IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

Combining ability through Line × Tester analysis in

Okra (*Abelmoschus esculentus* (L.) Moench)

P. Sri Sai Chaitanya[1*], Sadu Yashwanth [2], Mayur S. Dharvankar[3], G. Rajitha[4],

[1]M.Sc. Student, Department of Genetics and Plant breeding, School of Agriculture, Lovely Professional University, Jalandhar-144411, Punjab, India.

[3]Assistant Professor, Department of Genetics and Plant breeding, School of Agriculture, Lovely Professional University, Jalandhar-144411, Punjab, India.

(Author: P. Sri Sai Chaitanya)

Abstract

Okra (*Abelmoschus esculentus*) also called as bhindi, ochro or ladies' finger is a warm season vegetable crop. It is grown for its tender pods which are edible. The plants are cultivated in warm temperature, sub-tropical and tropical regions of the world. The realisable yield potential of okra is greater than what has been already achieved so far in the world. Improvement of high yielding varieties is mainly dependent on the genetic diversity of the crop. The investigation on combining ability and heterosis breeding methods are highly potential ways for achieving greater production and productivity. The combining ability effects for both general and specific combining abilities are estimated for various characters of okra using line × tester analysis mating design proposed by kempthrone which comprises of various lines, testers and their F1 hybrids. Here the parents and their hybrid crosses differ for specific combining ability effects and general combining ability effects and the best general combiners and specific combiners are evaluated for various traits like height of the plant, number of branches per plant, number of seeds per pod, internodal length, etc. the plants showing good combining abilities are used to accumulate the additive genes which are used for improvement of new varieties and hybrids with high fruit yield and yield components.

Keywords: okra, line × tester, general combining ability, specific combining ability, combiners.

Introduction:

Okra (*Abelmoschus esculentus (L.)* Moench) is commonly known as bhindi, 'Gumbo', ladies' finger or ochro, is one of the important vegetable crops of India, which is a flowering plant of Malvaceae family of Order Malvales. Its cultivation ranges throughout the tropical and sub-tropical zones and also in the hottest areas of the temperate zones of world for its fibrous edible fruits or pods. It is valued for its edible green pods or fruits. The plant grows around 2-3 meters tall with the leaves of 20-25 centimetres long, broad and lobed palmately with 5-7 lobes. The flowers are white to yellowish in colour with the spherical pollen of approximately 188 microns in diameter. The fruit of okra is known as capsule which ranges a size of up to 18cm with the pentagonal cross section consisting of numerous seeds. Okra is one among the most heat and drought tolerant species which can also tolerate heavy clay soils and requires 20-degree Celsius for seed germination. The most damaging diseases of okra are verticillium wilt causing yellowing and wilting of leaves, powdery mildew, root knot and leaf spot. Okra is polyploidy in nature having chromosome number 2n=130 or other series of 2n= 72,

108, 120, 132 or 144 with n=12 (Dutta and Naug, (1968). The origin of Okra is near Ethiopian region and during the course of evolution it spread out to North African and Middle East part of the world (Lamont W 1999, Tindall H. D 1983). It is one of the heat tolerant vegetable crops grown worldwide but prefers temperature ranges between 20° - 35°C. It is grown on a variable type of soil included the soil should have adequate drainage property with good amount of organic content (Akinyele B.O. *et.al.* 2007). Optimum pH of 6-6.5 is reported to be suitable for *Abelmoschus esculentus* cultivation. Considering world scenario, okra is grown in the area of around 1148 thousand hectares with the production of about 7896.3 thousand tonnes. Countries involves in okra cultivation are India, USA, Nigeria, Mexico, Pakistan, etc. Okra is an important vegetable crop for local market and export purposes. In case if India, Andhra Pradesh is the leading producer of okra followed by West Bengal. in terms of area, production and productivity (78.9 thousand hectares of area, production of approximately 1184.2 thousand tonnes with a productivity of 15 tonnes/hectare and area of 74 thousand hectares, production of 862 thousand tonnes with a productivity of 11.70 tonnes/hectare respectively).

Okra is an annually growing plant having life cycle of 90 to 100 days, multiplied using seeds generation after generation. It's having erect stem with branching; leaves are of alternate pattern whereas has auxiliary flowers. It grows in variable height ranges from 0.5 to 4 meters. Okra is an often-cross pollinated crop generally assisted by insects and extent of cross pollination ranges from minimum 4% to maximum 42 percent (Kumar, 2006). It is cultivated for its edible and fresh fruits or pods which contain very good amount of nutrients. In 100g of fresh and mature okra pods contains 6.4 g carbohydrates, 1.9g of protein, 3100 Cal energy, 0.2 g fat, 1.2 g fibers, 0.8g minerals and other vitamins like A, B and C. Okra is a potential foreign exchange crop accounts for almost 60% of the total fresh vegetables export from India (Rewale *et al.,* 2003). Okra also contains mucilage (1.6 g /100g of pod) i.e., thick and slimy substance present in fresh pods. It is actually polysaccharide, acidic in nature associated with proteins and other biomolecules (Woolfe *et al.,* 1977). Okra mucilage have medicinal property and can also be utilized for food and non-food products. Our country has diverse climatic conditions leads to the existence of variable numbers of okra cultivars showing wide variations among there qualitative and quantitative characters. Although okra is cultivated from past many years, still one of the significant problems with its production is non-availability of appropriate location specific high yielding cultivars. Therefore, the main aim of present study to exploit hybrid vigour ability of okra to produce hybrids that can further be utilized for crop improvement programme (Kumar *et al.,* 2006). Conventional methods of analysing heterosis are being going on several decades till now. This review aims at certain objectives which evaluate the perse performance of the parents and the hybrids obtained from them for some important traits, then determining the magnitude of GCA and SCA variances and their effects and to understand the nature of gene action for yield and its attributing traits and to know the heterosis to predict the superior hybrid combinations for characters under study. The development of yield and yield attributing characters or components requires selection of appropriate breeding methods which depend directly on general combining ability and specific combining ability of parents and hybrids. The estimation of general combining ability helps in the selection of good general combining parents which can be used in hybridisation programmes. estimation of specific combining ability helps in selection of the superior cross combinations in developing commercial hybrids. Estimation of variances among half sib families is an estimation made by general combining ability whereas estimates of full sib families give variances of specific combining ability. The additive variance is equal to general combining ability variance and dominance variance gives estimates of specific combining ability variance. The gca component is primarily a function of additive genetic variance, but if epistasis is present gca will also include additive × additive component. Sca function is primarily a dominance variance, but if epistasis is present sca will also include additive × additive, additive × dominance, dominance × dominance epistasis. The investigations are conducted for elite genotypes or lines of okra to study the association between different components, their direct effects, indirect effects on production, productivity, and quality in okra through line into tester analysis.

Methodology of work:

Line × tester analysis is a modified form of top cross which is used for measuring combining ability such as general combining ability and specific combining ability variances and their effects in large number of germplasm lines. This Line × tester analysis method was first developed by Kempthorne in 1957. In case of line× tester cross several number of lines and their testers are used. There the single parent is crossed to several number of inbreed lines which are known as testers and the hybrids obtained are known as test crosses. The analysis of this technique depends upon the first degree and second degree of statistics. In this method there is a restricted mating seen where some parents designated as lines or females and others as testers or males. Each male is to be mated with a set of female parents and male and female parents are not crossed to each other like male is not crossed to male and female to female, here the number of crosses are equal to mf crosses. The line × tester analysis provides information about general and specific combining ability variances and effects and also about dominant and epistatic components of genetic variances. The results obtained through this technique are highly precise. The major steps involved in this technique not only for okra but any crop involves selection of parents such as any inbreed lines, strains, germplasm lines, cultivars, etc and make their particular crosses in such a way that each female is crossed to each male from n number of crosses, then evaluation of material in the second year with their parents are grown in the replicated field trails and the obtained observations are noted or recorded. Such as days to flowering, 100 seed weight, diameter of the pod, length of the fruit, fruit weight, seed index, days to 50% flowering, etc. later the biometrical analysis is assessed as per the guidelines given by Kempthorne (1957). The estimates of general combining ability effects shows either parents were good combiners for few traits. The performance of parents has direct relation for their GCA effects in parents, which shows high gca effects for various parameters or traits. also observes good performance with respect to particular characters. The estimates of SCA effects the best hybrids possess sca effects for their fruit yield and its yield components. The SCA representing the non-additive gene action is major component used in heterosis breeding. Whereas the heterosis involves low × high combiners might be due to dominant and dominant and additive type of interactions. This is partially fixable. The cross of both poor combiners shows high specific combining ability for yield per plant. Whereas both parents show negative significant general combining ability due to complementation of the favourable genes for particular trait. So, this cannot be that parents having high general combining ability effects will only produce good hybrids (Dhankar *et.al.*, (2001)). The non-additive gene action is integral part of genetic architecture for different trait traits in the material used in okra.

The line × tester is done to know the heterosis and combining ability. the lines, testers, F1 hybrids and commercial checks are crossed and evaluated for quantitative characters and replication mean values are observed. The cross combinations made in line × testers design for the precise estimation of gene action. The recommended package of practices are to be followed to maintain a healthy crop. the spacing between row to row, and plant to plant has to be adopted as recommended. The observations seen are to be recorded or maintained separately and for randomly selected plants for various number of parameters like height of the plant, number of pods per branch, number of branches per plant, internodal length in cm, the node at which first flower appears, length of the fruit in cm, fruit weight, fruit width in cm, days to 50% flowering, number of seeds per pod, number of nodes per plant, seed index, 100 seed weight, pod yield in q/ha, diameter of the pod/fruit, fruit yield /plant, etc. the whole data is analysed by using statistical methods for all parameters/traits. The combining ability analysis is done using line into tester analysis method. The analysis of variance for general combining ability and specific combining ability for all the characters are taken and the mean squares due to gca and sca would be significant for all the parameters indicating the variability among general combining ability and specific combining ability for all the characters studied. The variance due to lines would be significant for few traits which differs from the variances due to testers which are significant for few characters/traits for example plant height, fruit weight etc. likewise the variances due to crosses would also be highly significant for all or few characters. The variances due to parents × crosses can also be highly significant for all traits or few should be considered. The significant variance explains the presence of good amount of genetic variability between parents and their crosses for their respective character's. The investigation studies also explain the performance of newly developed hybrids and their parents for productivity, production and quality traits for yield and yield attributing parameters/components. The crosses made between line and testers are evaluated along with the parents in randomized block designs with required number of replications with

the objective of assessing the newly developed hybrids for the production, productivity and quality traits in okra.

Combining ability and heterosis for yield and yield attributing characters through line into tester analysis in okra:

The combining ability effects estimated for different traits using line into tester analysis programme comprising of 24 hybrids obtained by crossing 8lines and 3 testers here the parents and hybrids differs significantly for the GCA and SCA effects KAO-25 and KAO-61 were found to be best general combiners among the lines and KAO-53×KAO-18, KAO-35×KAO-AA are found to be best crosses for yield per plant, resulting in nonadditive gene action is an integral component of genetic architecture of different characters in the materials used in okra. (Rc Jagadeesha (2007), D Weerasekara, (2008). Two Egyptian and 4 exotic parental genotypes of okra were self-pollinated for one generation to study heterosis and GCA for earliness, vegetative and yield component traits. Mean squares are found highly significant to all traits, providing evidence for presence of genetic variation among the genotypes the SCA and GCA mean squares were highly significant for all the traits studied. Majority of the crosses exhibited significant heterosis estimates over the mid parents. Pusa Sewani (P6) was excellent general combiners for all traits except for the average fruit weight per plant in grams. The cross combination (P1 × P6) showed desirable effects of SCA and significant heterosis for all traits except for no of branches per plant. These crosses should be used for constitution of okra hybrids. These findings reflect the presence of considerable heterosis values and says that non-additive gene effects played the major role in the inheritance of these traits. These promising crosses would be used in the improving of okra hybrids. Hazem (2013). The observed yield and its contributing traits in okra through the experiment which consists of 11 parents and 28 f1 hybrids taken in randomized block design for 11 characters. The GCA and SCA effects were significant for pod yield and yield attributing traits, 3 parents were identified as good general combiners for pod yield and can be used for exploiting further okra breeding programmes. Even the cross combinations were observed more promising for fruit yield and some of its related traits used as heterotic hybrids to get the high yielding transgressive seggregants. (N. V. Kayande (2018)). line into tester for combining ability and heterosis in okra using 51 hybrids generated by crossing 17 lines and 3 testers along with their parents in a randomized block design with 3 replications. they found the variance due to treatments, parents, crosses and parents vs crosses were highly significant except for the 100 seed weight. The highest heterosis over standard check for seed yield was observed in cross raj-12 × Parbhani Kranti. Parbhani Kranti has high GCA effects for all the characters and raj 12 exhibited high GCA effects for seed yield. Estimates of SCA effects showed that the best cross combinations for seed yield were Raj-12 × Parbhani Kranti and Baunia × Parbhani Kranti. (S.K. Dhankar (1994). combining ability effects for different traits comprising 32 crosses produced by crossing 8 lines and 4 testers. The GCA and SCA effects were significant for all the traits except for number of nodes per plant. The ratio of GCA and SCA variances indicated the preponderance of non-additive gene effect for inheritance of all traits. Pusa Sawani and AOL-09-07 showed good GCA for fruit yield and worthy to exploitation and segregation and varietal development. The estimates of SCA effects revealed the crosses JOL-0-05× AOL-09-02 and few were observed most promising for fruit yield and related traits. This suggested that heterosis breeding would be more suitable for improvement of these traits in okra. (Sapavadiya SB, kachhadia VH, Savaliy JJ (2019)). Information on the magnitude of combining ability was obtained for fruit yield per plant involving 15 diverse varieties (10 lines and 5 testers). It revealed that the magnitude of non-additive variance was higher for fruit yield per plant indicating the predominance of non-additive gene action in the inheritance of traits. Among females JOL-08-7 while among males, Parbhani Kranti was good general combiners for fruit yield per plant and related traits. The hybrid, JOL-08-7 × Parbhani Kranti having high SCA effects for fruit yield/plant desirable SCA effects for a no branches/plant, internodal length, fruit girth and days to 50% flowering. the good × good combinations result in capitalization of the non-additive effects. (K. Satish, A.V. Agalodia and D.B. Prajapati (2017). The Research Worked on mating design which comprises of 6 lines and 4 testers and 24 F1 hybrids. the parents and hybrid crosses differed significantly for the general combining ability and specific combining ability effects for all characters. Few lines and testers were observed as best general combiners for plant height, no of branches/plant etc. likewise for SCA few were noted as best combiners and the best combiners are expected to accumulate additive genes that can be exploited for development of open pollinated varieties and cross Parbhani Kranti × Hisar Unnat showed highest specific

combining ability for green fruit yield and its components and are potential source for screening of high yielding F1 hybrid varieties. (Jag Paul Sharma and AK Singh). The investigation which was carried out with the objective of identifying good combiners and to assess the magnitude of heterosis for growth characters. maximum heterosis was observed in the cross KO-2 X PK (48.20) for plant height and few others for number of leaves, internodal length, and the cross KO-6 X PK and KO-13 X V5 exhibited significant negative heterosis over the best parent, and such. Non additive gene action was predominant for all most all the traits. (Y.A. Lyngdoh, R. Mulge and A. Shadap). Another experiment reported that lines like Arka Abhay, VRO-5, VRO6. JBS-2 and testers like Pusa Sawani proved to be good general combiner and VRO-6 x Pusa Sawani was the good specific combiner for most of the yield and yield attributing traits during rainy seasons of 2007 and 2008. Annapurna and S.P. Singh (2007,2008). Research conducted Randomized Block Design with three replications for 14 parents (10 lines and 4 testers) and their 40 resultant F1s. Predominant role of non-additive gene action in the inheritance of the traits was indicated by Combining ability analysis that the magnitude of non-additive variance was higher for fruit yield per plant and its contributing traits. For fruit yield per plant and related traits VIO 47672 among females and among males, GAO – 5 were good general combiners. The hybrid, IC – 045796 x GJO – 3 having high SCA effects for fruit yield per plant also registered high and desirable SCA effects for number of branches per plant, number of fruits per plant, fruit length, fruit diameter and fruit weight. (S. J. More, K. N. Chaudhari, A. I. Patel and Dhwani Patel (2015).

Line x tester analysis for gene action:

Most of the economic characters of okra are polygenically controlled and are greatly influenced by the environment in which it is grown. Since yield related traits are polygenically determined the choice has to be made with the combining ability effects and predominant type of gene action that influence the variation of such characters. the pooled analysis of variance indicated highly significant differences for all 17 characters among 55 genotypes under study. The cross combinations having one or both of the parents with positively significant general combining ability effects for total and marketable yield/plant could be utilized in recombinant breeding with single plant (IC45732 selection in the passing generations to capitalize additive gene action to develop lines or varieties with the higher total and marketable yield/plant in okra. (M. T. Reddy, K. Haribabu, M. Ganesh and H. Begum. (2011)). Research conducted for estimation of Gene action in bhindi at Annamalai University, reported that variance due SCA was higher than that of the variance due to GCA for all the six characters viz., Days to first flowering, Plant height at maturity, Number of branches per plant, Number of fruits per plant, Single fruit weight, Fruit yield per plant. The variance due to dominance was more than that of additive genetic variance for all six characters of interest. Importance of both dominance and epistasis for evolving genotypes with higher fruit yield was revealed in the study. the contribution of line into tester to the total variance was higher for plant height at maturity and no of branches/plant. The contribution of testers to the total variance was higher for few traits indicating the importance of both testers and lines × testers interaction to the total variance. (Joshi, J.L. and Murugan, S. (2013). “Genetic analysis of yield and its components in Okra with 108 treatment (45 F1s, 45 F2s develop through line x tester technique along with 15 lines and three testers viz., Azad Bhindi-1(Azad Ganga), Azad Bhindi-4 (Azad Mohini), Parbhani Kranti, in a Randomized Block Design with three replications. The observations were recorded and Analysis of variance showed highly significant differences for all the characters viz., days to flowering, height of plant (cm), number of branches plant, number of nodes plant, number of first fruiting node, length of internode (cm), length of fruit (cm), width of fruit (cm), number of fruits plant and yield plant. Among all lines, AB-2, 7110, P-7, VRO-6, AB-3 and KS-440 were good general combiners on the basis of combining ability for most of the yield contributing traits in both the generations and tester AB-1 was found to be good general combiner for most of the yield contributing traits. For fruit yield the cross combinations KS440 x AB-1 and AB-2 x PK were found desirable based on SCA effects. (Vivek Pandey (2017)). Experiments conducted during summer 2009 and late kharif 2009 at Vegetable Research Station, Hyderabad, reported that knowledge on the genetic system controlling the quantitative traits is more important for devising an efficient selection program through the use of a suitable mating design. They opined that both the additive and non-additive gene effects operated in the 10 genetic expression of the traits. Relative magnitude of GCA and SCA variances indicated preponderance of non-additive gene action for majority of the characters studied except number of branches for plant and fruit width. The use of a population improvement method in the form of diallel selective mating or mass selection with concurrent random mating might lead to release of new varieties with higher yield in Okra. They

concluded that that parental lines P5), P6 (IC89819), and P7 (IC89976) could be exploited beneficially in future by adopting appropriate breeding strategy. The crosses C23 (IC29119-B × IC99716), could be exploited for the production of F1 hybrids for late kharif season after further testing in multiple locations in the state. The crosses C17 (IC27826-A × IC111443) and C42 (IC89976 × IC111443) could be utilized in recombination breeding in to evolve high yielding varieties suitable for late kharif season. (Medagam Tirupathi Reddy, Kadiyala Hari Babu, Mutyala Ganesh, Hameedunnisa Begum, Jampala Dilipbabu, and Reddivenkatagari Subbarama Krishna Reddy. (2013)).

Line into tester analysis for nutritional attributes:

Thirty-three hybrids were developed by crossing seven lines and three testers for 26 parameters for productivity and quality traits. The variance due to parents vs. hybrids was also significant for all traits except plant height at 45 days after sowing, days to first flowering, fruit diameter and seed yield/plant. The lines L7, L1 and L3 may be utilized as parent stocks for breeding for growth parameters, earliness, yield and quality traits etc, among the hybrids L3 X T2, L7 X T2 showed specific combiners for almost characters as per results in F5 generation which attain homozygosity. So, selection is effective for qualitative traits of okra in this generation, showed the potential nutritional importance and it has significant role in improved nutrition in okra genotypes. (Sujata Padepalli, Satish D, Babu AG, Rekha Chittapur, Dr. Prabhuling G).

CONCLUSION:

The Combining ability analysis done through line into tester mating design is determined by the Analysis of variance due to parents and hybrids for different characters are presented in different experiments conducted at various research stations. The anova shows significant difference among the hybrids for all the characters taken into account. The combining ability variances were estimated for all the characters for general combining ability effects for the parents and specific combining ability effects. The characters under study can be considered as number of branches per plant, plant height in cm, number of pods per plant, fruit diameter in cm, number of seeds per pod, fruit yield per plant, days to maturity, number of pods per branch, number of branches per plant, internodal length in cm, the node at which first flower appears, length of the fruit in cm, fruit weight, fruit width in cm, days to 50% flowering, number of seeds per pod, number of nodes per plant, seed index, 100 seed weight, pod yield in q/ha, diameter of the pod/fruit, fruit yield /plant, etc. the parents which have high gca effect can be categorised as good general combiners and may be used as the parents in hybridization programme of okra. The genetic ability variances if showed higher magnitude of gca variances in some cases indicates preponderance of additive gene action, but in some cases sca variances are high which indicates preponderance of dominance/non-additive gene action. on the basis of sca effects few hybrids cross combinations like KS440 x AB-1 and AB-2 x PK, Parbhani Kranthi x A.B 1 were found to be promising for the fruit yield per plant suggests that these hybrids may be further exploited for further breeding programmes. As per the estimates of GCA the genotypes Pusa Sawani, Parbhani Kranti, K.S 325, P-7, VRO-6, AB-3 and KS-440 were good general combiners on the basis of combining ability and may be used as the parents in hybridization programme in okra.

References:

"The plant list: A working list of all plant species". Retrieved 3rd October 2014.

Akoktar P.K, D.K. De and Dubey U.K, Genetic studies on fruit yield and yield attributes of okra, Electronic journal of Plant breeding, 5(1): 38-44 (Mar 2014).

C. C. Nwangburuka, O.B., Kehinde, O.A. Adegbite, O.A. Denton, Mitotic chromosomes in abelmoschus esculentus, Annals of biological research,2011, 2(4): 85-90.

Lorendana Mihaela, Mihaela Croitoru, Milica Dima, Preliminary results concerning the behaviour of varities of okra on the sandy soils of south Oltenia, annals of university of Craiova-agriculture, cadastre series49(1),127-130,2019.

Franklin M. Martin, Okra, Potential multiple purpose crop for the temperate zones and tropics, economic botany 36(3),340-345, 1982.

Samiksha verma, R.S. Patel, V.K. Prakash, Kumar. S., Genetic divergence in okra, ind. J. Pure app. Biosci. 8(4),635-638.

Ayushi Yadav, Krishna Kumar Mishra and Aneeta Yadav, studies on combining ability through line into tester analysis in okra, international journal of current microbiology and applied sciences, vol-9(6):494-499, (2020).

Jag Paul Sharma and Singh A.K et.al, Line × Tester Analysis for Combining ability in okra, Vegetable science (2012) 39 (2): 132-135.

Weerasekar. D, Jagadeesh R.C, Wali M.C, Salimath P.M, Hosamani R.M, Combining ability of yield and yield components in Okra, Karnataka J. Agric. Sci., 21(2), (187-189): 2008.

Hazem A. Obidiella -Ali, Eldekashy M.H.Z and Helaly A.A, Combining ability and heterosis studies for yield and yield components in some cultivars of okra, American-Eurasian J. Agric. And Environ. Sci., 13(2): 162-167, 2013.

Kayande. N. V, Khumbalkar H. B and Shinde Sachin, Selection of parents based on combining ability studies in okra, Int.J Curr. Microbial. App. Sci (2018) Special Issue-6:1935-1940.

Dhankar S.K, Saharan B.S, Dhankar B.S, Heterosis and combining ability in okra, Tropical Agriculture Research Vol.6 1994.

Sapavadiya SB, Kachhadia VH, Savaliya J, Sapovadiya MH and Virendra Singh Shekawat, Study on combining ability for fruit yield and its related attributes in okra, The Pharma Innovation Journal 2019; 8(6): 31-34.

Satish k, Agalodia A. V and Prajapati D. B, Combining ability for yield and its attributing traits in okra, Int.J. Curr. Microbial. App. Sci (2017) 6(9): 1944-1954.

Lyngdoh Y.A, Mulge. R and Shadap. A, Heterosis and combining ability in near homozygous lines of okra for growth parameters, The Bioscan 8(4): n1275-1279, 2013.

Makhdoom MI, Kouser P Wani, Khan SH, Asharf Bhat M, Hussain K, Afroza B and Nabi Ambreen, Combining ability analysis in okra, Journal of Pharmacognosy and Phytochemistry2018; 792): 460-465.

Annapurna and Singh S.P, Analysis of combining ability status and nature of gene action among hybrids for yield and quality traits in okra, International Journal of pure and applied Bioscience, Int. J. Pure App. Biosci. 6(2): 1547-1553 (2018).

More S.J, Chaudari K.N, Patel A.I, and Dhwani Patel, combining ability analysis for fruit yield and yield attributing traits in okra, Trend in Biosciences 8(14), Print: ISSN 0974-8431, 3630-3637,2015.

Joshi, J. L. and Murugan. S, Studies on geneaction in Bhindi, International Journal of Development Research, Vol. 3, Issue, 03, pp.001-003, March,2013.

Reddy M.T, Haribabu k, Ganesh. M, Begum. H, Combining ability analysis for growth, earliness and yield attributes in okra, Thai Journal of Agricultural Sciences 2011,44(3): 207-218.

Sujata Padadalli, Satish. D, Babu A. G, Rekha Chittapur, Dr. Prabhuling and Dr. Daadapur Peeyade, Studies on combining ability in Okra through line × Tester analysis for productivity and quality traits, Journal of pharmacognosy and phytochemistry 2019;8(4): 639-643.