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Yield Analysis of okra (*Abelmoschus Esculentus* (L.) Moench) Accessions Using performance Index and Ranking Methods

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Abstract

Plant breeders select genotypes based on performances across varied environments and years for stability. Various methods are used to identify good performing genotypes, but performance index (PI), mean rank index (MRI) and scatter diagram (SD) methods are rapid, easy and practicable approach to selecting superior genotypes. This study assesses pod yield of nineteen okra accessions in replicated experiments for two years in three environments representing okra growing areas of south west, Nigeria. The pod yield/plot analysis revealed that NGB00469, NGB00467, NGB00371, NGB00514, NGB00328 and NGB00322 are high yielding across the 6environments. The PI was highest for NGB00469 (94), NGB00467 (83), NGB00371 (67), NGB00514 (56), NGB00328 (50) and NGB00322 (50). MRI was very low (≤6) for these six accessions. Scatter diagram identified and classified the six accessions as outstanding. The PI, MRI and SD methods are simple and easy alternative methods devoid of cumbersome calculation for identifying superior okra accessions.

Keywords: *Okra accessions; Performance index; Rank; Classification; Adaptable*

Introduction

Okra (*Abelmoschus esculentus* (L.) Moench) is native of West Africa, one of the commonly grown vegetable crops in the tropics due to warm climates. It is an important fruit vegetable crop with good source of calorie (4550Kcal/kg) for human consumption as could be boiled, fried or cooked (Reddy 2010, Benchasr 2012, Gemede et al. 2015). It contains 86% of water, 2.2% of protein, 10% of carbohydrate, 0.2% of fat and vitamins A, B and C (Christo and Onuh 2005, Vishnu 2018); Okra is grown for its tender fresh pods which are rich in vitamins, minerals and protein (Mbah et al. 2009, Gemede et al. 2015). The mature seeds can be roasted, ground and added to coffee as an adubiant, the okra leaves could be used as animal feeds, young leave can be consumed as salad and the dried leaves can be grounded into powder for storage (Prota 2004, Benchasr 2012). Okra mucilage is suitable for medicinal and industrial applications, the stem for extraction of fiber, ease of cultivation, bountiful returns and high export potential (FAO 1996, Reddy 2010, Vishnu 2018).

Germplasm is an indispensible material to plant breeders and it is plays key role for genetic improvement of any crop. Inbred line development is an important means of crop improvement before they are released as superior genotypes. Okra pod yield is a

complex quantitative trait as it is governed by a large number of genes and considerably affected by the environments and years. Selection of okra lines based on individual location and could be faulty and misleading, thus the need for multiple location and year evaluations to identify and select superior and stable genotypes (Hammon and Van Sloten 1989, Ishaq and Falusi 2008, Kumar et al. 2010, Benchasr 2012).

Significant tests are used for discriminating between genotypic performances, thus, significantly similar or different means are assigned same or different alphabets as identifiers of similar or dissimilarity. This is a universally established procedure, but it tends to be cumbersome especially if the number of varieties increases, large data set and evaluation is done across several environments and years, thereby making easy and quick identification of superior genotypes very difficult and near impossible. This paper present an alternative, simple and practicable approach; performance index (PI), mean rank index (MRI) and scatter diagram (SD) to evaluate and identify superior genotypes among pod yield of nineteen okra breeding accessions.

Material and Methods

Nineteen okra accessions were obtained from National Centre of Genetic Resources and Biotechnology, Ibadan, Nigeria (NACGRAB) for this study. The nineteen accessions were grown for 2 years (2017 and 2018) and 3 locations; Teaching and Research Farm of the Federal University of Agriculture, Abeokuta (Rainforest, Latitude 7°27'N, Longitude 3°23'E, 638m ASL, Alfisol soil, average rainfall and temperature are 1130m and 28°C), research field of NACGRAB (Derived savannah, Latitude 7°40'N, Longitude 3°92'E, 230m ASL, Clayey loam soil, average rainfall and temperature are 1420mm and 25°C) and research field of College of Education, Ijanikin (Mangrove swamp, Latitude 6°52'N, Longitude 3°37'E, 41m ASL, Alluvial soil, average rainfall and temperature are 1508m and 22°C).

The experiment was laid in a Randomized Complete Block Design, replicated three times for the two cropping seasons (2017 and 2018). The nineteen accessions were sown using 3 seeds/hole and later thinned to 2 plants/hole at a spacing of 0.30 x 0.60m intra and inter row, 6m long row and 4rows/plot. Recommended crop management practices were followed to raise successful okra as recommended by National Institute of Horticultural Research and Training (NIHORT 1986). Okra fruits were picked as fresh marketable fruits from the 2 central rows for each accession throughout the harvesting period. The okra fruits were weighed as yield per plot for each of the nineteen accessions.

Pod yield values per plot of the accessions were analyzed using analysis of variance procedure described by Panse and Sukhatme (1985). The Performance Index for each accession was computed using mean values of pod yield/plot (kg/plot). The accession means were arranged in descending order of magnitude based on year, location and year × location. The Least Significance Difference (LSD) value calculated from the analysis of variance for each year, location and year × location interaction were subtracted from the first mean. The result obtained was compared to the remaining accession means. The number of accession means that were less than this value indicated the number of accessions that were significantly inferior to the first variety mean. This number was designated as 'm'. The procedure was repeated thereafter for the second and subsequent accession means. Thus, series of 'm' values is obtained for each year of study, locations and combination of year × location as suggested by Fasoulas (1983). The individual 'm' values were used to calculate the cultivar performance index (PI) as defined by Fasoulas (1983):

$$\text{PI} = \frac{m}{n-1} \times 100$$

Where m = the number of significantly inferior accessions,
n = number of varieties tested.

In computing the mean rank index (MRI); the pod yield/plot of the accession tested in each of the 6 environments were ranked from 1 to 19, each accession was summed as rank total (RT) and divided by 6 to get the mean rank index (MRI). The best accession has the lowest value of MRI, preferably less than average mean total. Scatter diagram (SD) was plotted graphically by plotting PI across 6 environments against accession MRI and using mean values of PI and MRI as the divisors. The SD was used to identify and classify the nineteen accessions according to yield performance superiority.

Results and Discussion

Mean performance of okra accessions

Accessing the pod yield performance of okra in 2017, Table 1; NGB00469 had PI of 100 for both Abeokuta and Ijanikin and 89 for Ibadan, thus, it is outstandingly the highest yielding accession. Therefore, NGB00469 is superior to 18 accessions in Abeokuta and Ijanikin, but out yielded 89% of the accessions in Ibadan. Accessions NGB00469, NGB00467, NGB00371, NGB00514, NGB00328

and NGB00322 had PI above 40 in each of the locations in 2017, thus, they performed better than the rest accessions in 2017. While NGB00362 performed well at Ijanikin and Ibadan only with PI of 50 in 2017. Accessions with the same PI value indicate that the accessions performances were not significantly different. Accessions NGB00332, NGB00452 and NGB00335 had zero PI value for the 3 location in 2017 are not significantly better than any accession, while NGB00350 and NGB00375 are not better than any accession at Ibadan only for 2017 indicating some level of accession by location interaction interplay. These accessions show differential performance in the years and locations of evaluation, variability was also reported in okra by Sharma and Prasad (2015), Vishnu et al. (2018).

		Abeokuta			Ijanikin			Ibadan		
S/No.	Accession	Mean kg/plot	m	p	Mean kg/plot	m	p	Mean kg/plot	M	p
1	NGB00469	28.67	18	100	21.16	18	100	25.51	16	89
2	NGB00467	22.67	13	72	18.03	16	89	23.22	15	83
3	NGB00371	21.33	12	67	14.07	9	50	19.85	12	67
4	NGB00514	19.67	12	67	17.40	15	83	21.60	14	78
5	NGB00328	18.67	9	50	14.66	9	50	19.13	12	67
6	NGB00322	18.33	8	44	15.26	10	56	16.94	10	56
7	NGB00362	17.00	5	28	14.72	9	50	16.31	9	50
8	NGB00302	14.67	3	17	13.55	8	44	12.86	5	28
9	NGB00466	14.33	2	11	14.77	9	50	14.01	6	33
10	NGB00396	14.00	2	11	12.80	6	33	13.47	5	28
11	NGB00360	13.67	2	11	10.07	3	17	11.20	2	11
12	NGB00343	13.33	2	11	11.35	4	22	10.25	1	6
13	NGB00320	12.67	2	11	11.66	4	22	10.82	1	6
14	NGB00297	12.33	2	11	10.90	3	17	9.96	1	6
15	NGB00350	12.00	1	6	9.82	3	17	8.75	0	0
16	NGB00375	11.00	1	6	9.13	2	11	8.01	0	0
17	NGB00332	9.67	0	0	7.20	0	0	8.00	0	0
18	NGB00452	7.33	0	0	6.80	0	0	7.09	0	0
19	NGB00335	6.00	0	0	5.47	0	0	5.16	0	0
Location Mean		15.12	-	-	12.57	-	-	13.80	-	-

Table 1: *Performance of nineteen okra accessions according to mean and performance index (PI), 2017.*

Similar trend was seen in 2018, Table 2; NGB00469 performed better than 17 accession at Abeokuta and Ibadan, and better than 16 accessions in Ijanikin. Accession NGB00467 performance was consistent in 2018, out yielding 89% of the accessions evaluated. The same accessions that were outstanding in 2017, performed significantly better in 2018; NGB00469, NGB00467, NGB00371, NGB00514, NGB00328 and NGB00322 had PI above 40 in each of the locations in 2018, except NGB00322 that had 39 at Abeokuta. These results indicate that these accessions were consistently stable across the 3locations of evaluation for 2018. Six accessions; NGB00297, NGB00350, NGB00375, NGB00332, NGB00452 and NGB00335 were not significantly different from each other and not better than any accession at the 3location in 2018. NGB00320 had zero value of PI at Abeokuta but better than 17% of the accessions in Ijanikin and 6% of the accessions in Ibadan for 2018. Location mean accession pod yield/plot was lower for Abeokuta and Ibadan in 2018 and slightly higher at Ijanikin in 2018 than 2017 Table 1 and 2. Ijanikin had the least location mean, while Abeokuta had the highest location mean for each year, thus, Ijanikin was low yielding and Abeokuta was high yielding environments. Kumar et al. (2010) and Singh et al. (2017) in assessing okra genotypes recorded low environmental mean yield due to poor performing genotypes.

Abeokuta					Ijanikin			Ibadan		
S/No.	Accession	Mean kg/plot	m	p	Mean kg/plot	M	p	Mean kg/plot	M	P
1	NGB00469	26.33	17	94	22.14	16	89	25.17	17	94
2	NGB00467	24.71	16	89	20.10	16	89	23.02	16	89
3	NGB00371	20.62	12	67	19.11	11	61	20.00	11	61
4	NGB00514	18.32	10	56	16.02	8	44	17.04	9	50
5	NGB00328	17.67	8	44	16.08	8	44	16.67	8	44
6	NGB00322	17.31	7	39	15.91	8	44	16.14	8	44
7	NGB00362	16.00	5	28	15.05	7	39	15.98	7	39
8	NGB00302	14.33	5	28	16.23	9	50	15.92	7	39
9	NGB00466	13.45	3	17	15.66	8	44	15.45	7	39
10	NGB00396	13.06	2	11	12.64	5	28	13.00	5	28
11	NGB00360	12.63	2	11	12.31	5	28	12.35	4	22
12	NGB00343	12.33	2	11	11.83	5	28	11.68	3	17
13	NGB00320	11.00	0	0	11.14	3	17	10.96	1	6
14	NGB00297	10.87	0	0	9.29	0	0	10.00	0	0
15	NGB00350	8.95	0	0	7.56	0	0	8.11	0	0
16	NGB00375	8.33	0	0	7.40	0	0	7.93	0	0
17	NGB00332	7.67	0	0	6.09	0	0	7.15	0	0
18	NGB00452	6.72	0	0	6.07	0	0	7.03	0	0
19	NGB00335	6.09	0	0	5.83	0	0	6.00	0	0
Location Mean		14.02	-	-	12.97	-	-	13.66	-	-

Table 2: *Performance of nineteen okra accessions according to mean and performance index (PI), 2018.*

Accession rating across year and location

Influence of environments on genotype is an essential consideration in any plant breeding programme, genotype by environment brings out genotypic performance as stable/adaptable genotypes to specific or across environments and years. Several methods are in use to study genotype by environment interaction and classify genotype according to their performance (Eberhart and Russell 1966, Perkins and Jinks 1968, Lin 1982). However, a simple, easy to understand and rapid alternative is the cultivar performance index approach. The differential genotypic performances as rating of nineteen okra accessions across locations, years and year × location used in this study are presented in Table 3; accession NGB00469, NGB00467, NGB00371, NGB00514 and NGB00328 had P value across years (Py) of 50 and above for each of the 3locations. Accession NGB00322 and NGB00362 with Py of 50 in Ijanikin and Ibadan only, while NGB00302 and NGB00466 are adapted to Ijanikin only by out yielding 50% of the accessions evaluated across 2years at the 3locations. Evaluation of the 19 accession across 3locations for 2 years revealed that accession NGB00469, NGB00467, NGB00371, NGB00514, NGB00328 and NGB00322 are superior to over and better than 40% of the accession in both years. Accession NGB00362 was superior to over 50% of the accessions in 2017 only, thus, expressed yearly effect on it performance. Evaluations across 2years and 3locations performance index (Pys) indicate that accession NGB00469, NGB00467, NGB00371, NGB00514, NGB00328 and NGB00322 were superior, consistent and better than other accessions evaluated. Accession NGB00350, NGB00375, NGB00332, NGB00452 and NGB00335 are poor performing throughout the evaluations, they are consistently low yielding accessions across the 2years and 3locations of evaluation. The 6 environments used in this study serve as good environmental discriminant in accession × location expression. Similarly, Alake and Ariyo (2012), Akotkar et al. (2014), Sanket et al. (2018) reported influence of environments on okra genotypic performance using different approach.

Locations across 2years (Py)					Years across 3locations (Ps)		Across 2 years & 3 locations (Pys)
S/No.	Accession	Abeokuta	Ijanikin	Ibadan	2017	2018	
1	NGB00469	94	94	94	100	94	94
2	NGB00467	83	83	89	83	89	83
3	NGB00371	67	56	67	67	61	67
4	NGB00514	61	56	67	67	50	56
5	NGB00328	50	50	56	61	44	50
6	NGB00322	39	50	50	50	44	50
7	NGB00362	28	50	50	50	39	39
8	NGB00302	17	50	33	22	39	28
9	NGB00466	17	50	33	28	33	28
10	NGB00396	11	27	28	22	28	22
11	NGB00360	11	17	17	11	22	17
12	NGB00343	11	22	6	11	17	17
13	NGB00320	6	22	6	11	6	11
14	NGB00297	0	17	6	11	0	6
15	NGB00350	0	6	0	6	0	0
16	NGB00375	0	0	0	6	0	0
17	NGB00332	0	0	0	0	0	0
18	NGB00452	0	0	0	0	0	0
19	NGB00335	0	0	0	0	0	0

Table 3: *Rating of nineteen okra accessions using performance index (PI) approach.*

Ranking of 19 okra accessions and mean yield are presented in Table 4; accession NGB00469, NGB00467 and NGB00371 had the first to third best pod yield respectively in 2017 at the 3 locations except NGB00371 that came fourth position in Ibadan. Accession NGB00469 in 2018 came first, second and third in Abeokuta, Ibadan and Ijanikin, while NGB00467 and NGB00371 came first in Ibadan and Ijanikin. Accession NGB00467 was second in both Abeokuta and Ijanikin, while NGB00371 came third in Abeokuta and Ibadan in the evaluation done in 2018. These accessions expressed their best pod yield in areas of good locational influences due to genotype x environment interaction. Similarly, accessions NGB00469, NGB00467, NGB00371, NGB00514, NGB00328 and NGB00322 occupy top 6 positions in each of the 3 locations and 2 years, these accessions had MRI less than 40, RM of less than 7 and their pod yield is higher than 16kg/plot, also higher than the overall mean pod yield of 13.69kg/plot. The top six accession average pod yield ranged from 24.83-16.65 kg/plot, thus, they are potential high yielding accessions. Accession NGB00350, NGB00375, NGB00332, NGB00452 and NGB00335 were consistently the last five accessions in the 2years and 3locations, and they had very high RT, MRI and pod yield of less than 10kg/plot.

Grouping of okra accession

The scatter diagram in Figure 1 classified the 19 accessions evaluated across 3 locations and 2 years, and using their RM to plot the diagram. The scatter diagram classify the accessions into four groups; A, B, C and D. Group A had 7 accessions; NGB00469, NGB00467, NGB00371, NGB00514, NGB00328, NGB00322 and NGB00362 that have high Pys and low RM with high and consistent Pod yield. The accessions in group A are valuable and highly desired as outstanding accessions. Group B has no accession, group C has 3 accessions, these accessions have low Pys and RM, thus, they could be of moderate breeding value due to their RM. Nine accessions have low Pys and high RM, they are grouped in quadrant C, all the 9 accessions have low pod yield for the 2 years and 3 locations of evaluations, thus, they are poor performing accessions and are not desirable for yield improvement.

			2017			2018				
S/No.	Accession	Abeokuta	Ijanikin	Ibadan	Abeokuta	Ijanikin	Ibadan	Rank Total	Rank Mean	Mean yield (kg/plot)
1	NGB00469	1	1	1	1	3	2	9	1.50	24.83a
2	NGB00467	2	2	2	2	2	1	11	1.83	21.96a
3	NGB00371	3	3	4	3	1	3	17	2.83	19.16ab
4	NGB00514	4	4	3	4	6	4	25	4.17	18.34ab
5	NGB00328	5	8	5	5	5	5	33	5.50	17.15ab
6	NGB00322	6	5	6	6	7	6	36	6.00	16.65ab
7	NGB00362	7	7	7	7	9	7	44	7.33	15.84bc
8	NGB00302	8	9	10	8	4	8	47	7.83	14.59bc
9	NGB00466	9	6	8	9	8	9	49	8.17	14.61bc
10	NGB00396	10	10	9	10	10	10	59	9.83	13.16c
11	NGB00360	11	11	11	11	11	11	66	11.00	12.04c
12	NGB00343	12	13	13	12	12	12	74	12.33	11.80c
13	NGB00320	13	12	12	13	13	13	76	12.67	11.38c
14	NGB00297	14	14	14	14	14	14	84	14.00	10.56c
15	NGB00350	15	15	15	15	15	15	90	15.00	9.20cd
16	NGB00375	16	16	16	16	16	16	96	16.00	8.63cd
17	NGB00332	17	17	`17	17	17	17	102	17.00	7.63d
18	NGB00452	18	18	18	18	18	18	108	18.00	6.84d
19	NGB00335	19	19	19	19	19	19	114	19.00	5.76d
							Mean Pod Yield			13.69

Table 4: *Ranking of okra accession performances based on rank total.*

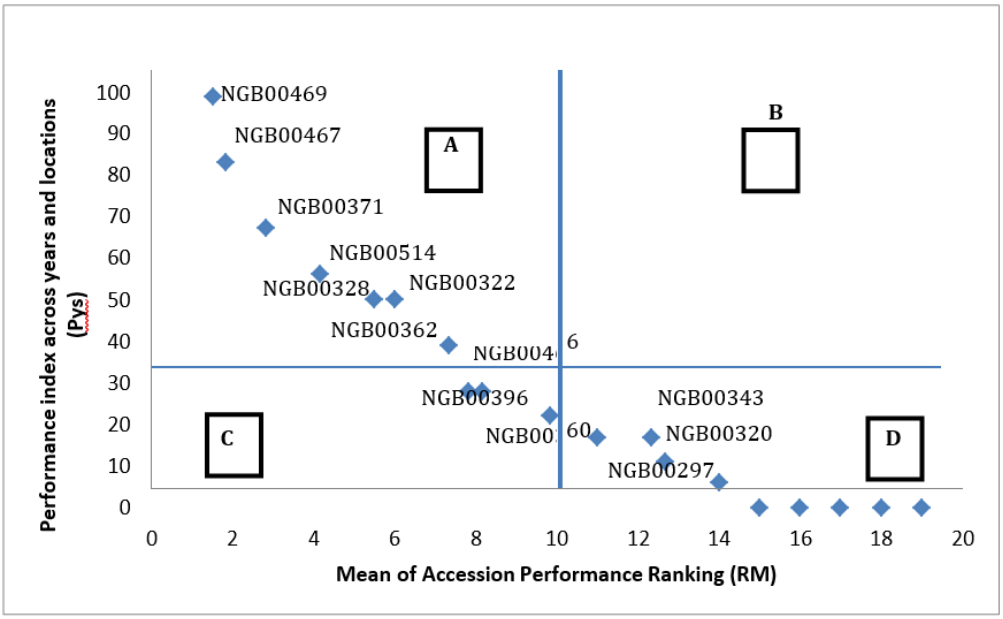

Figure 1: *Scatter diagram of okra accessions.*

Conclusion

All the ranking methods used were consistent in identifying six accessions; NGB00469, NGB00467, NGB00371, NGB00514, NGB00328 and NGB00322 as superior accessions. The methods used in this study are better alternative approach without much calculation, ease of computation, interpretation and simple to identify top performing accessions. It is therefore concluded that the methods used here, particularly scatter diagram are valuable for plant breeders that need to make quick decision for selecting outstanding genotypes.

References

1. Akotkar PK, De DK and Dubey UK (2014) Genetic studies on fruit yield and yield attributes of okra (Abelmoschus esculentus L. Moench). Electronic Journal of Plant Breeding 5 (1): 38-44.
2. Alake CO and Ariyo OJ (2012) Comparative analysis of genotype x environment interaction in West African okra (Abelmoschus esculentus (L.) Moench). Journal of Agricultural Science 4(4): 135-150.
3. Benchasr S (2012) Okra (Abelmoschus esculentus (L.) Moench) as a valuable vegetable of the World. Ratar Povrt 49: 105-112.
4. Christo EI and Onuh MO (2005) Influence of Plant spacing on the growth and yield of okra (Abelmoschus esculentus(L) Moench). In: Orheruata AM (ed.) Proceedings of the 39th Conference of the Agricultural society of Nigeria (ASN) held at Benin 9-13 October p. 51-53.
5. Eberhart SA and Russell WA (1966) Stability parameters for comparing varieties. Crop Science Journal 6: 36-40.
6. Fasoulas AC (1983) Rating cultivars and trials in applied breeding. Euphytica 32(3): 939- 943.
7. Finlay KW and Wilkinson GN (1963) The analysis of adaptation in plant breeding programmes. Australian Journal Agricultural Research 14: 742-754.
8. Food and Agriculture (FAO) (1996) The conservation and sustainable utilization of plant genetic resources for food agriculture. Paper presented at International Technical Conference on Plant Genetic Resources, Leipazig, Germany, 17-23, June.
9. Gemede H F, Haki GD, Beyene F, Woldegiorgis AZ and Rakshit SK (2015) "Proximate, mineral, and antinutrient compositions of indigenous Okra (Abelmoschus esculentus) pod accessions: Implications for mineral bioavailability". Food Science & nutrition 4 (2): 223- 233.
10. Hammon S and Van Sloten DH (1995) Okra. In: Smart, J & Simmonds, N.W. (eds.). Evolution of crop plants. 2nd Edition. Longman, London, United Kingdom, p. 350-357.Ishaq MN and Falusi OA (2008) Germplasm conservation and its impact on crop improvement in Nigeria. Crop Research 36 (1 & 2): 285.
11. Kumar S, Dagnoko S, Haougui S, Ratnadass A and Pasternak D (2010) Okra (Abelmoschus spp.) in West and Central Africa: potential and progress on its improvement. African Journal Agricultural Research 25: 3590-3598.
12. Lin CS (1982) Comparing varieties by a cluster method directly related to genotype- environment interaction mean square. Theoretical and Applied Genetics 62: 277-280.
13. Mbah EU, Notindge DO and Keke CJ (2009) Growth and yield of cassava/okra intercrop on acid ultisol. In: Proceedings of the 43rd Annual conference of Agricultural Society of Nigeria (ASN). Abuja 20-23rd October p. 19-23.
14. National Institute of Horticultural Research and Training (NIHORT) (1986) Vegetable Programme recommended practices, Annual Report of the Horticultural Research Institute, Nigeria, 29p.
15. Panse VG and Sukhatme PV (1985) Statistical methods for Agricultural Workers. ICAR, New Delhi, p. 63-69.
16. Perkins JM and Jinks JL (1968) Environments and genotype environmental components of variability. III. Multiple lines and crosses. Heredity 23: 339-356.
17. Plant Resources of Tropical Africa (PROTA) (2004) Status of the conservation of indigenous leaf vegetable, 263p.
18. Reddy MT (2010) Genetic diversity, heterosis, combining ability and stability in okra (Abelmoschus esculentus (L.) Moench). Ph. D. Thesis, Acharya N. G. Ranga Agricultural University, Rajendranagar, Hyderabad, 313p.
19. Sanket JM, Chaudhari KN, Vaidya GB and Chawla SL (2018) Genotype x Environment Interaction and Stability Analysis for Earliness, Seed Yield and Fruit Yield in Okra Using the Additive Main Effect and Multiplicative Interaction (AMMI). International Journal of Current Microbiology and Applied Science 7(03): 373-383.
20. Sharma AK and Prasad K (2015) Genetic divergence, correlation and path coefficient analysis in okra. Indian Journal of Agricultural Research 49 (1): 77-82.
21. Singh N, Singh DK, Sati UC, Rawat, M and Pandey P (2017) Genetic analysis studies in okra (Abelmoschus esculentus (L.) Moench). International Journal of Pure Applied Biosciences 5(4): 361-367.

22. Vishnu Priyanka D, Thirupathi Reddy M, Begum H, Sunil N and Jayaprada M (2018) Studies on genetic variability, heritability and genetic advance in genotypes of okra (Abelmoschus esculentus (L.) Moench). International Journal of Pure Applied Biosciences 7(5): 401- 411.