Determination of Intercharacter Relationships among Agronomic Traits of Diverse Okra (*Abelmoschus esculentus* (L.) Moench) Collections in Coastal Regions of Tamil Nadu

Abstract

The present investigation aimed to determine the intercharacter relationships among morphological characters in a diverse collection of 48 okra genotypes, including landraces, exotic, and indigenous accessions grown in coastal region of Tamil Nadu, with the objective of enhancing yield through selection. Both phenotypic and genotypic correlation coefficient analyses were conducted. The results revealed that fruit yield had a highly significant and positive correlation with fruit girth, fruit weight, the number of fruits per plant, and the harvest period. Conversely, a highly significant negative genotypic correlation was observed with days to 50% flowering, plant height, and days to first harvest. Path coefficient analysis provided further insights, indicating that days to first harvest, fruit weight, and the number of fruits per plant had positive direct effects on fruit yield per plant. In contrast, days to 50% flowering had a negative direct effect on yield. These findings suggest that selecting for traits such as earlier harvest, increased fruit weight, and a higher number of fruits per plant could lead to the development of superior okra cultivars with a balanced combination of traits, ultimately enhancing overall crop performance and sustainability in different agro-ecological zones.

Keywords: Correlation, Okra (*Abelmoschus esculentus* (L.) Moench), Path analysis

Introduction

Okra (*Abelmoschus esculentus* (L.) Moench), is predominantly cultivated in the tropical and sub-tropical regions. Okra is familiarly termed as Bhendi, Lady's finger and Gumbo (Patel *et al.*, 2023). It stands as a key vegetable crop during the summer and rainy seasons. It is commonly accepted that okra's origin can be traced to the Hindustan region, mainly India, Pakistan, and Burma (Gola *et al.*, 2021). Okra is a member of the Malvaceae family and is recognized for its hibiscus-like flowers. The cultivated okra has a unique chromosome number of 2n = 130. In Bhendi, cross pollination is prevalent, varying between 4% and 19% (Verma *et al.*, 2016). A significant proportion of up to 42%, relies on entomophily, implying the importance of insects in facilitating pollen exchange among Bhendi flowers (Kumar, 2006). India stands as the foremost global producer of okra, contributing a substantial 73% to the total production of Okra. Renowned for its nutritional and medicinal properties, okra is an important source of vitamins, minerals, and fiber. The fresh green pods are rich in vitamin C, Vitamin A and Vitamin K as well as folate, calcium, potassium, and magnesium (Ranga *et al.*, 2022). Biochemically, okra is notable for its high mucilage content, which has applications in both culinary and medicinal fields. Mucilage from okra is used as a natural thickening agent in foods, used as plasma alternative, helps in blood regulating blood sugar and cholesterol levels (Das *et al.*, 2019). The seeds of okra are also rich in oil (16-20%) and protein, making them a valuable component in food and feed industries. Roasted and ground okra seeds are used as coffee substitute. Given that yield, being a quantitative trait, is influenced by diverse factors, a comprehensive understanding of the degree of association between yield and yield related attributes is crucial for designing effective breeding programs. Correlation studies are frequently utilized to examine the inter-relationships between dependent and independent variables, as the degree of improvement correlates with the genetic diversity present in genotypes (Rahaman, 2015). However, correlation alone does not reveal the direct and indirect effects of characters on yield. Therefore, the integration of path coefficient analysis is essential, as it delineates the cause-and-effect relationships of specific traits and aids in the formulation of selection indices useful for the genetic enhancement of yield. Path coefficient analysis further elaborates both the direct and indirect association of each parameter to the overall yield.

Materials and Methods

The experimental materials employed in this research comprises of 48 diverse genotypes including landraces, indigenous and exotic collections obtained from NBPGR, New Delhi and various other geographical locations of India. The research was conducted in an agriculture farm, near Sivapuri village, Tamil Nadu during January – May 2022. Each genotype was planted in three replications in randomized block design (RBD) giving a spacing of 60 x 30 cm. Standard agronomic practices and pest control measures were implemented throughout the growing season. For data collection, from each genotype 5 plants were randomly picked and tagged. Quantitative traits data was systematically recorded following the IPGRI,1991 descriptor list for okra outlined by the International Plant Genetic Resources Institute. The observations were taken from five tagged plants for 12 characters, *viz.*, days to 50% flowering (D50H), days to first harvest (DFH), no of primary branches per plant, fruit length (cm), plant height (cm), fruit weight (gm), fruit girth (mm), peduncle length (mm), number of locules per plant, harvest period, no of fruits per plant and fruit yield per plant (kg). Calculations for genotypic correlation coefficients between characteristics were carried out using the components of variance and covariance, as outlined by Panse and Sukhatme (1967). Path coefficient analysis, as introduced by Wright (1921) and refined by Dewey and Lu (1959), was utilized to determine the direct and indirect contributions of various parameters to the overall correlation coefficients with total fruit yield per plant. The data analysis was carried out using TNAUSTAT and R Studio statistical software.

No need to code

Result and Discussion

Direct selection based on yield is ineffective because yield is a polygenically regulated variable. Yield is a dependent character determined by the interactions of different component traits with one another and with the crop's growing environment. To identify the contributors to yield, correlation and path analysis studies were conducted on yield and its component characters. A positive correlation between desired traits is advantageous for plant breeders, as it enables the simultaneous enhancement of both traits. In terms of phenotypic correlation, fruit yield per plant showed a positive and significant correlation with fruit weight (0.788), harvest period (0.145), fruit girth (0.316) and number of fruits per plant (0.559) and a negative significant correlation with days to 50% flowering (-0.204), plant height (-0.208) and days to fruit harvest (-0.196) as mentioned in Table 1. A positively significant phenotypic correlation between yield and a character indicates that, at level of observable traits, increase in that character associates with the increase of yield. A significant and negative phenotypic correlation indicates that increase in that character results in the decrease on the yield. Since phenotypic correlation includes environmental effects, the observed relationship might be influenced by growing conditions. At genotypic level, fruit yield per plant exhibited a positive significant correlation with fruit weight (0.789), number of fruits per plant (0.559), harvest period (0.203), fruit girth (0.378) and a negative significant genotypic association with days to 50% flowering (-0.281), days to first harvest (-0.349) and plant height (-0.273) as shown in Table 2. A positively significant genotypic correlation coefficient among yield and a character indicates that, increase in that character indirectly increases the overall yield. And a negative significant genotypic correlation indicates that increase in that character decreases the overall yield. These traits can be focused on for genetic improvement since they are driven by genetic factors and result in consistent yield improvements across different environments since they are not influenced by environmental factors. Reddy *et al.*, (2013) observed a similar positive association of fruit yield per plant with the number of fruits per plant. Archana *et al.*, (2015) reported a positive correlation with the harvest period, and Rynjah *et al.*, (2020) found a positive association with fruit girth. Conversely, Thulasiram *et al.*, (2017) documented a negative association between fruit yield per plant and days to first fruit harvest in okra.

Correlation studies determine the yield contributing characters but do not provide information regarding nature and number of contributions made by different independent characters towards yield. Yield is a complex trait influenced by multiple factors. Some factors are major components that directly affect yield, while others indirectly impact yield by influencing the behavior and growth of other components. Path analysis helps to identify the direct and indirect relationships of these factors on yield. At the genotypic level, the characters days to first harvest, number of fruits per plant and fruit weight exhibited high positive direct effect on fruit yield per plant. The improvement of these characteristics directly leads to an increase in the yield per plant. Days to 50% flowering and fruit thickness exhibited negative direct effect on fruit yield per plant and an increase in the level of these traits leads to a decrease in the average yield per plant. Similar results were reported for positive direct effect on yield per plant by Komolafe *et al.*, (2022) and Rajani *et al.*, (2022) for number of fruits per plant and Tulasiram *et al.*, (2017) for fruit weight. Negative direct effects conform with Nbeaa *et al.*, (2023) for days to 50% flowering and Chavan *et al.*, (2019) for fruit girth.

The residual effect was 0.03848, negligible and insignificant. A negligible residual effect in path analysis indicates that the method used in the path analysis effectively explains almost all the variability in the dependent variable. This suggests that the traits included in the analysis are comprehensive and highly predictive. Comparison between significant correlation coefficient analysis and path analysis (direct effects) contributing to each trait towards fruit yield per plant indicated that fruit weight, number of fruits per plant and harvest period had significant positive correlation and positive direct effect on fruit yield per plant. These traits directly influence the yield and selection of these traits can effectively enhance overall crop performance. Fruit girth had significant positive correlation and negative direct effect on fruit yield. Traits plant height and days to first harvest had significant negative correlation and positive direct effect on fruit yield per plant.

While the character days to 50% flowering had negative significant correlation and negative direct effect on fruit yield per plant.

Conclusion

In the current study, fruit yield per plant has a positive correlation with fruit weight, number of fruits per plant, harvest period, and fruit girth. The selection of these characters would help to increase yield. Path analysis reveals the cause-and-effect relationship of traits and aids in the identification of traits with direct and indirect effects on yield. The traits number of fruits per plant, fruit weight, and days to first harvest all had a positive and direct effect on yield, indicating that improving these traits will directly contribute to increased yield.

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Table 1: Phenotypic Correlation coefficient estimates of traits in Okra

Traits	D50F	PH	NPB	DFH	FL	FT	FW	PL	NLPP	NFPP	HP	FYPP
D50F	**1.00**	-0.022	-0.338**	0.603**	-0.191**	0.202*	0.117	0.152	0.120	-0.446*	0.179*	-0.204*
PH		**1.00**	0.197*	-0.093	0.276*	-0.175	-0.253**	0.200	0.071	-0.006	-0.003	-0.208*
NPB			**1.00**	-0.349**	0.016	0.074	-0.014	-0.013	0.052	0.103	0.140	0.080
DFH				**1.00**	-0.093	0.093	-0.015	0.191*	0.170*	-0.308**	0.042	-0.196*
FL					**1.00**	-0.160	-0.015	0.122	0.014	0.088	-0.036	0.098
FG						**1.00**	0.622**	-0.085	0.472**	-0.256**	0.296**	0.316**
FW							**1.00**	-0.031	·0.314**	0.024	0.235**	0.788**
PL								**1.00**	0.155	-0.011	0.064	-0.051
NLPP									**1.00**	-0.196	0.136	0.115
NFPP										**1.00**	-0.072	0.559**
HP											**1.00**	0.145*
FYPP												**1.00**

***, ** indicate level of significance at 5% and 1%, respectively.**

D50F: Days to 50% flowering; PH: Plant height (cm); NPB: Number of primary branches per plant; DFH: Days to first harvest; FL: Fruit length (cm); FW: Fruit weight (gm); FG: Fruit girth (mm); PL: Peduncle length (cm); NLPF: Number of locules per fruit; NFPP: Number of fruits per plant; HP: Harvest period; FYPP: Fruit yield per plant (kg).

Table 2: Genotypic Correlation coefficient estimates of traits in Okra

Traits	D50F	PH	NPB	DFH	FL	FT	FW	PL	NLPP	NFPP	HP	FYPP
D50F	**1.00**	-0.056	-0.448**	0.865**	-0.245	0.359	0.186	0.223	0.128	-0.653	0.265	-0.281**
PH		**1.00**	0.255	-0.081	0.342	-0.214	-0.311	0.269**	0.085	-0.031	-0.001	-0.273*
NPB			**1.00**	-0.548	0.033	0.106	-0.026	0.061	0.067	0.114	0.204	0.089
DFH				**1.00**	-0.066	0.158	-0.020	0.280	0.218	-0.533	0.076	-0.349*
FL					**1.00**	-0.251	-0.023	0.139	0.006	0.111	-0.040	0.120
FG						**1.00**	0.767	-0.109	0.547**	-0.314	0.394**	0.378*
FW							**1.00**	-0.100	0.353	0.005.	0.306	0.789**
PL								**1.00**	-0.182	-0.020	0.018	-0.081
NLPP									**1.00**	-0.222	0.175	0.133
NFPP										**1.00**	-0.106	0.559**
HP											**1.00**	0.203*
FYPP												**1.00**

***, ** indicate level of significance at 5% and 1%, respectively.**

D50F: Days to 50% flowering; PH: Plant height (cm); NPB: Number of primary branches per plant; DFH: Days to first harvest; FL: Fruit length (cm); FW: Fruit weight (gm); FG: Fruit girth (mm); PL: Peduncle length (cm); NLPF: Number of locules per fruit; NFPP: Number of fruits per plant; HP: Harvest period; FYPP: Fruit yield per plant (kg).

Table 3: Genotypic Path matrix (diagonal and bold are direct effects and off diagonal are indirect effects) for fruit yield per plant in okra

Traits	D50F	PH	NPB	DFH	FL	FT	FW	PL	NLPP	NFPP	HP	FYPP
D50F	**-0.440**	-0.0018	-0.0246	0.2795	0.0099	-0.0706	0.1936	-0.0016	-0.0105	-0.2408	0.0254	-0.282
PH	0.0247	**0.033**	0.0140	-0.0263	-0.0138	0.0422	-0.3231	-0.0020	-0.0070	-0.0116	-0.0001	-0.270
NPB	0.1971	0.0083	**0.055**	-0.1771	-0.0014	-0.0210	-0.0272	-0.0004	-0.0055	0.0424	0.0197	0.090
DFH	-0.3808	-0.0027	-0.0302	**0.323**	0.0027	-0.0312	-0.0209	-0.0020	-0.0178	-0.1966	0.0074	-0.349
FL	0.1081	0.0112	0.0019	-0.0213	**-0.040**	0.0494	-0.0241	-0.0010	-0.0006	0.0411	-0.0039	0.121
FT	-0.1580	-0.0070	0.0059	0.0512	0.0102	**-0.197**	0.7949	0.0008	-0.0446	-0.1160	0.0378	0.378
FW	-0.0821	-0.0102	-0.0014	-0.0065	0.0009	-0.1508	**1.036**	0.0007	-0.0288	0.0019	0.0294	0.789
PL	-0.0982	0.0088	0.0034	0.0905	-0.0057	0.0216	-0.1037	**-0.007**	0.0149	-0.0077	0.0018	-0.081
NLPP	-0.0567	0.0028	0.0037	0.0705	-0.0003	-0.1077	0.3666	0.0013	**-0.081**	-0.0818	0.0168	0.134
NFPP	0.2874	-0.0010	0.0063	-0.1722	-0.0045	0.0619	0.0054	0.0002	0.0181	**0.368**	-0.0102	0.559
HP	-0.1165	-0.0004	0.0113	0.0248	0.0016	-0.0775	0.3174	-0.0001	-0.0143	-0.0392	**0.096**	0.203

D50F: Days to 50% flowering; PH: Plant height (cm); NPB: Number of primary branches per plant; DFH: Days to first harvest; FL: Fruit length (cm); FW: Fruit weight (gm); FG: Fruit girth (mm); PL: Peduncle length (cm); NLPF: Number of locules per fruit; NFPP: Number of fruits per plant; HP: Harvest period; FYPP: Fruit yield per plant (kg).