 f-h	348.9 c-f	7.7 e-g	7.5 b-d	63.5 ij
Greengold	104.4 f	26.8 de	353.0 b-d	7.6 e-g	7.2 b-f	66.7 g-i
MF-03	104.0 f	23.4 f-h	333.5 hi	7.7 e-g	7.3 b-e	66.2 h-j
Anarkali	107.6 ef	25.5 ef	335.3 g-i	7.6 e-g	7.3 b-e	68.3 f-i
Ikra-02	122.0 ab	34.0 ab	362.9 ab	7.1 g	6.2 g	77.3 ab
MF-02	104.3 f	28.6 cd	326.7 ij	7.7 e-g	7.3 b-e	67.0 f-i
PrabhaniKaranti	103.5 f	24.9 e-g	342.0 e-h	8.7 b	7.5 b-d	61.7 j
Pen Beauty	104.9 f	23.6 f-h	348.1 c-f	7.5 fg	7.7 bc	65.4 h-j
Click-5769	104.9 f	23.8 f-h	338.2 f-h	8.0 c-f	7.5 b-d	63.4 ij
Kiran-51	112.6 de	22.1 h	345.7 c-g	7.8 d-f	6.7 d-g	66.5 hi
Ikra-04	119.0 bc	32.2 b	356.5 bc	7.3 fg	6.3 fg	76.1 a-d
SabzPari	118.5 b-d	32.6 ab	348.2 c-f	8.2 b-e	6.5 e-g	71.5 e-g
Mean	111.2	28.2	344.8	7.9	7.1	68.2
Significance	***	***	***	***	***	***
LSD Value	5.42	2.01	9.32	0.56	0.76	4.22

***,* show significant at $P \leq 0.01$ and $P \leq 0.05$ levels; while, NS = non-significant

Data represent the means of three replications of two separate experiments conducted during the years 2014 and 2015. Means having different letters are significantly different at $P \leq 0.05$ according to DMRT Test

Table 2: Comparison of okra genotypes for fruit length, fruit girth, fruits plant^{-1}, average fruit weight, and protein and ascorbic acid contents

Genotypes	Fruit length (cm)	Fruit girth (cm)	Fruits plant^{-1} (No.)	Average fruit weight (g)	Protein contents (%)	Ascorbic acid (mgg^{-1})
Patel	14.8 a	5.7 a-c	23.2 bc	13.4 a-c	14.7 a	0.26 bc
Durga	14.1 a	5.4 b-e	22.5 cd	13.1 a-c	14.0 ab	0.28 ab
Rama Krishna	14.4 a	5.5 a-d	25.9 a	14.3 a	14.7 a	0.30 a
ArkaAnamika	10.8 g	5.2 de	18.6 f-i	11.5 e-g	12.5 de	0.24 cd
Greenstar	11.7 c-g	5.2 de	18.6 f-i	11.7 d-g	12.5 de	0.23 d
Evergreen	11.1 fg	5.1 e	20.6 d-f	11.6 d-g	12.7 c-e	0.23 d
Line Brand	14.2 a	5.7 ab	23.9 bc	13.7 ab	14.7 a	0.29 a
Tulsi	12.0 b-g	5.2 de	19.1 e-i	11.6 d-g	12.7 c-e	0.26 bc
Anmol	11.5 d-g	5.7 a-c	20.7 d-f	11.8 d-f	13.4 b-d	0.24 cd
Sudani	12.6 b-d	5.8 a	16.1 j	10.5 g	11.7 e	0.20 e
OH-152	13.0 b	5.2 de	18.2 g-j	11.4 e-g	12.4 de	0.24 cd
Okra-7100	12.4 b-e	5.8 a	20.2 e-h	12.8 b-d	12.6 de	0.24 cd
Super Green	11.7 c-g	5.5 a-d	19.0 e-i	11.5 e-g	12.7 c-e	0.24 cd
Greengold	12.7 bc	5.2 de	18.9 f-i	11.4 e-g	13.1 b-d	0.26 bc
MF-03	11.1 fg	5.1 e	18.0 g-j	11.6 d-g	12.6 de	0.23 d
Anarkali	12.1 b-f	5.2 de	18.7 f-i	11.3 e-g	12.6 de	0.25 cd
Ikra-02	14.1 a	5.7 ab	24.6 ab	14.0 ab	13.7 bc	0.28 ab
MF-02	11.9 b-g	5.0 e	17.9 ij	11.7 d-g	13.3 b-d	0.26 bc
PrabhaniKaranti	11.4 e-g	5.1 de	17.0 ij	11.0 fg	12.6 de	0.24 cd
Pen Beauty	11.7 c-g	5.2 de	17.4 ij	11.4 e-g	13.2 b-d	0.26 bc
Click-5769	10.8 g	5.1 e	17.4 ij	11.5 e-g	12.7 c-e	0.25 cd
Kiran-51	10.9 g	5.3 c-e	17.6 ij	12.4 c-e	12.6 de	0.25 cd
Ikra-04	14.8 a	5.8 a	21.1 de	13.7 ab	13.0 b-d	0.24 cd
SabzPari	12.7 bc	5.4 b-e	20.2 e-g	13.2 a-c	13.4 b-d	0.26 bc
Mean	12.4	5.4	19.8	12.20	13.1	0.25
Significance	***	*	***	***	***	***
LSD Value	1.00	0.33	1.83	1.05	0.90	0.02

***,* show significant at $P \leq 0.01$ and $P \leq 0.05$ levels; while, NS = non-significant

Data represent the means of three replications of two separate experiments conducted during the years 2014 and 2015. Means having different letters are significantly different at $P \leq 0.05$ according to DMRT Test

Table 3: Comparison of okra genotypes for tenderness of fruit picked at 6th, 8th, 10th and 12th days after flower opening

Genotypes	Tenderness at 6th day (Newton)	Tenderness at 8th day (Newton)	Tenderness at 10th day (Newton)	Tenderness at 12thday (Newton)
Patel	2.1 h	3.1 kl	4.2 i	5.7 mn
Durga	2.1 h	3.1 kl	4.3 i	5.3 n
Rama Krishna	2.1 h	3.0 kl	4.1 i	5.3 n
ArkaAnamika	2.7 b-d	3.7 d-h	5.6 c-f	8.1 c-g
Greenstar	2.6 b-e	3.5 g-k	5.8 b-e	7.7 f-j
Evergreen	2.6 b-e	3.6 f-i	5.5 c-g	7.7 e-i
Line Brand	2.2 gh	3.3 h-l	4.9 h	6.2 l-n
Tulsi	2.7 b-e	3.5 g-l	4.9 gh	7.2 h-j
Anmol	2.4 e-g	3.7 e-h	5.0 f-h	7.2 h-j
Sudani	3.9 a	5.9 a	7.5 a	11.5 a
OH-152	2.8 bc	3.6 g-i	6.4 b	7.7 e-i
Okra-7100	2.2 gh	3.8 c-g	5.1 f-h	7.1 i-k
Super Green	2.6 b-e	4.2 bc	5.8 b-e	7.9 d-i
Greengold	2.7 b-e	3.9 c-g	5.1 e-h	8.3 c-f
MF-03	2.8 b	4.4 b	6.0 bc	8.6 b-f
Anarkali	2.3 f-h	3.5 g-l	5.8 b-d	7.4 g-j
Ikra-02	2.1 h	3.3 i-l	5.0 gh	6.0 l-n
MF-02	2.8 b	4.2 b-d	5.7 c-e	8.7 b-d
PrabhaniKaranti	2.7 b-e	4.0 b-f	6.4 b	9.3 b
Pen Beauty	2.5 c-f	3.8 c-g	5.8 b-e	8.9 bc
Click-5769	2.7 b-e	4.1 b-e	5.8 b-e	8.6 b-e
Kiran-51	2.5 d-g	3.6 f-i	5.8 b-e	7.8 d-i
Ikra-04	2.3 f-h	3.5 g-j	5.3 d-h	6.8 j-l
SabzPari	2.3 f-h	3.5 g-i	5.4 d-h	8.0 d-h
Mean	2.54	3.75	5.46	7.59
Significance	***	***	***	***
LSD Value	0.23	0.37	0.57	0.78

***,* show significant at $P \leq 0.01$ and $P \leq 0.05$ levels; while, NS = non-significant

Data represent the means of three replications of two separate experiments conducted during the years 2014 and 2015. Means having different letters are significantly different at $P \leq 0.05$ according to DMRT Test

Table 4: Estimation of GV, PV, GCV, PCV, H^2, GA and GA as percent of mean of all traits of okra genotypes

Parameters	GV	PV	GCV (%)	PCV (%)	H^2 (%)	GA	GA (as % of mean)
Plant height	53.90	60.27	6.61	6.98	89.5	14.23	12.80
No. of leaves plant^{-1}	17.19	18.67	14.70	15.32	90.1	8.07	28.63
Leaf area	147.46	179.53	3.52	3.88	82.2	22.68	6.58
Stem diameter	4.01	5.30	9.18	10.56	75.6	3.59	16.44
Days to flowering	11.40	13.57	8.93	9.75	84.0	6.38	16.86
Internodal length	0.43	0.62	8.33	10.01	69.4	1.13	14.30
Days to marketable fruit	0.41	0.62	8.98	11.10	65.5	1.07	15.09
Fruiting span	28.00	34.55	7.75	8.62	81.0	9.81	14.38
Fruit length	1.62	1.98	10.25	11.35	81.6	2.37	19.08
Fruit girth	0.05	0.09	4.31	5.69	57.4	0.37	6.72
No. of fruits plant^{-1}	6.23	7.47	12.61	13.81	83.4	4.67	23.61
Average fruit weight	0.98	1.39	8.13	9.66	70.7	1.72	14.07
Fruit weight plant^{-1}	2518.2	2879.6	19.27	20.60	87.5	96.67	37.12
Protein contents	0.52	0.81	5.48	6.89	63.3	1.18	8.99
Ascorbic acid	0.0004	0.0006	8.00	9.79	68.3	0.04	13.93
Fruit Tenderness							
6 days after flowering	0.12	0.18	13.58	16.47	68.0	0.59	23.08
8 days after flowering	0.29	0.41	14.29	17.09	69.8	0.93	24.59
10 days after flowering	0.55	0.66	13.52	14.91	82.2	1.38	25.25
12 days after flowering	1.90	2.13	18.19	19.25	89.4	2.69	35.43

GV: Genotypic variance, PV: Phenotypic variance, GCV: Genotypic coefficient of variation, PCV: Phenotypic coefficient of variation, H^2: Broad sense heritability, GA: Genetic advance, GA as % of mean: Genetic advance as percent of mean

Highly significant difference among genotypes for all attributes measured is an indication of significant genetic variability and diversity among genotypes (Hidayatullah *et al*., 2008). Hence, the scope for improvement of okra for studied traits is relatively high. All genotypes exhibited erect growth habit, which is beneficial for better interception of light (Hanson, 2005). Maximum number of leaves plant^{-1}, leaf area, fruit length, average fruit weight and plant height are important traits from selection point of view to get bumper yield (Haydar *et al*., 2007). Significantly positive association of yield plant^{-1}of okra with other related traits was confirmed by Ahiakpa *et al.* (2013), who indicated that

selection on the basis of these traits, can improve the breeding efficiency of okra. Variation for days to flowering, which ranged from 31 to 45 days, can help to select promising genotypes ('Rama Krishna', 'Ikra-02', 'Line Brand' and 'Ikra-04') for early flowering and fruiting, which can prolong the fruiting span and ensure availability of okra early in the market. Sharma *et al.* (2009) also emphasized on selection of genotypes with early flowering, which is beneficial to get early and more production. Number of nodes on main stem with minimum intermodal distance and number of fruits plant^{-1} are interrelated as observed in 'Ikra-02', 'Rama Krishna'and'Ikra-04'. These results were in agreement with the findings of Ashraful and Hossain (2006) who performed selection of okra genotypes with shortest internodal distance due to their potential to bear maximum number of fruits plant^{-1}.Okra genotypes also exhibited significant variation in fruit and yield traits *viz.*, fruit length, girth, average fruit weight, fruit number plant^{-1} and total yield plant^{-1}. 'Rama Krishna', 'Ikra-02', 'Line Brand', 'Ikra-04', 'Durga' and 'Patel' produced highest number of long, green and tender fruits with maximum average fruit weight, which contributed in enhancing total fruit yield of these genotypes and were considered superior over all other studied genotypes. In this study, fruit traits including fruits plant^{-1}, average fruit weight, fruit length and girth were positively associated with total yield plant^{-1}. Likewise, positive association of fruit number, size and individual fruit weight with total fruit weight plant^{-1} was also earlier envisaged by Adeniji and Aremu (2007) in okra and by Susic *et al.* (2002) in tomato. High fruit yield plant^{-1} of okra is the goal of breeders (Ashraful and Hossain, 2006) and they usually perform selection on the basis of traits closely associated with fruit yield (Adeniji and Peter, 2005). Fruit traits including number of fruits plant^{-1}, length, girth, individual fruit weight and total yield plant^{-1} of okra are genetically controlled traits, which have breeding values for effective selection to develop high yielding varieties (Binalfew and Alemu, 2016). 'Patel', 'Durga', 'Rama Krishna', 'Ikra-02', 'Line Brand' and 'Ikra-04' exhibited maximum fruit yield plant^{-1}, which can be incorporated in further breeding program of okra to develop high yielding okra varieties with good quality.

Okra fruits with higher firmness are less preferred for fresh consumption; while tender dark coloured fruits are always appreciated by the consumers (Olivera *et al*., 2012). Significant variations among genotypes for fruit tenderness harvested at 6th, 8th, 10th and 12th days after flower opening were also observed. Among the genotypes, fruits of 'Rama Krishna', 'Ikra-02' and 'Ikra-04', 'Patel', 'Durga' and 'Line Brand' retained their tenderness even at longest harvesting interval, *i.e.* 12th day after flower opening, as compared to other genotypes. So, these genotypes can be employed in breeding program to develop varieties, which can retain tenderness of fruits for longer days (Sinnadurai, 1992). Abundant pubescence on fruits and stem is disliked by the consumers (Akinyele and Oseikita, 2006) as well as by the field labour as observed in 'Sudani'.

Higher values of PCV than GCV for traits are indicative of influence of environment on the expression of desired traits (Mehta and Asati, 2008); while magnitude of broad sense heritability indicates the reliability with which a genotype can be known by its phenotypic expression (Sharma *et al*., 2009). However, values of GCV and PCV were recorded almost equal for a number of traits including plant height, number of leaves plant^{-1}, leaf area, days to flowering, fruit length, number of fruits plant^{-1}, fruit weight plant^{-1}, fruiting span and fruit tenderness, which indicated little environmental influence on the expression of traits, thereby providing opportunity for effective selection of these traits in okra (Mohanty, 2002). It is evident from the results (Table 4) that high broad sense heritability was recorded for most of the traits except fruit girth and days to marketable fruit where moderate to low heritability was noticed. Likewise, GA as percent of mean was recorded high for most of the traits except leaf area, fruit girth and protein contents, which was in consonance to the findings of Tasisa *et al.* (2011) and Ullah *et al.* (2012). High heritability coupled with high GCV and GA as percent of mean were also noticed for firmness of fruits harvested on 6th, 8th, 10th and 12th days after flower opening, which were effective for selection to develop long, tender and high yielding varieties of okra.

Conclusion

The findings of this study revealed that Rama Krishna, Ikra-02, Line Brand, Patel, Ikra-04 and Durga produced 35.4%, 32.4%, 28.8%, 20.9%, 18.7% and 11.5% more yield plant^{-1}respectively, in comparison to locally grown genotype "Sabz Pari". Likewise, fruits of these genotypes remained tender at all intervals of picking after flower opening. Moreover, highest values of heritability parameters for fruit quality traits indicated significantly high breeding values effective for selection and to incorporate in breeding programs for quality improvement of okra.

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