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Studies on genetic divergence (D²) for fruit yield and its contributing traits in okra [*Abelmoschus esculentus* L. Moench]

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Abstract
The present investigation entitled "Studies on genetic divergence (D²) for fruit yield and its contributing traits in okra [*Abelmoschus esculentus* L. Moench]", was conducted during *Kharif* 2019. The experiment comprised of thirty genotypes at Main Experimental Station, Department of Vegetable Science, Acharya Narendra Deva University of Agriculture and Technology, Narendra Nagar (Kumarganj), Ayodhya, Uttar Pradesh, India. The study of genetic divergence among the thirty genotypes of okra was carried out using Mahalanobis D² statistics. The thirty genotypes of were grouped into six different non over lapping clusters Table 1. Cluster II was the biggest consisting of 8 genotypes followed by IV consisting (6 genotypes), V consisting (5 genotypes), cluster I, III (4 genotypes) and cluster VI has 3 genotypes. Experimental material for study consisted of 30 genotypes including three checks (Parbhani Kranti, Pusa Sawani and Pusa Makhmali). The experiment was conducted in Randomised Block Design with three replications. Each genotypes consisted of three rows spaced 60 cm with plant to plant spacing of 30 cm. Observation were recorded for fourteen different characters of okra *i.e.* node to first flower appearance, days to 50% flowering, plant height (cm), crop duration, number of branches per plant, days to first fruit harvest, number of nodes per plant, total soluble solid (^{0}B.), fruit length (cm), fruit circumference (cm), average fruit weight (g), number of fruits per plant, marketable fruit yield per plant (g) and total fruit yield per plant (g).

Keywords: okra, genetic divergence, cluster and genotype.

Introduction
Okra [*Abelmoschus esculentus* (L.) Moench 2n=2x=130] is an economically important vegetable crop grown in tropical and sub-tropical parts of the world. Okra is the most traditional and popular vegetable of India and extensively cultivated in summer as well as in rainy season throughout India. The largest area and production of okra is in India followed by Nigeria in the world. Okra is an African word and is native to northern Africa including the area of Ethiopia and Sudan. It is grown commercially in India, Turkey, Iran, Western Africa, Yugoslavia and Bangladesh. India ranks first in the world. In India okra is commercially grown in Gujarat, Maharashtra, Andhra Pradesh, Uttar Pradesh, Madhya Pradesh and West Bengal. India ranks first in the world with 73 % of total world production. During 2018-2019 the okra crop had an average productivity of 11.9 mt/ha covers an area of 0.53 m ha with annual production of 6.85 mt all over India. Okra is cultivated for its green non-fibrous fruits or pods containing round seeds. Mucilage is obtained from the dry roots and stem soaked in water over night and are used for clarifying sugarcane juice in jaggery or gur making (Chauhan, 1972) [3]. The greenish yellow edible oil has a pleasant taste and odour, and is high in unsaturated fats such as oleic acid and linoleic acid. The oil content of the seed is quite high at about 40%. Okra is excellent source of iodine which is beneficial for the control of goiter disease. 100g of consumable unripe bhindi fruit contains 10.40g dry matter, 3100 calorie energy, 1.80g protein, 6.4g carbohydrates, 0.2g fat, 1.2g fiber, 0.7 g minerals, 66.0 mg calcium, 56.0mg phosphorus, 6.9mg sodium, 30.0mg sulphur 1.0mg iron, 103.0mg potassium and 0.10mg carotene.

Material and methods
The experiment was conducted at Main Experimental Station, Department of Vegetable Science, Acharya Narendra Deva University of Agriculture and Technology, Narendra Nagar (Kumarganj), Ayodhya, Uttar Pradesh, India during *Kharif* 2019. The experimental material for study consisted of 30 genotypes including three checks (Parbhani Kranti, Pusa Sawani and Pusa Makhmali). The experiment was conducted in Randomised Block Design with three replications. Each genotypes consisted of three rows spaced 60 cm apart with plant to plant spacing of 30 cm. Observation were recorded for fourteen different characters of okra *i.e.* node to first flower appearance, days to 50% flowering, plant height (cm), crop duration, number of branches per plant, days to first fruit harvest, number of nodes per plant, total soluble solid (^{0}B.), fruit length (cm), fruit circumference (cm), average fruit weight (g), number of fruits per plant, marketable fruit yield per plant (g) and total fruit yield per plant (g).

Results and discussion
Cluster II was the biggest cluster consisting 8 genotypes followed by cluster IV consisting 6 genotypes, cluster V consisting 5 genotypes, cluster I, III (4 genotypes) and cluster VI (3 genotypes). The distribution pattern of genotypes

among different clusters also indicated that there is no geographical parallelism in the grouping indicating that genotypes of different geographical origin may grouped together or vice-versa.

Intra and Inter-cluster distance
The estimates of inter- and intra-cluster distances represented by D^2 values are given in Table 2. The intra cluster D2 values ranged from 2.353 (cluster VI) to 3.020 (cluster IV). The maximum inter-cluster distances were observed between cluster II to cluster VI (5.038) which suggested that members of these two clusters were genetically very diverse to each other. The inter-cluster values between cluster II to cluster IV, cluster VI to cluster V, cluster I to cluster VI, cluster IV to VI, cluster III to VI, cluster I to cluster VI were high value. The minimum inter-cluster distances between cluster I to cluster I followed by cluster IV to cluster VI. The higher inter-cluster distance indicated greater genetic divergence between the genotypes of those clusters, while lower inter-cluster values between the clusters suggested that the genotypes of the clusters were not much genetically diverse from each other. Prakash *et al.* (2010) and Shaikh *et al.* (2013) had also reported maximum contribution by days to 50% flowering.

Table 1: Clustering pattern of thirty genotypes of okra on the basis of Mahalanobis D^2 statistics

Cluster number	No. of genotypes	Genotypes
I	4	EMS-8-1, GS-43, BO-13 and Pusa Sawani (C)
II	8	BCO-1, DOV-91-4, Hissar Unnat, Azad Bhindi-2, Kashi Vibhuti, Parbhani Kranti (C), Pusa Makhmali (C) and Arka Abhay
III	4	Kashi Satdhari, SB-6, Punjab Padmini and Kashi Kranti
IV	6	Pusa A-4, Larm-1, GO-3, Vindi Vaphy, Kashi Mangali and Avinash-46-1
V	5	Kashi Lila, Kashi Pragati, VRO-22, MISO-77 and Selection-21
VI	3	Bhindi S-51, Super Green Gold and Arka Anamika

Table 2: Intra and inter cluster D^2 values for six cluster in okra

Clusters	I	II	III	IV	V	VI
I	2.411	3.031	3.588	4.365	3.372	4.045
II		2.429	3.384	5.032	3.719	5.038
III			2.756	4.453	3.218	4.146
IV				3.020	4.415	4.287
V					2.926	3.112
VI						2.353

Table 3: Cluster means for fourteen fruit yield and its contributing characters in 30 okra genotypes

Characters	Node to first flower appearance	Days to 50% Flowering	Plant height (cm)	Crop duration	Number of branches per plant	Days to first fruit harvest	Number of nodes per plant	Total Soluble Salt (^{0}B)	Fruit Length (cm)	Fruit circumference (cm)	Average fruit weight (g)	Number of fruits per plant	Marketable fruit yield per plant (g)	Total fruit yield per plant (g)
I	7.29	41.82	102.35	114.99	5.21	48.44	10.71	11.77	9.16	6.00	16.35	10.37	137.33	182.26
II	6.98	42.13	113.39	118.39	4.21	49.16	10.10	11.79	10.83	5.62	18.15	9.39	118.22	157.41
III	6.73*	44.93	90.88	109.50	4.16	51.83	13.34	14.45	9.51	6.13	13.30	8.23	125.68	163.44
IV	8.04**	45.92	117.54	122.86	4.34	52.77	10.29	13.10	10.30	5.63	18.37	8.99	129.24	165.83
V	6.74	45.97	132.03	116.27	4.87	52.93	9.14	12.38	9.13	5.42	18.31	7.92	104.76	144.99
VI	6.77	44.40	115.68	122.00	5.22	51.17	11.69	13.89	9.05	5.04	17.44	10.20	110.12	141.79

*Lower value, **Higher value

Cluster means
The intra-clusters mean for fourteen characters in okra are given in Table 3. A perusal of table showed that cluster means for different traits indicated considerable differences between

the clusters. Highest cluster mean for node to first flower appearance character cluster IV (8.04) while lowest in cluster III was observed. Highest cluster mean for days to 50 % flowering character in cluster V while, lowest in cluster II was

observed. Highest cluster mean for Plant height character was observed in the cluster V while, lowest in cluster III (90.88). The lowest cluster mean for crop duration was observed in cluster III (109.50) while, highest in cluster IV (122.86). Highest cluster mean for Number of branches per plant character was observed in the cluster VI (5.22) while, lowest cluster III (4.16). Highest cluster mean for days to first fruit harvest character was observed in the cluster V (52.93) while, lowest in cluster I (48.44). Number of nodes per plant lowest cluster mean was observed in cluster V while, highest in cluster III.

Total soluble solid cluster mean was observed lowest in cluster I while, highest in cluster III (14.45). Highest cluster mean for fruit length character was observed in the cluster II while, lowest in cluster I. Highest cluster mean for fruit circumference character was observed in the cluster III while, lowest in cluster VI. Average fruit weight cluster mean was observed in lowest in cluster III (13.30) while, highest in the cluster I (18.37).

Highest cluster mean for number of fruits per plant character was observed in the cluster I (10.37) followed by cluster VI (10.20) while, the lowest in cluster V (7.92). Highest cluster mean for marketable fruit yield per plants character was observed in the cluster I (137.33) followed by cluster IV (29.24) while, lowest in cluster V. Highest cluster mean for total fruit yield per plant character was observed in the cluster I (182.26) followed by cluster IV while, the lowest in cluster VI (141.79). The analysis of percent contribution of characters towards total genetic divergence between thirty genotypes of okra had been given in Table 4. The maximum contribution in manifestation of total genetic divergence was made by days to first fruit harvest (10.56) followed by node to first flower appearance (9.62). The minimum contribution were recorded in case of crop duration (9.48), number of branches per plant (8.58), days to 50 % flowering (8.55), plant height (7.61), fruit circumference (6.83), marketable fruit yield per plant (8.26), total fruit yield per plant (6.21), fruit weight (6.16), number of nodes per plant (5.10), number of fruit per plant (5.65), fruit length (4.81) and total soluble solid (4.58)

Table 4: Per cent contribution of fourteen characters toward total genetic divergence in okra

Sr. No.	Character	Percent contribution
1.	Node to first flower appearance	9.62
2.	Days to 50% Flowering	8.55
3.	Plant height (cm)	7.61
4.	Crop duration	9.48
5.	Number of branches per plant	8.58
6.	Days to first fruit harvest	10.56
7.	Number of nodes per plant	5.10
8.	Total Soluble Solid (ºB)	4.58
9.	Fruit Length (cm)	4.81
10.	Fruit circumference (cm)	6.83
11.	Average fruit weight (g)	6.16
12.	Number of fruits per plant	5.65
13.	Marketable fruit yield per plant (g)	6.26
14.	Total fruit yield per plant (g)	6.21

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