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Phenotypic Correlation and Path Coefficient and Relative Importance Studies in Okra *Abelmoschus esculentus* (L.) Moench.

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Abstract: The experiment was undertaken to study correlation and path coefficient and relatively importance to yield and its components traits in Okra. The experimental material consisted of six generations (P1, P2, F1, F2, BC1 and BC2) through two crosses, which were evaluated in Completely Randomized Block Design (RCBD) with three replications at the Agriculture Scientific Center in Latakia during the summer of 2020. The result of phenotypic correlation revealed that yield per plant had positively significant correlation with fruit diameter (0.53), positively highly significant correlation with fruit weight (0.65), and negatively highly significant correlation with days for first flowering and days to 50% flowering (-0.56, -0.63), respectively in the first hybrid (Lathkani 6× Lathkani 10). In the second hybrid (Lathkani 7× Lathkani 9), yield per plant has exhibited positively and highly significant correlation with numbers of fruit per plant, numbers of flowers per plant, fruit length, fruit diameter and fruit weight (0.95, 0.96, 0.76, 0.65, 0.64), respectively. The high positively direct effect on yield per plant was contributed by fruit weight followed by days to 50% flowering in the first hybrid. Numbers of fruits per plant had desirably direct effect on yield per plant in the second hybrid. Hence, direct selection based on these traits would result in simultaneous improvement of previously mentioned traits and yield in Okra.

Keywords: Okra, Path analysis, Phenotypic correlation, Relative importance, Yield.

Introduction

Okra (*Abelmoschus esculentus* (L.) Moench) belongs to the family of Malvaceae, and it is widely grown in tropical and sub-tropical parts of the world (Shivaramegowda *et al*., 2016). Ethiopia, Sudan and Northeast Africa are the original home of Okra, and it widely spreads in many countries of the world (Salih & Mansoor, 2019). Fresh and immature fruit of okra is used as vegetable. Okra is an important source of fat, carbohydrate, fiber, calcium, phosphorous, iron, iodine, magnesium & vitamins (C, A & B) (Samim *et al.,* 2018). The main aim of any breeding program is to produce large yield. To select an efficient breeding method, it is important to have a enough knowledge of yields and yield

components traits and their relationship with quantitative traits. Correlation analysis helps in identifying the trait that would result to the enhancing the desirably associated trait (Sravanthi *et al*., 2021).

Yield is a complex character resulting from multiplicative interactions of various yield-attributing traits. Therefore, association studies between yields with other traits will be important for breeders to plan the hybridization program and to evaluate the individual plants in segregating generations (Aminu *et al*., 2016). For any effective selection program, it would be desirable to consider the relative magnitude of association of various traits with yield. Path analysis divides the correlation coefficient into measures of direct and indirect effects, providing an understanding of the direct and indirect contribution of each trait to yield (Kang *et al*., 1983).

Considering the importance of the above-mentioned points, the present investigation aims to study the association among traits and the direct and indirect effects of some important yield components on fruit yield in Okra genotypes by adopting path analysis.

Materials & Methods

The current study on correlation and path coefficient analysis in Okra was undertaken during the summer of 2020 at the Agriculture Scientific Center in Latakia.

The six generations of Okra (P1, P2, F1, F2, BC1 & BC2) through two crosses were evaluated in Completely Randomized Block Design (RCBD) with three replications .Planting was done on ridges and furrows with a spacing of (70 × 40 cm). The standard recommendations for agronomic practices and plant protection were followed to grow healthy plants. Observations were recorded on ten plants for parents and F1s, twenty plants for backcrosses & forty plants for F2s in each replication, excluding the border ones according to (Mistry, 2013). The data were recorded on the number of the first flowering node, the height of the first flowering node, days to first flowering, days to 50% for flowering, number of flowers per plant, number of fruits per plant, leaf length (cm), fruit length (cm), fruit diameter (cm), number of fruit ridges, fruit weight, yield per plant and pollen vitality.

The correlation coefficient analysis was performed according to the method suggested by (Snedecor & Cochran, 1981). Path coefficient analysis suggested by Dewey & Lu (1959) was carried out to know the direct and indirect effect of the traits on Okra plant yield. Relative importance was estimated employing this formula:

$$\boldsymbol{RI = |CD_i| / \sum_i |CD_i| \times 100}$$

Results & Discussion

Phenotypic correlation coefficient

It is necessary to study, assess and understand the relationship between yield and yield-attributing traits before exercising selection. With this view in mind, the phenotypic correlation coefficients were computed between various traits under the present study and presented in table (1).

Positively and significant association of fruit yield was observed with fruit diameter (0.53) and positively and highly significant correlation with fruit weight (0.65). Whereas negatively and highly significant correlation was found fruits yield, with days to first flowering and Days to 50% flowering (-0.56, -0.63) respectively, in the first hybrid. Positively and highly significant correlation

was recorded between fruit yield with numbers of flowers per plant, numbers of fruits per plant, fruit length, fruit diameter & fruit weight (0.96, 0.95, 0.76, 0.65, & 0.64) respectively, in the second hybrid. Similar results for days to the first flowering, numbers of fruits per plant and fruit diameter by (Ibrahim *et al.,* 2013). For number of fruit per plant by (Rai *et al*., 2022)

Days to 50% flowering had highly significant and positively correlated with days to first flowering (0.57, 0.95) in the first and second hybrids, respectively. These were in line with the findings of (Nirosha *et al.,* 2014). Negatively and significant association of Days to 50% flowering was observed with fruit diameter (-0.55), and highly negatively significantly correlated with fruit weight (-0.67). Whereas positively and highly significant correlation was found between Days to 50% flowering on the number of the first flowering node (0.91), height of the first flowering node (0.91) in the second hybrid. Singh *et al*. (2017) recorded similar results for the first flowering node.

Days to first flowering have depicted positively and highly significant correlation with numbers of flowers and fruits per plant (0.65) and the height of the first flowering node (0.63), and negatively and highly significant correlation with fruit diameter (-0.65) and fruit weight (-0.80) in the first hybrid. The Number of the first flowering node (0.84) and the height of the first flowering node (0.83) exhibited positively and highly significant correlation with days to first flowering, and fruit weight (-0.65) exhibited negatively and highly significant correlation with days to first flowering in the second hybrid. Such results were also reported by (Sravanthi *et al*., 2021) who found that fruit weight has recorded negatively and highly significant association with days to first flowering and days to 50% for flowering.

Negatively and highly significant association of fruit weight was observed with numbers of flowers and fruits per plant (-0.74) and height of the first flowering node (-0.78) and negatively significant correlation with fruit length (-0.46). Whereas positively and highly significant correlation was found fruits weight with fruit diameter and number of fruit ridges (0.79, 0.61) respectively, in the first hybrid. Fruit weight has depicted negatively highly significant correlation with the number of the first flowering node and the height of the first flowering node (-0.64, -0.65) respectively, and positively highly significant correlation with fruit length and fruit diameter (0.62, 0.69) respectively in the second hybrid. Similar results for fruit diameter and fruit length were reported by (Aminu *et al*., 2016). For fruit length by (Rashwan, 2011).

Numbers of fruit ridges exhibited negatively and highly significant correlation with number of fruits per plant, numbers of flowers per plant, the number of the first flowering node, the height of the first flowering node & fruit length (-0.66, -0.66, -0.69, -0.75, and -0.77) respectively, and positively and highly significant correlation with fruit diameter (0.81) in the first hybrid.

Fruit diameter has depicted negatively and significant correlation with numbers of flowers per plant (-0.54), numbers of fruits per plant (-0.54) and fruit length (0.49), and negatively and highly significant correlation with the number of the first flowering node (-0.73) and the height of the first flowering node (-0.79) in the first hybrid. Fruit diameter

exhibited positively and significant correlation with numbers of flowers per plant and numbers of fruits per plant (0.55, 0.54) respectively, positively and highly significant correlation with fruit length (0.82), and negatively and highly significant association with numbers of the first the flowering node and the height of the first flowering node (-0.63, -0.66) respectively, in the second hybrid. This was different from previous observations made by (Yora *et al*., 2018) who reported that fruit diameter exhibited negatively and highly significant correlation with fruit length.

Fruit length exhibited positively and highly significant correlation with numbers of flowers per plant, numbers of fruits per plant, the number of the first flowering node & the height of the first flowering node (0.84, 0.85, 0.70, and 0.78) respectively, in the first hybrid. Fruit length was recorded positively and highly significant correlation with numbers of flowers per plant and numbers of fruits per plant (0.74, 0.70) respectively, in the second hybrid. That is supported by Sravanthi *et al*. (2021) for numbers of fruits per plant.

Positively and highly significant association of the height of the first flowering node was observed with numbers of flowers per plant (0.77), numbers of fruits per plant (0.77) and the number of the first flowering node (0.83) in the first hybrid. The height of the first flowering node was recorded highly significant and positively correlation with numbers the first flowering node (1.00) in the second hybrid. The number of the first flowering node exhibited positively and significant correlation with numbers of flowers per plant and numbers of fruits per plant (0.49, 0.50) respectively, in the first hybrid. Positively and highly significant correlation of number of flowers per plant was observed with number of fruits per plant (1.00, 0.99) in the first and second hybrids respectively.

Path analysis

Path coefficient analysis divides the correlation coefficients into direct and indirect effects of a set of independent variables on the dependent variable. This analysis helps to understand whether the relationship of these traits with yield is due to the direct effect of the trait, reflects a true relationship between them and if selection can be practiced for such a variable to improve yield. For estimating the direct and indirect effect of constituent characters on yield, the path coefficient analysis of yield contributing traits with yield per plant in the first hybrid is included in table (2).

Fruit diameter had negligibly direct positively effect on yield per plant (0.089). Further, it exhibited highly positively indirect effect through fruit weight (0.939) and highly negatively indirect effect through days to first flowering (-0.631) on fruit yield per plant.

Fruit weight exerts positively very high direct effect on yield (1.192) and bigger than correlation coefficient between this trait and yield. Days to 50% flowering (-0.997) exerted negatively high direct effect on yield, and bigger than negatively correlation coefficient between this trait and yield. This indicates that correlation explains the true relationship and the direct selection through fruit weight and days to 50% flowering, which will be effective to improve yield in this hybrid. These results were showing similarity with Rajani *et al*. (2022) for days to 50% flowering.

Table (1): Correlation coefficients among yield and yield-related traits in two hybrids.

rph	hybrid	Y	D50%fl	D1fl	Fw	No.l	FD	FL	H1nfl	No1nfl	No.fr
No.fl	1	0.01	-0.18	0.65**	-0.74**	-0.66**	-0.54*	0.84**	0.77**	0.49*	**1.00****
	2	0.96**	-0.16	-0.3	0.46	-0.12	0.55*	0.74**	-0.12	-0.1	**0.99****
No.fr	1	0.01	-0.19	0.65**	-0.74**	-0.66**	-0.54*	0.85**	0.77**	0.50*	**1**
	2	0.95**	-0.18	-0.31	0.42	-0.08	0.54*	0.70**	-0.11	-0.09	**1**
No1fln	1	-0.07	-0.25	0.27	-0.44	-0.69**	-0.73**	0.70**	0.83**	1	
	2	-0.2	0.91**	0.84**	-0.64**	-0.3	-0.63**	-0.37	1.00**	1	
H1fln	1	-0.3	-0.04	0.63**	-0.78**	-0.75**	-0.79**	0.78**	1		
	2	-0.23	0.91**	0.83**	-0.65**	-0.32	-0.66**	-0.39	1		
FL	1	0.27	-0.32	0.38	-0.46*	-0.77**	-0.49*	1			
	2	0.76**	-0.24	-0.25	0.62**	-0.07	0.82**	1			
FD	1	0.53*	-0.17	-0.65**	0.79**	0.81**	1				
	2	0.65**	-0.55*	-0.46	0.69**	0.09	1				
No.l	1	0.06	0.22	-0.4	0.61**	1					
	2	-0.07	-0.43	-0.32	0.22	1					
Fw	1	0.65**	-0.2	-0.80**	1						
	2	0.64**	-0.67**	-0.65**	1						
D1fl	1	-0.56**	0.57**	1							
	2	-0.4	0.95**	1							
D50%fl	1	-0.63**	1								
	2	-0.3	1								

**Significant at 1% level of probability ($P_{0.01}$= 0.5425), *Significant at 5% level of probability ($P_{0.05}$= 0.4683). Y: yield. D50%fl: days to 50% flowering. D 1fl: days to first flowering. Fw: fruit weight. No. L: number of fruit ridges. FD: fruit diameter. FL: fruit length. H1fln: height of the first flowering node. No. 1fln: the number of the first flowering node. No. fr: number of fruits per plant. No.fl: number of flowers per plant.

Table (2): Direct and indirect effects of casual variables on fruit yield/plant in the first hybrid Lathkani 6× Lathkani 10.

Lathkani 6× Lathkani 10	fruit diameter	fruit weight	pollen vitality	days to first flowering	days to 50% flowering
fruit diameter	**0.089**	0.07	-0.038	-0.058	-0.015
fruit weight	0.939	**1.192**	-0.411	-0.955	-0.236
pollen vitality	-0.038	-0.031	**0.089**	0.039	0.065
days to first flowering	-0.631	-0.781	0.429	**0.976**	0.555
days to 50% flowering	0.172	0.197	-0.725	-0.567	**-0.997**
correlation coefficient	0.53*	0.65**	-0.66**	-0.56**	-0.63**

Values in bold indicate directly effect of different characters on fruit yield.
**Significant at 1% level of probability ($P_{0.01}$= 0.5425), *Significant at 5% level of probability ($P_{0.05}$= 0.4683).

Days to first flowering have highly positively direct effect on yield (0.976), but the correlation coefficient between this trait and yield was negative, which indicates the indirect effects seem to be the cause of association. In this situation, the indirect causal factors are to be considered simultaneously for selection.

Pollen vitality recorded negligible positively direct effect on yield (0.089), whereas negatively high indirect effect via fruit weight and days to 50% flowering (-0.411, -0.725) respectively, and positively high indirect effect via day to first flowering (0.429).

For estimating the direct and indirect effect of constituent characters on yield, the path coefficient analysis of yield contributing traits with yield per plant in the second hybrid is included in table (3).

Table (3): Direct and indirect effects of casual variables on fruit yield/plant in the first hybrid Lathkani 7× Lathkani 9.

Lathkani 7× Lathkani 9	Number of flowers per plant	Number of fruit per plant	Leaf length	Fruit length	Fruit diameter	Fruit weight
number of flowers per plant	**0.168**	0.167	0.155	0.124	0.092	0.077
number of fruit per plant	0.454	**0.458**	0.421	0.319	0.246	0.194
leaf length	0.254	0.253	**0.276**	0.203	0.175	0.141
fruit length	-0.026	-0.025	-0.026	**-0.036**	-0.029	-0.022
fruit diameter	-0.012	-0.012	-0.014	-0.018	**-0.022**	-0.016
fruit weight	0.123	0.114	0.137	0.166	0.185	**0.268**
correlation coefficient	0.96**	0.95**	0.95**	0.76**	0.65**	0.64**

Values in bold indicate direct effect of different characters on fruit yield.
**Significant at 1% level of probability ($P_{0.01}$= 0.5425), *Significant at 5% level of probability ($P_{0.05}$= 0.4683).

Numbers of flowers per plant exerted positively low direct effect on yield (0.168). Further, it exhibited highly indirect positively effect through numbers of fruits per plant (0.454) on yield per plant. Numbers of fruits per plant had high positively direct effect on yield per plant (0.458). Similar results were reported by and Nirosha *et al*. (2014) and Singh *et al*. (2017) for this trait.

Leaf length exerted positively moderate direct effect on yield per plant (0.276). It exhibited highly indirect positively effect through numbers of fruits per plant (0.421).

Fruit length had negligibly direct negatively effect on yield per plant (-0.036). Whereas it exhibited highly indirect positively effect through numbers of fruits per plant (0.319) on yield per plant.

Fruit diameter had negligibly direct negatively effect on yield per plant (-0.022). Further, it recorded moderately indirect positively effect through numbers of fruits per plant (0.246). Fruit weight exerted positively moderate direct effect on yield per plant (0.268).

Relative importance

Relatively importance of contribution yield components traits to yield in the first hybrid is presented in table (4).

Table (4): Relative importance of contribution yield components traits to yield in the first hybrid Lathkani 6× Lathkani 10.

RI%	fruit diameter	fruit weight	pollen vitality	days to first flowering	days to 50% flowering
fruit diameter	**0.105**				
fruit weight	2.209	**18.738**			
pollen vitality	0.089	0.968	**0.105**		
days to first flowering	1.486	24.558	1.011	**12.555**	
days to 50% flowering	0.404	6.193	1.71	14.599	**13.112**

Residual effect =16.3782

RI%: relative importance. Values in bold indicate directly effect of different characters on fruit yield.

Indirectly effect of fruit weight via days to first flowering has the highest relative importance of contribution to yield (24.558%) followed by relatively importance of directly effect of fruit weight (18.738%), relatively importance of indirect effect of days to first flowering via days to 50% flowering (14.599%), relative importance of directly effect of days to 50% flowering (13.112%) and relative importance of direct effect of days to first flowering (12.555%). This suggests that selection of these traits *viz*, fruit weight, days to first flowering and days to 50% flowering would enhance the yield in this hybrid. The residual effect was (16.38%), which means that motioned traits explained about 83.62% of variability in the fruit yield. The reason may be due to high and significant correlation of these traits and fruit yield. Asghari-Zakaria *et al*. (2006) mentioned that

Number of tubers per plant, tuber size, and plant height in potato were considered as the important variables in sequential path analysis.

Relatively importance of contribution yield components traits to yield in the second hybrid is presented in table (5). Indirectly effect of numbers of fruit per plant via leaf length has the highest relative importance of contribution to yield (19.688%) followed by relatively importance of directly effect of numbers of fruit per plant (17.787%) and relative importance of indirectly effect of numbers of flowers per plant via numbers of fruits per plant (12.963%).

Table (5): Relative importance of contribution yield components traits to yield in the first hybrid Lathkani 7× Lathkani 9.

RI%	Number of flowers	Number of fruit per plant	Leaf length	Fruit length	Fruit diameter	Fruit weight
Number of flowers	**2.401**					
Number of fruit per	12.963	**17.787**				
Leaf length	7.246	19.688	**6.448**			
Fruit length	0.75	1.929	1.227	**0.108**		
Fruit diameter	0.352	0.937	0.668	0.111	**0.043**	
Fruit weight	3.507	8.827	6.407	1.006	0.706	**6.096**

Residual effect =0.9339
RI%: relative importance. Values in bold indicate direct effect of different characters on fruit yield

That suggests that selection of numbers of fruit per plant would enhance the yield in this hybrid. The residual effect was (0.93%), that means that studied traits explain about (99.07%) of variability in the yield. The reason seems to be high and significant correlation of these traits with fruit yield. Worley *et al*. (1974) found that the lint/seed had the secondary contribution in the development of lint yield in cotton.

Conclusion

Yield per plant exhibited significant positively association with fruit diameter, and highly significant positively association with fruit weight in the first hybrid, and with numbers of flowers per plant, numbers of fruits per plant, fruit length, fruit diameter & fruit weight in the second hybrid. Further, negatively and highly significant correlation of fruit yield with days to first flowering and days to 50% flowering in the first hybrid. Direct selection based on these traits would result in simultaneous improvement of above-mentioned traits and yield per plant in Okra. Fruit weight, days to first flowering and days to 50% flowering in the first hybrid, and numbers of fruits per plant in the second hybrid are important traits to be considered for genetic improvement in fruit yield per plant, since these traits have direct and indirect effects on yield, and their direct and indirect effects have the highest relative importance of contribution to yield.

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Contributions of Authors

B.A.T.: Constructed the idea and hypothesis for research.

R.N.: planned the methodology, collection and analyzed the data, wrote the manuscript.

E.A.: Took responsibility for land preparation and provided tools and equipment that were vital for the project.

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Conflicts of interest

As for the requirements of the publishing policy, there is no potential conflict of interest for the authors.

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دراسة معاملي الارتباط المظهري والمرور والاهمية النسبية لصفة الانتاج في الباميا *Abelmoschus esculentus (L.)* Moench.

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المستخلص: نفذت التجربة لدراسة معاملي الارتباط المظهري والمرور والأهمية النسبية لصفة الإنتاج والصفات المكونة له في الباميا. تكونت المادة التجريبية من الأجيال (P1، P2، F1، F2، BC1 & BC2) لهجينين والتي تم تقييمها وفق تصميم القطاعات العشوائية الكاملة في مركز البحوث العلمية الزراعية في اللاذقية في صيف 2020. كشفت نتائج الارتباط المظهري أن إنتاج النبات الواحد امتلك ارتباطاً موجباً ومعنوياً مع قطر الثمرة (0.53)، وارتباطاً موجباً وعالي المعنوية مع وزن الثمرة (0.65)، وارتباطاً سالباً وعالي المعنوية مع عدد الأيام لبدء الإزهار وعدد الأيام لإزهار 50% من النباتات (-0.56، -0.63)، على الترتيب في الهجين الأول (Lathkani 10 × Lathkani 6). وفي الهجين الثاني (Lathkani 9 × Lathkani 7). أظهر إنتاج النبات الواحد ارتباطاً موجباً وعالي المعنوية مع كل من عدد الثمار على النبات وعدد الأزهار على النبات الواحد وطول الثمرة وقطر الثمرة ووزن الثمرة (0.95، 0.96، 0.76، 0.65 و0.64)، على الترتيب. كان التأثير المباشر الموجب على إنتاج النبات الواحد يعود إلى وزن الثمرة متبوعاً بعدد الأيام لإزهار 50% من النباتات في الهجين الأول. سجل عدد الثمار على النبات تأثير مباشر مرغوب على إنتاج النبات الواحد في الهجين الثاني. وهكذا فإن الانتخاب المباشر اعتماداً على هذه الصفات سيؤدي تحسين الصفات المذكورة سابقاً بشكل متزامن مع الإنتاج في الباميا.

كلمات مفتاحية: الباميا، الإنتاج، الارتباط المظهري، معامل المرور، الأهمية النسبية