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Correlation analysis for fruit yield and its related traits in okra [*Abelmoschus esculentus* (L.) Moench]

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Abstract
The goal of the current investigation was to examine the relationships between genotype and phenotype for traits that contribute to yield. Eleven parental lines, including three checks, make up the experimental material for this study. The Lx T mating design was used to create 33 cross combinations from 11 female lines and 3 testers, and sufficient F_1 seeds were produced in the *Kharif* of 2021. The experiment was carried out to determine the direction and strength of the association between characters, correlation studies were conducted at both the phenotypic and genotypic levels. It shows that environmental factors had a relatively small impact on the genotypic expression of correlation, which was a strong inherent association between the various studied characters. Fruit yield per plant was significantly positively correlated with plant height, number of nodes per plant, internodal length, number of fruits per plant, fruit weight, fruit length, and weight of 100 seeds. This shows how these characters have simultaneously improved due to selection.

Keywords: Character association, genotypic, phenotypic, correlation, fruit yield, and okra

Introduction

Okra [*Abelmoschus esculentus* (L.) Moench] is a fast-growing, economically significant annual vegetable crop that has taken the lead among the vegetables. Originating in tropical Africa, the Subtropics, and India, okra is a tropical and subtropical plant that is primarily cultivated in warm tropical and subtropical climates around the world (Charrier, 1984) [3]. The wild species of *Abelmoschus ficulneus* (L.), *A. crinitus*, *A. angulosus*, and *A. tuberculatus* are restricted to Asia and Australia, with the exception of *A. ficulneus,* which is also found in tropical Africa. The three cultivated species, *Abelmoschus esculentus* (L.) Moench, *A. manihot* (L.) Medikus, and *A. moschus* Medikus, are found. According to morphological studies, the West African perennial okra-like plant known as "Guineen" that is grown in Ghanaian villages is intermediate between *A. esculentus* and *A. manihot*. Okra is referred to by numerous regional names throughout the world, including Lady's Finger in England, Gumbo in America, Guino-gombo in Spanish, Guibeiro in Portuguese, and Bhindi in India (Chevalier, 1940) [4].

Okra plants grow in an indeterminate manner. Stress from both biotic and abiotic sources has a significant impact on flowering, which is an ongoing process. Typically, the plant produces its first flower one to two months after being sown. After flowering, the fruit, which is a capsule, develops quickly. The greatest increase in fruit length, height, and diameter occurs between the fourth and sixth day following pollination. Fruit is typically picked for consumption at this stage. Okra pods are harvested when they are immature, have a high mucilage content, but before they become extremely fibrous. On average, fruit fibre production starts on the sixth day after fruit development and significantly increases on the ninth day.

In order to breed okra to the desired genotype for our trait of interest, breeding programmes may greatly benefit from knowledge of the genetic diversity and relationships among okra germplasm. Evolutionary biology and various genetic improvement programmes have long focused on characterising and quantifying genetic diversity. For the wise use of plant genetic resources, knowledge of the genetic diversity within and among closely related crop varieties is crucial (Kante *et al.*, 2022) [10]. A statistical technique known as the correlation coefficient determines the strength and direction of a relationship between two or more variables. Correlation, then, measures the strength of the relationship between different characters and establishes the character components from which a selection can be made to increase yield. It reveals how two or more variables are related to one another.

For the selection of superior genotypes and improvement of any trait, correlation and path coefficient analysis are prerequisites for improving any crop, including okra. Correlation analysis aids in the selection of superior genotypes from a variety of genetic populations by providing information about yield components. The correlation studies merely track how yield and other traits are related. Partitioning a set of pair-wise cause-effect relationships into direct and indirect effects can make the information revealed by the correlation coefficients more useful (Kang *et al*., 1983) [9].

Materials and Methods

The present investigation for correlation studies in yield and yield contributing characters in okra genotypes was conducted at Breeder Seed Production Unit V.N.M.K.V. Parbhani during *summer* (crossing) 2021 and *kharif* 2021. Experimental material for the proposed work consists of 11 exotic okra lines obtained from NBPGR, New Delhi and 3 testers. Total 50 genotypes comprising 33 crosses, 11 exotic lines, 3 testers and 3 checks *i.e* Mahyco bhindi No.10, Pusa Sawani and Parbhani okra. This material was sown in a Randomized Block Design with two replications. A spacing of 60cm between the rows and 30cm within the plant was adopted.

The genetic analysis was earned out adopting line x tester mating design as suggested by Kempthorne (1957) [11]. To understand the degree of relationship between different characters the genotypic and phenotypic correlation coefficients were carried out from their respective variances and co-variances as formulae suggested by Johnson *et al.* (1955) [8].

Results and Discussion

It is essential for a successful selection process to understand the type of relationship that exists between various traits and yield per plant. The essence of the relationship between various traits and yield per plant at both the genotypic and phenotypic levels was ascertained using correlation coefficient analysis. In order to calculate the interrelationship of various traits with yield per plant at both the genotypic and phenotypic level, a correlation study was conducted in 50 okra genotypes for 18 characters. Correlation estimates were compared to tabulated values at the 5% and 1% level of significance in order to determine their significance. Tables 1 and 2 show the genotypic and phenotypic correlation coefficients for 18 characters among 50 genotypes.

Fruit yield per plant is a complex trait that is poly genetically controlled and results from the multiplicative interaction with yield components. A dependent variable, yield depends on the overall impact of traits that contribute to yield. These factors significantly alter the system of fruit yield as a whole, both in terms of magnitude and direction. Direct selection for fruit yield is ineffective because fruit yield per plant has a complex quantitative character and is more influenced by the environment. Due to their interdependence, when one character undergoes a change, a series of other characters also undergo changes. In any selection program, it is crucial to research the relationship between yield and the traits that contribute to it.

In both genotypic and phenotypic levels, the trait plant height has a positive and significant relationship with the number of nodes per plant (0.4407, 0.4411), the inter-nodal length (0.801, 0.8843), the number of fruits per plant (0.4086, 0.3978), the weight (0.354, 0.3391), the length (0.467, 0.4379), and the yield per plant (0.5011, 0.4875). At both the genotypic and phenotypic levels, plant height has shown a significant and unfavourable correlation with pod borer infestation (-0.5597, -0.4735) and YVMV incidence (-.0.2862, -0.2691), respectively. Dhankhar *et al*. (2002) [26], Adiger *et al*. (2011) [1], Koundinya *et al*. (2013) [13], Rajat *et al*. (2018) [20], Sravanthi *et al*. (2021) [25], and Samiksha *et al.*, (2021) [23]. All reported similar results. At both the genotypic and phenotypic levels, the number of branches was negatively and significantly correlated with fruit weight (-0.2921, -0.2318), fruit length (-0.3848, -0.3705), pod borer infestation (-0.384, -0.2561), incidence of YVMV (-0.2908, -0.2307), and yield per plant (-0.2928, -0.2597). Similar result were reported by Koundinya *et al*. (2013) [13], and Jadhav *et al*., (2022) [7].

The number of nodes per plant showed a positive and significant correlation with fruit weight (0.5853), number of seeds per fruit (0.2802), and yield per plant (0.4698) at the genotypic level, and with days for 50% flowering (0.2017), days until first harvest (0.2041), fruit weight (0.5535), leaf area (0.2323), number of seeds per fruit (0.2745), 100 seed weight (0.2319), days needed to produce marketable fruit (0.2041), and yield per Nodes per plant have shown a significant and adverse relationship (-0.2809, -0.2504) with pod borer infestation at both the genotypic and phenotypic levels, respectively. Nasit *et al*. (2009) [16] and Kumar *et al*. (2019) [14] both came to the same conclusion (2019).

Internodal length has, at the genotypic and phenotypic levels, respectively, shown positive and significant correlation with fruit number per plant (0.3857, 0.3719), fruit length (0.4295, 0.4008), and yield per plant (0.3137, 0.3116). At both genotypic and phenotypic levels, internodal length has shown a significant and negative correlation with the number of seeds per fruit (-0.3928, -0.3786), 100 seed weight (-0.3695, -0.3498), pod borer infestation (-0.473, -0.397), and YVMV incidence (-0.3383, -0.3375). The findings agree with those of Nirosha *et al*. (2014) [17] and Adiger *et al*. (2011) [1].

At both the genotypic and phenotypic levels, the number of ridges per fruit has demonstrated a positive and significant association with days to 50% flowering (0.3489, 0.3144), days to first harvest (0.3439, 0.3114), fruit diameter (0.505, 0.4915), and days required to marketable fruit (0.3439, 0.3114). However, both at the genotypic and phenotypic levels, the trait number of ridges per fruit has shown a negative and significant association with the number of fruits per plant (-0.2875, -0.2863). Only at the phenotypic level has the trait, "number of ridges per fruit," demonstrated a positive and significant correlation with fruit weight (0.2424), fruit length (0.2391), leaf area (0.2451), and the number of seeds per fruit (0.211). The same outcome was attained by Kerure *et al*. (2017) [12].

At both the genotypic and phenotypic levels, the character days to 50% flowering has shown a positive and significant correlation with the number of days to first harvest (0.9964, 0.9911), fruit weight (0.382, -0.3162), fruit diameter (0.3956, -0.3195), number of seeds per fruit (0.7247, -0.6252), and days needed to produce marketable fruit (0.9964, 0.9911). Days to 50% flowering showed a negative and significant correlation (-0.497, -0.4233) with the number of fruits per plant, both genotypically and phenotypically. The relationship between the number of days until the first harvest was significant and favourable.

Table 1: Genotypic correlation for yield and its contributing traits in okra

	Plant Height	No of Branches	No of Nodes per Plant	Inter-nodal Length	Number of Ridges per Fruit	Days for 50% flowering	Number of days to first harvest	Number of fruits per plant	Fruit Weight	Fruit Length	Fruit Diameter	Leaf Area	Number of Seeds Per Fruit	100 Seed Weight	Days required to marketable fruit	Pod Borer Infestation (%)	Incidence of YVMV (%)	Yield/ Plant
Plant Height	1.000																	
No of Branches	-0.0802 NS	1.000																
No of Nodes per Plant	0.4407 **	0.1217 NS	1.000															
Inter-nodal Length	0.8801 **	-0.1412 NS	-0.0355 NS	1.000														
Number of Ridges per Fruit	-0.1694 NS	0.061 NS	-0.113 NS	-0.1295 NS	1.000													
Days for 50% flowering	-0.1331 NS	0.1277 NS	0.2163 NS	-0.262 NS	0.3489 *	1.000												
Number of days to 1st harvest	-0.1117 NS	0.1171 NS	0.223 NS	-0.2389 NS	0.3439 *	0.9964 **	1.000											
Number of fruits per plant	0.4086 **	-0.1624 NS	0.1311 NS	0.3857 **	-0.2875 *	-0.497 **	-0.4702 **	1.000										
Fruit Weight	0.354 *	-0.2921 *	0.5853 **	0.092 NS	0.2457 NS	0.382 **	0.389 **	0.1876 NS	1.000									
Fruit Length	0.467 **	-0.3848 **	0.1673 NS	0.4295 **	0.2596 NS	0.0631 NS	0.0603 NS	0.379 **	0.6213 **	1.000								
Fruit Diameter	-0.1967 NS	-0.1463 NS	-0.1104 NS	-0.1616 NS	0.505 **	0.3956 **	0.3823 **	-0.3393 *	0.179 NS	0.0934 NS	1.000							
Leaf Area	0.1387 NS	-0.0505 NS	0.2343 NS	0.04 NS	0.2475 NS	0.357 *	0.3897 **	-0.116 NS	0.43 **	0.2107 NS	0.1675 NS	1.000						
Number of Seeds Per Fruit	-0.2177 NS	2e-04 NS	0.2802 *	-0.3928 **	0.2155 NS	0.7247 **	0.7248 **	-0.5207 **	0.3408 *	-0.0658 NS	0.5463 **	0.2674 NS	1.000					
100 Seed Weight	-0.2112 NS	-0.2632 NS	0.2352 NS	-0.3695 **	0.1956 NS	0.0344 NS	0.026 NS	0.2828 *	0.457 **	0.4216 **	-0.0058 NS	0.1411 NS	0.0478 NS	1.000				
Days required to marketable fruit	-0.1117 NS	0.1171 NS	0.223 NS	-0.2389 NS	0.3439 *	0.9964 **	1 **	-0.4702 **	0.389 **	0.0603 NS	0.3823 **	0.3897 **	0.7248 **	0.026 NS	1.000			
Pod Borer Infestation (%)	-0.5597 **	-0.384 **	-0.2809 *	-0.473 **	-0.1221 NS	0.0477 NS	0.0452 NS	0.0905 NS	0.0614 NS	-0.1623 NS	0.1373 NS	-0.1037 NS	0.206 NS	0.3132 *	0.0452 NS	1.000		
Incidence of YVMV (%)	-0.2862 *	-0.2908 *	0.1075 NS	-0.3833 **	0.0727 NS	0.2702 NS	0.2598 NS	-0.2051 NS	0.1937 NS	0.1392 NS	0.0992 NS	0.117 NS	0.1604 NS	0.2912 *	0.2598 NS	0.1178 NS	1.000	
Yield/Plant	0.5011 **	-0.2928 *	0.4698 **	0.3137 *	-0.08 NS	-0.081 NS	-0.0583 NS	0.7811 **	0.7538 **	0.624 **	-0.1271 NS	0.176 NS	-0.1289 NS	0.4561 **	-0.0583 NS	0.0982 NS	7e-04 NS	1.000

*, ** denotes significance at 5% and 1% respectively

Table 2: Phenotypic correlation for yield and its contributing traits in okra

	Plant Height	No of Branches	No of Nodes per Plant	Inter-nodal Length	Number of Ridges per Fruit	Days for 50% flowering	Number of days to first harvest	Number of fruits per plant	Fruit Weight	Fruit Length	Fruit Diameter	Leaf Area	Number of Seeds Per Fruit	100 Seed Weight	Days required to marketable fruit	Pod Borer Infestation (%)	Incidence of YVMV (%)	Yield/ Plant
Plant Height	1.000																	
No of Branches	-0.0731 NS	1.000																
No of Nodes per Plant	0.4411 **	0.0937 NS	1.000															
Inter-nodal Length	0.8843 **	-0.1183 NS	-0.0257 NS	1.000														
Number of Ridges per Fruit	-0.1572 NS	0.0776 NS	-0.1064 NS	-0.1189 NS	1.000													
Days for 50% flowering	-0.1116 NS	0.1442 NS	0.2017 *	-0.2288 *	0.3144 **	1.000												
Number of days to 1st harvest	-0.1002 NS	0.1392 NS	0.2041 *	-0.2151 *	0.3114 **	0.9911 **	1.000											
Number of fruits per plant	0.3978 **	-0.1695 NS	0.1374 NS	0.3719 **	-0.2863 **	-0.4233 **	-0.4125 **	1.000										
Fruit Weight	0.3391 **	-0.2318 *	0.5535 **	0.096 NS	0.2424 *	0.3162 **	0.3248 **	0.181 NS	1.000									
Fruit Length	0.4379 **	-0.3705 **	0.1621 NS	0.4008 **	0.2391 *	0.0448 NS	0.0505 NS	0.3617 **	0.5974 **	1.000								
Fruit Diameter	-0.1795 NS	-0.1044 NS	-0.1037 NS	-0.145 NS	0.4915 **	0.3195 **	0.3019 **	-0.3115 **	0.1675 NS	0.076 NS	1.000							
Leaf Area	0.1353 NS	-0.0425 NS	0.2313 *	0.0391 NS	0.2451 *	0.3118 **	0.3409 **	-0.1131 NS	0.4159 **	0.2055 *	0.1611 NS	1.000						
Number of Seeds Per Fruit	-0.2095 *	-0.002 NS	0.2745 **	-0.3786 **	0.211 *	0.6252 **	0.6248 **	-0.4981 **	0.3296 **	-0.064 NS	0.5286 **	0.267 **	1.000					
100 Seed Weight	-0.1974 *	-0.2453 *	0.2319 *	-0.3498 **	0.1879 NS	0.021 NS	0.0124 NS	0.2788 **	0.4335 **	0.4079 **	-0.012 NS	0.1388 NS	0.0479 NS	1.000				
Days required to marketable fruit	-0.1002 NS	0.1392 NS	0.2041 *	-0.2151 *	0.3114 **	0.9911 **	1 **	-0.4125 **	0.3248 **	0.0505 NS	0.3019 **	0.3409 **	0.6248 **	0.0124 NS	1.000			
Pod Borer Infestation (%)	-0.4735 **	-0.2561 *	-0.2504 *	-0.397 **	-0.0945 NS	0.0706 NS	0.0732 NS	0.0294 NS	0.017 NS	-0.1464 NS	0.1056 NS	-0.0825 NS	0.1792 NS	0.2926 **	0.0732 NS	1.000		
Incidence of YVMV (%)	-0.2691 **	-0.2307 *	0.0972 NS	-0.3575 **	0.0706 NS	0.22 *	0.2102 *	-0.1861 NS	0.1625 NS	0.0987 NS	0.0883 NS	0.1038 NS	0.1403 NS	0.2568 **	0.2102 *	0.1063 NS	1.000	
Yield/Plant	0.4875 **	-0.2597 **	0.4516 **	0.3116 **	-0.0806 NS	-0.0793 NS	-0.0667 NS	0.7815 **	0.7486 **	0.5979 **	-0.1137 NS	0.1682 NS	-0.1236 NS	0.4388 **	-0.0667 NS	0.0307 NS	-0.0105 NS	1.000

Fruit characteristics at the genotypic and phenotypic levels include fruit weight (0.389, 0.3248), fruit diameter (0.3823, 0.3019), leaf area (0.3897, 0.3409), number of seeds per fruit (0.7248, 0.6248), and days needed to produce marketable fruit (1, 1). At both the genotypic and phenotypic levels, the number of days until the first harvest was significantly (-0.4702, -0.4125) inversely correlated with the number of fruits per plant. The outcomes agree with those of Nirosha *et al*. (2014) [17].

At both the genotypic and phenotypic levels, the trait, the number of fruits per plant, has demonstrated a significant and positive correlation with fruit length (0.379, 0.3617), 100 seed weight (0.2828, 0.2788), and fruit yield per plant (0.7811, 0.7815), respectively. While the trait, "number of fruits per plant," has demonstrated a significant negative correlation with "fruit diameter" (-0.3393, -0.3115), "number of seeds per fruit" (-0.5207, -0.4981), and "days to marketable fruit" (-0.4702, -0.7815) at the genotypic and phenotypic levels, respectively. The results are correspondence with Nasit *et al*. (2009) [16], Ghosh *et al*. (2010) [27], Meena *et al*. (2017) [15] and Rathava *et al*. (2019) [21]. Fruit length (0.6213, 0.5974), leaf area (0.43 0.4159), number of seeds per fruit (0.3408, 0.3296), weight of 100 seeds (0.457 0.4335), days needed to produce marketable fruit (0.389, 0.3248), and yield per plant (0.7538 0.7486) have all shown positive and significant correlations with fruit weight. Nasit *et al*. (2009) [16], Nirosha *et al*. (2014) [17], and Sravanthi *et al*. (2021) [25] all came to the same conclusion.

At both the genotypic and phenotypic levels, fruit weight has demonstrated a positive and significant correlation with 100 seed weight (0.4216, 0.4079) and yield per plant (0.624, 0.5979). These findings agree with those of Nasit *et al*. (2009) [16], Rathava *et al*. (2019) [21], Ashraf *et al*. (2020) [2], and Sravanthi *et al* (2021). Fruit diameter has at the genotypic and phenotypic levels, respectively, shown a positive and significant correlation with the number of seeds per fruit (0.5463, 0.5286) and the number of days needed to produce a marketable fruit (0.3823, 0.3019). The outcomes are in agreement with Pithiya *et al* (2017) [19]. At both the genotypic and phenotypic levels, leaf area has demonstrated a positive and significant correlation with the number of days needed to produce marketable fruit (0.3897, 0.3409). At both the genotypic and phenotypic levels, the number of seeds per fruit has shown a positive and significant correlation with the number of days needed to produce a marketable fruit (0.7248, 0.6248).

At both the genotypic and phenotypic levels, 100 seed weight has shown a significant and positive correlation with pod borer infestation (0.3132, 0.2926), YVMV incidence (0.2912, 0.2568), and yield per plant (0.4561, 0.4388), respectively. Saryam *et al*. (2015) [24] and Raval *et al*. (2019) [22] both came to similar conclusions. Days to marketable fruit and incidence of YVMV (0.2102) at the phenotypic level have, respectively, shown positive and significant correlation. At both the genotypic and phenotypic levels, Pod Borer Infestation (%) has demonstrated a non-significant correlation with the incidence of YVMV (0.1178), (0.1063). At the genotypic and phenotypic levels, the incidence of YVMV (%) has shown a non-significant correlation with yield per plant.

Conclusion

In present study, yield per plant (g) has shown significant and positive association with number of fruits per plant, fruit weight (g), fruit length (cm), fruit diameter (cm), number of nodes per plant, plant height (cm), internodal length (cm) and 100 seed weight (g) at both genotypic and phenotypic level. Therefore, main emphasis on improvement of these characters should be given, while making the selection in okra genotypes. Hence, higher yield could be obtained by exerting selection pressure over any of these traits.

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