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Genetic Assessment for Fruit Yield and Horticultural Traits in Okra [*Abelmoschus esculentus* (L.) Moench]

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A B S T R A C T

Significant differences were observed among the genotypes for all the traits, indicated presence of sufficient variation. The estimates of PCV and GCV were high for first fruit producing node. Moderate PCV and GCV were noticed for days to 50 per cent flowering, plant height, fruit yield per plant, fruits per plant, nodes per plant and internodal length. High heritability along with high genetic advance were observed for days to 50 per cent flowering, fruit yield per plant, fruits per plant and nodes per plant indicating the role of additive gene action for their inheritance indicating these characters could be improved through direct selection. Fruit yield per plant showed positive association with plant height, harvest duration, fruits per plant, nodes per plant, fruit length and average fruit weight, while negative association with days to 50 per cent flowering, days to first picking, first fruit producing node, internodal length and dry matter.The number of fruits per plant had maximum direct effect on fruit yield per plant followed by days to 50 per cent flowering, average fruit weight and plant height. Harvest duration, days to first picking, first fruit producing node, internodal length, fruits per plant and fruit length contributed to fruit yield per plant indirectly.

Introduction

Okra [*Abelmoschus esculentus* (L.) Moench, 2n=130] is commonly known by many local names in different parts of the world. It is known as Guino-Gombo in Spanish, Guibeiro in Portuguese and Bhindi in India. Even within India, different names have been given in different regional languages (Chauhan, 1972). Young immature pods of okra can be consumed in different forms (Ndunguru and Rajabu, 2004). It has been grown commercially in India, Turkey, Iran, Western Africa, Yugoslavia, Bangladesh, Afghanistan, Pakistan, Burma, Japan, Malaysia, Brazil, Ghana, Ethiopia, Cyprus and the Southern United States. In India, it is cultivated around the year in one or other region due to wide range of climatic condition in different parts of the countryand is sixth important and popular vegetable crop. In India, the major okra producing states are West Bengal, Bihar, Odisha, Andhra Pradesh, Gujarat, Jharkhand, Chhattisgarh and Maharashtra. It is an amphidiploid of *Abelmoschus tuberculatus* with 2n=58 and unknown species with 2n=72.

Physiologically, it is a day neutral plant. The crop remains in bearing almost throughout the year except during winter from mid-November to mid-January in the plains.

Tender immature fruits are used in a variety of ways as cooked vegetable, boiled or fried, soups, sauces, stews in meat, frozen, canned and dehydrated products. It is also used in thickening of soups and gravies because of its high mucilage content. Its ripe seeds can be dried, roasted and ground to be used as a coffee substitute (Gemede *et al.,* 2015). The oil from its seeds is utilized in perfume industry. The dried fruit shell and stem containing crude fibre are used in paper industry. For a year round consumption sun dried, frozen and sterilized fruits are also important market products. Nutritionally, okra green fruits are rich in vitamins (C, A and B) and minerals (Ca, P, Mg and Fe). It also contains iodine and is, therefore, recommended for the treatment of goitre. Mucilage and fibre content present in okra helps in lowering down the glucose level of blood, hence, good for diabetic patients.

The progress in breeding for yield and its component characters of any crop is poly genetically controlled, environmentally influenced and determined by magnitude and nature of their genetic variability (Wright, 1935 and Fisher, 1981). Genetic variability and character association are pre-requisites for improvement of any crop including okra for selection of superior genotypes and improvement of any trait (Krishnaveni *et al.*, 2006). It is very difficult to judge whether observed variability is highly heritable or not. Moreover, knowledge of heritability is essential for selection based improvement as it indicates the extent of transmissibility of a character into future generations. Knowledge of correlation between yield and its contributing characters are basic and foremost attempt to find out guidelines for plant selection. The path analysis advised by (Dewey and Lu, 1959). Provides an effective means of finding out direct and indirect causes of associations and permits a critical examination of given correlation and measure relative importance of each factor. Such information reveals the possibility of simultaneous improvement of various attributes and also helps in increasing the efficiency of selection of complex inherited traits. Keeping in view the above facts, the present investigation was undertaken to assess the genetic parameters of variability among genotypes for fruit yield and related horticultural traits in order to identify the most promising okra lines and correlation, path coefficient among yield and its contributing characters using 19 okra genotypes (Table 1).

Materials and Methods

The present investigation was carried out at the Experimental Farm of Department of Vegetable Science and Floriculture, CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur during summer rainy season of2016. The experimental farm situated at 32˚ 6’ N latitude, 76˚ 3’ E longitude and 1291 m altitude. The place is characterized by severe winters and mild summers with high rainfall during monsoon. Agro-climatically, the location represents mid-hill zone of Himachal Pradesh and is characterized by humid-sub temperate climate. The experimental material consisted of 19 promising germplasm of okra Table 2. The experiment was laid out in a Randomized Complete Block Design with three replications. Seeds of okra were sown on 28thMay 2016 and each entry was accommodated in three rows spaced 45 cm apart with an intra-row spacing of 15 cm. Farm Yard Manure [@ 10 tonnes/ha] and chemical fertilizers (100 kg N, 50 kg P_2O_5, 50 kg K_2O /ha) were applied as per the recommended package of practices. Half dose of N and full doses of P_2O_5 and K_2O were applied at the time of field preparation. The remaining half dose of N was top dressed in two equal amounts, first at earthing up and second after one month. The intercultural operations including thinning, irrigations and pest-control were carried out in accordance with the recommended package of practices. The observations were recorded from 10 randomly selected plants from each treatment and their average values were used for statistical analysis.

The data on various characters *viz.*, days to 50 per cent flowering, days to first picking, plant height (cm), harvest duration (days), fruit yield per plant (g), fruits per plant, first flowering node, nodes per plant, internodal length (cm), fruit length (cm), fruit diameter (cm), average fruit weight, and dry matter were recorded. The mean values were subjected to statistical analysis (ANOVA) as suggested by (Panse and Sukatme, 1984). Phenotypic and genotypic co-efficient of variation (Burton and De-Vane, 1953), heritability, genetic advance as per cent mean were calculated. For categorizing the magnitude of different parameters, the following limits were used;

PCV, GCV and ECV

> 30 % = High
15-30 % = Moderate
<15 % = Low

Heritability (h^2_{bs})

> 80% = High
50-80% = Moderate
< 50% = Low

Genetic advance

> 30% = High
20-30% = Moderate
< 20 % = Low

Correlation coefficient was computed by using the formula of Johnson *et al.,* (1955) and path coefficient by Dewey and Lu (1959).

Results and Discussion

The analysis of variance showed that the variance due to genotypes was significant for all the traits studied (Table 3), indicating thereby the presence of genetic variability in the experimental material. There was highly significance differences were recorded for all the characters studied. The estimates of mean, genotypic co-efficient of variance (GCV), phenotypic co-efficient of variance (PCV), heritability (h^2), genetic advance (GA) and genetic advance over mean for different characters are presented in Table 4. The phenotypic coefficient of variation ranged from 9.90 % for days to first fruit picking to 42.05 % for first fruit producing node. The estimates of GCV and PCV were high for first fruit producing node, moderate for days to 50 per cent flowering, plant height, fruit yield per plant, fruits per plant, nodes per plant and internodal length. High to moderate values of PCV and GCV are indicative of sufficient variability ensuring ample scope for improvement through selection. There are a number of reports (Sawant *et al.,* 2014; Kandasamy 2015; Chandramouli *et al.,* 2016a; Badiger *et al.,* 2017; Makhdoomi *et al.,* 2018 and Vishnu Priyanka *et al.,* 2018) in support and contradiction to the present study.

In general the phenotypic values were higher than genotypic values, but differences were less for days to 50% flowering, days to first picking, harvest duration, fruit yield per plant, fruits per plant and nodes per plant, suggesting that these characters were less influenced by the environmental factors and thus selection on phenotypic basis would holds good. These results are in agreement with earlier finding Badiger *et al.,* (2017), Makhdoomi *et al.,* (2018) and Vishnu Priyanka *et al.,* (2018). The genotypic coefficient of variation alone is not sufficient to estimate the heritable variation present in a present population. But, heritability along with genetic advance provides a more reliable estimate for predicting the selection. High magnitude of broad sense heritability was noticed for days to 50 per cent flowering (94.24%), days to first picking (89.39%), fruit yield per plant (89.53%), fruits per plant (90.98%) and nodes per plant (80.98%), indicating that these traits were less influenced by the environment. This suggested that the large proportion of phenotypic variance has been attributed to the genotypic variance and hence reliable selection could be made for these traits on the basis of phenotypic expression. However, moderate heritability was recorded for plant height (79.15%), first fruit producing node (76.01%), harvest duration (74.92%), internodal length (63.80%), average fruit weight (62.59%) and dry matter (51.94%). Fruit diameter (45.32%) and fruit length (43.99%) exhibited low heritability (<50%), which suggested that there is considerable role of environment for the expression of these traits. Higher estimates of heritability had also been found by earlier workers for days to 50 per cent flowering and picking (Jindal *et al.,* 2010 and Kerure *et al.,* 2017), fruits per plant (Duggi *et al.,* 2013 and Vishnu Priyanka *et al.,* 2018), nodes per plant (Sawant *et al.,* 2014and Makhdoomi *et al.,* 2018) and fruit yield per plant (Kandasamy 2015and Makhdoomi *et al.,* 2018). Moderate heritability had also been found by earlier workers for plant height (Reddy *et al.,* 2012 and Sawant *et al.,* 2014), first fruit producing node (Reddy *et al.,* 2012 and Kerure *et al.,* 2017), harvest duration (Duggi *et al.,* 2013), internodal length (Chandramouli *et al.,* 2016a and Badiger *et al.,* 2017) and average fruit weight (Mallesh *et al.,* 2015 and Kerure *et al.,* 2017). Similarly, for fruit diameter low heritability was recorded by Karri and Acharyya 2012 and Vishnu Priyanka *et al.,* 2018.

Though, the heritability estimates provide the information on the magnitude of inheritance of quantitative characters, it does not indicate the magnitude of genetic gain obtained by selection of best individual from the best population. So, heritability along with genetic advance is more useful for selection than heritability alone. The study revealed that the characters days to 50 per cent flowering (30.38%), plant height (32.94%), fruit yield per plant (55.13%), fruits per plant (42.35%), first fruit producing node(65.84%), nodes per plant (35.49%) and internodal length (34.76%) had higher genetic advance as per cent of mean. Lower genetic advance was exhibited by the characters days to first picking (18.23%), harvest duration (18.36%), fruit length (15.90%), fruit diameter (14.93%) and dry matter (12.02%). High heritability coupled with high genetic advance as per cent of mean were observed for days to 50 per cent flowering, fruit yield per plant, fruits per plant and nodes per plant. High to moderate heritability with high to moderate genetic advance for plant height, first fruit producing node, internodal length and average fruit weight confirming the preponderance of additive genes in controlling the expression of these characters and thus were found to be providing better opportunity for effective and reliable selection for these characters. High heritability with low genetic advance was observed for days to first picking. Moderate heritability with low genetic advance noticed for the traits harvest duration and dry matter and low heritability coupled with low genetic advance for the traits fruit length and fruit diameter suggests the preponderance of non-additive gene action and consequently improvement of these traits through recombination breeding is possible. Improvement of these traits through straight selection might not give desirable results. Similar results were obtained by earlier workers in case of fruit yield per plant (Mallesh *et al.,* 2015 and Chandramouli *et al.,* 2016a), fruits per plant (Khajuria *et al.,* 2015 and Kerure *et al.,*2017), nodes per plant (Chandramouli *et al.*, 2016a and Goswami *et al.*, 2016), plant height (Sawant *et al.,* 2014 and Kerure *et al.,* 2017), first fruit producing node (PhaniKrishna *et al.*, 2015 and Kerure *et al.*, 2017), internodal length (Badiger *et al.*, 2017), average fruit weight (Mallesh *et al.*, 2015; Badiger *et al.*, 2017 and Kerure *et al.*, 2017), days to first picking (Badiger *et al.*, 2017), harvest duration (Duggi *et al.*, 2013), fruit length (Karri and Acharyya, 2012; Kerure *et al.*, 2017) and fruit diameter (Karri and Acharyya, 2012).

The phenotypic and genotypic correlation coefficients between different characters are presented in Table 5. Genotypic coefficient of correlation, in general, were greater in magnitude than the corresponding phenotypic ones, indicating that there is a strong inherent association between various characters and phenotypic expression of correlation was lessened under the influence of environment. Fruit yield per plant showed positive association with fruits per plant, nodes per plant, average fruit weight, harvest duration, fruit length and plant height were observed at genotypic and phenotypic levels, indicating mutual association of these traits. Looking at these association appeared that higher fruit yield can be obtained by increasing fruits per plant, nodes per plant, average fruit weight, harvest duration, fruit length, and plant height.Positive association of fruit yield per plant was reported with fruits per plant (Archana *et al.*, 2015 and Kumar *et al.*, 2016), nodes per plant (Archana *et al.*, 2015 and Patil *et al.*, 2016), average fruit weight (Archana *et al.*, 2015 and Singh *et al.*, 2017), harvest duration (Chandramouli *et al.*, 2016b), fruit length (Chandramouli *et al.*, 2016b and Prasath *et al.*, 2017) and plant height (Patil *et al.*, 2016 and Rajeev *et al.*, 2017).

Table.1 List of okra genotypes and their sources

Sr. No.	Genotype	Source
1	Palam Komal	CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur
2	9801	CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur
3	VRO-4	Indian Institute of Vegetable Research, Varanasi
4	Parbhani Kranti	Marathwada Agricultural University, Parbhani
5	P-8	Punjab Agricultural University, Ludhiana, Punjab
6	Hisar Unnat	CCS Haryana Agricultural University, Hissar, Haryana
7	Tulsi-1	CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur
8	SKBS-11	SK University of Agricultural Sciences and Technology, Srinagar
9	VRO-6	Indian Institute of Vegetable Research, Varanasi
10	P-20	CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur
11	Parmil-1	CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur
12	IC-169468	NBPGR, Regional Station, Dr. PDKV Campus, Akola, Maharashtra
13	P-21	CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur
14	Pusa A-4	Indian Agricultural Research Institute, New Delhi
15	Japan Red	Japan
16	Japan 5-Ridged	Japan
17	Japan Round	Japan
18	Japan Thick	Japan
19	Kanpur local	Local area, Kanpur

Table.2 Analysis of variance for quantitative and quality traits in 19genotypes of okra

Source	d.f	Quantitative traits: Phenological and structural traits				Quantitative traits: Fruit yield trait								Quality traits
		Days to 50% flowering	Days to first picking	Plant height (cm)	Harvest duration (days)	Fruit yield per plant (g)	Fruits per plant	First fruit producin g node	Nodes per plant	Internodal length (cm)	Fruit length (cm)	Fruit diameter (cm)	Average fruit weight (g)	Dry matter (%)
Replication	2	15.91	10.12	166.62	4.08	308.89	0.61	0.41	0.14	2.19	2.91	0.01	2.34	0.13
Genotypes	18	200.53*	89.35*	3253.35*	107.64*	7,226.42*	16.51*	2.12*	16.84*	37.70*	9.44*	0.16*	13.63*	1.80*
Error	36	4.01	3.40	262.64	10.81	271.13	0.53	0.20	1.22	6.00	2.81	0.05	2.27	0.42

*Significant at 5% level

Table.3 Estimates of Phenotypic coefficient of variation (PCV), Genotypic coefficient of variation (GCV), Heritability and genetic advance in 19 genotypes of okra

S. No.	Characters	Range	Mean±S.E(m)	Variability (%)		Heritability (%)	Genetic advance as (%) of mean
				PCV	GCV		
I. Quantitative traits							
a) Phenological and structural traits							
	Days to 50 per cent flowering	46.33-77.00	53.29 ±1.16	15.65 (M)	15.19 (M)	94.24(H)	30.38 (H)
	Days to first picking	52.00-73.33	57.19 ±1.07	9.90 (L)	9.36 (L)	89.39 (H)	18.23 (L)
	Plant height (cm)	110.80-241.71	175.66 ±9.36	20.21(M)	17.98 (M)	79.15 (M)	32.94 (H)
	Harvest duration (days)	40.66-60.00	55.18 ±1.90	11.90 (L)	10.30(L)	74.92 (M)	18.36 (L)
b)	**Fruit yield traits**						
	Fruit yield per plant (g)	94.25-261.92	170.23 ±9.51	29.89 (M)	28.28(M)	89.53 (H)	55.13 (H)
	Fruits per plant	7.50-15.03	10.71 ±0.42	22.60 (M)	21.55(M)	90.98 (H)	42.35 (H)
	First fruit producing node	1.10-4.47	2.18 ±0.26	42.05 (H)	36.66(H)	76.01 (M)	65.84 (H)
	Nodes per plant	8.53-16.33	11.92 ±0.64	21.28 (M)	19.15 (M)	80.98 (H)	35.49 (H)
	Internodal length (cm)	8.90-22.77	15.39 ±1.41	26.45 (M)	21.13 (M)	63.8 (M)	34.76 (H)
	Fruit length (cm)	8.41-15.54	12.78 ±0.97	17.54 (M)	11.64(L)	43.99 (L)	15.9 (L)
	Fruit diameter (cm)	1.37-2.40	1.80 ±0.12	15.10 (M)	10.77(L)	45.32 (L)	14.93 (L)
	Average fruit weight (g)	10.71-18.85	15.77 ±0.87	15.61 (M)	12.35(L)	62.59 (M)	20.12 (M)
II.	**Quality traits**						
	Dry matter (%)	6.80-10.53	8.35 ±0.38	11.23 (L)	8.10 (L)	51.94 (M)	12.02 (L)

H=High, M= Medium, L= Low

Table.4 Estimates of correlation coefficients at the phenotypic (P) and genotypic (G) levels for quantitative and quality traits in okra

Traits		Quantitative traits										Quality traits	
		Phenological and structural traits			Fruit yield trait								
		Days to first picking	Plant height (cm)	Harvest duration (days)	Fruits per plant	First fruit producing node	Nodes per plant	Internodal length (cm)	Fruit length (cm)	Fruit diameter (cm)	Average fruit weight (g)	Dry matter (%)	Fruit yield per plant (g)
Days to 50 per cent flowering	P	0.879**	0.090	-0.744**	-0.505**	0.707**	-0.500**	0.533**	-0.181	0.514**	-0.045	0.500**	-0.402**
	G	0.959**	0.138	-0.881**	-0.552**	0.862**	-0.557**	0.707**	-0.333*	0.763**	-0.036	0.700**	-0.437**
Days to first picking	P		0.016	-0.863**	-0.447**	0.740**	-0.445**	0.425**	-0.271*	0.437**	-0.148	0.525**	-0.423**
	G		-0.000	-0.941**	-0.484**	0.895**	-0.519**	0.495**	-0.381**	0.723**	-0.288*	0.699**	-0.488**
Plant height (cm)	P			0.223	0.259	-0.096	0.251	0.469**	0.376**	0.062	0.336*	-0.210	0.355**
	G			0.285*	0.292*	-0.230	0.373**	0.483**	0.744**	0.114	0.491**	-0.347**	0.424**
Harvest duration (days)	P				0.567**	-0.733**	0.580**	-0.423**	0.365**	-0.315*	0.245	-0.540**	0.554**
	G				0.627**	-0.963**	0.681**	-0.410**	0.473**	-0.674**	0.461**	-0.766**	0.660**
Fruits per plant	P					-0.564**	0.922**	-0.579**	0.348**	-0.207	0.216	-0.446**	0.862**
	G					-0.680**	1.000**	-0.685**	0.506**	-0.405**	0.371**	-0.610**	0.910**
First fruit producing node	P						-0.535**	0.422**	-0.399**	0.371**	-0.387**	0.610**	-0.620**
	G						-0.657**	0.490**	-0.681**	0.540**	-0.648**	1.000**	-0.791**
Nodes per plant	P							-0.614**	0.368**	-0.279*	0.248	-0.400**	0.817**
	G							-0.632**	0.541**	-0.392**	0.332*	-0.549**	0.900**
Internodal length (cm)	P								-0.094	0.231	0.112	0.204	-0.395**
	G								0.144	0.490**	0.081	0.346**	-0.477**
Fruit length (cm)	P									-0.028	0.427**	-0.432**	0.487**
	G									-0.480**	0.775**	-0.760**	0.709**
Fruit diameter (cm)	P										0.068	0.230	-0.125
	G										0.250	0.773**	-0.199
Average fruit weight (g)	P											-0.219	0.664**
	G											-0.495**	0.718**
Dry matter (%)	P												-0.449**
	G												-0.692**

* Significant at 5% level, **Significant at 1% level

Table.5 Estimation of direct and effects of quantitative and quality traits on fruit yield per plant at the phenotypic (P) and genotypic (G) levels in okra

Genotypes/Traits		Quantitative traits												
		Phenological and structural traits fruit yield traits											Quality traits	
		Days to 50 per cent flowering	Days to first picking	Plant height (cm)	Harvest Duration (days)	Fruits per plant	First fruit producing node	Nodes per plant	Internodal length (cm)	Fruit length (cm)	Fruit diameter (cm)	Average fruit weight (g)	Dry matter (%)	Fruit yield per Plant (g)
Days to 50% flowering	P	**0.075**	-0.100	0.004	0.039	-0.388	0.013	0.030	-0.044	-0.001	-0.007	-0.023	-0.002	-0.402**
	G	**0.675**	-1.368	0.019	0.905	-0.637	-0.109	0.018	0.122	0.090	0.129	-0.007	-0.272	-0.437**
Days to 1st picking	P	0.066	**-0.110**	0.001	0.046	-0.344	0.014	0.027	-0.035	-0.002	-0.006	-0.076	-0.003	-0.423**
	G	0.647	**-1.426**	-0.000	0.966	-0.559	-0.113	0.016	0.085	0.103	0.122	-0.058	-0.272	-0.488**
Plant Height	P	0.007	-0.002	**0.043**	-0.012	0.200	-0.001	-0.015	-0.040	0.003	-0.001	0.171	0.001	0.355**
	G	0.093	0.000	**0.134**	-0.293	0.337	0.029	-0.012	0.083	-0.202	0.019	0.099	0.135	0.424**
Harvest Duration	P	-0.055	0.095	0.010	**-0.053**	0.436	-0.014	-0.035	0.035	0.003	0.004	0.125	0.003	0.554**
	G	-0.595	1.342	0.038	**-1.026**	0.723	0.122	-0.022	-0.071	-0.128	-0.114	0.093	0.297	0.660**
Fruits per plant	P	-0.038	0.049	0.011	-0.030	**0.769**	-0.011	-0.055	0.048	0.003	0.003	0.110	0.002	0.862**
	G	-0.373	0.691	0.039	-0.643	**1.154**	0.086	-0.032	-0.118	-0.137	-0.069	0.074	0.237	0.910**
1st fruit producing node	P	0.053	-0.082	-0.004	0.038	-0.434	**0.019**	0.032	-0.035	-0.003	-0.005	-0.197	-0.003	-0.620**
	G	0.581	-1.276	-0.031	0.988	-0.784	**-0.127**	0.021	0.084	0.184	0.091	-0.131	-0.394	-0.791**
Nodes per plant	P	-0.037	0.049	0.011	-0.031	0.709	-0.010	**-0.060**	0.051	0.003	0.004	0.126	0.002	0.817**
	G	-0.376	0.740	0.050	-0.698	1.175	0.083	**-0.032**	-0.109	-0.147	-0.066	0.067	0.213	0.900**
Internodal length	P	0.040	-0.047	0.020	0.022	-0.445	0.008	0.037	**-0.083**	-0.001	-0.003	0.057	-0.001	-0.395**
	G	0.477	-0.706	0.065	0.421	-0.790	-0.062	0.020	**0.172**	-0.039	0.083	0.016	-0.134	-0.477**
Fruit length	P	-0.013	0.030	0.016	-0.020	0.268	-0.007	-0.022	0.008	**0.008**	0.000	0.218	0.002	0.487**
	G	-0.225	0.543	0.100	-0.486	0.584	0.086	-0.017	0.025	**-0.271**	-0.081	0.156	0.295	0.709**
Fruit diameter	P	0.038	-0.048	0.003	0.017	-0.160	0.007	0.017	-0.019	-0.000	**-0.013**	0.035	-0.001	-0.125
	G	0.515	-1.031	0.015	0.691	-0.467	-0.068	0.012	0.084	0.130	**0.169**	0.051	-0.300	-0.199
Average fruit weight	P	-0.003	0.016	0.015	-0.013	0.166	-0.007	-0.015	-0.009	0.003	-0.000	**0.510**	0.001	0.664**
	G	-0.024	0.410	0.066	-0.473	0.428	0.082	-0.011	0.014	-0.210	0.042	**0.202**	0.192	0.718**
Dry matter	P	0.037	-0.058	-0.009	0.029	-0.343	0.011	0.024	-0.017	-0.003	-0.003	-0.111	**-0.005**	-0.449**
	G	0.472	-0.997	-0.046	0.786	-0.704	-0.128	0.017	0.060	0.206	0.131	-0.100	**-0.388**	-0.692**

Residual effect: P= 0.01552, G= -0.00642 Bold values indicate direct effects

The negative association of fruit yield per plant was observed with internodal length (Mohammad and Marker 2017), days to 50 per cent flowering Kerure *et al.,* (2017), days to first picking Prasath *et al.,* (2017) and first fruit producing node Mohammad and Marker (2017) (Table 5). The negative association of fruit yield was also reported with dry matter Arora *et al.,* (2008).

Fruits per plant positive and strong association with nodes per plant and fruit length; harvest duration with fruits per plant, nodes per plant and fruit length; plant height with internodal length and fruit length; first fruit producing node with internodal length, fruit diameter and dry matter; fruit length with average fruit weight and could be improved through selection based on either of these characters. Correlation analysis revealed that direct selection for the traits like plant height, harvest duration, fruits per plant, nodes per plant, fruit length and average fruit weight could be effectively used as selection indicates for improvement of okra.

In path coefficient analysis, where the total genotypic association between fruit yield per plant and other characters revealed that maximum direct contributing was made by fruits per plant (1.154) followed by days to 50 per cent flowering (0.675), average fruit weight (0.202) and plant height (0.134). The high positive indirect effect was found in case of harvest duration, days to first picking, first fruit producing node, internodal length, fruits per plant and fruit length. These have been corroborated by Kerure *et al.,* (2017) and these were most important characters for selection and these traits can also be relied upon for improving fruit yield of the crop.

The genetic architecture of fruit yield per plant is based on the balance or overall net effect produced by various yield components interacting with one another. Based on the studies on genetic variability, correlation and path analysis, it may be concluded that plant height, harvest duration, fruits per plant, number of fruiting nodes, fruit weight, shorter internodal length, fruit length and days to first picking appeared to be primary yield contributing characters and could be relied upon for selection of genotypes to improve genetic yield potential of okra.

Author's declaration

The authors declare that the manuscript has not been submitted to any other journal for publication at the same time and will not be sent to other journal when communicated to The International Journal of Current Microbiology and Applied Science until the rejection. The authors have no conflict of interest.

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