Original Research Article

Character associationand path analysis for yield and its components and yellow vein mosaicresistant in Okra[*Abelmoschus esculentus* (L.)Moench.]

Abstract

Aims: Select ion of the better parents for desirable characters specially earliness, yield and yield attributing characters,, fruit quality and resistant to yellow vein mosaic.

Study design: The experiment was conducted in Randomized Block Design having 25 genotypes in three replications.

Place and Duration of Study: The present investigation, carried out in the *kharif* seasons of 2016 at the field experimentation centre of the Department of Horticulture, Sam Higginbottom University of Agriculture, Technology & Sciences, Prayagraj (U.P.). The site is located between 25.87°N latitude and 81.15^{o} E longitude at 78 m above the sea level. The soils of the study areas are sandy to sandy loam in texture and moderately well to well drained with ground water irrigation facility. Methodology: In the present investigation, 25 genotypes have been grown in the *kharif* seasons of 2016. Good agricultural practices were done to grow the crop. The observations on 5 randomly selected plants from each genotypes in each replication were recorded for 15 quantitative and qualitative traits viz. plant height (cm), no. of branches/plant, no of leaves/plant, days to first flowering, days to 50% flowering, first flowering node, fruit length (cm), fruit diameter (cm), fresh fruit weight (g), no. of fruits/plant, fruit yield/plant (g), fruit yield/plot (g), YVMV incidence (%) YVMV severity (%) and crude fibre content (%).The data were subjected to statistical analysis to estimate the genetic correlation coefficient analysis. Genotypic and phenotypic correlation coefficients were calculated according to the formula given by *Miller et al.* (1958)

Results:

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Comment [UC1]: Very poor abstract

On the basis of data calculated and analysed, the positive and significant correlation was recorded between Days to First Flowering with Days to 50% Flowering (0.94) and Fruit Weight (g) with Fruit Yield/plant (g) (0.91). indicating that effective improvement through these characters could be achieved in okra. Fruit weight showed maximum positive direct effect on fruit yield per plant at both genotypic and phenotypic level. YVMV incidence % was recorded minimum in the genotype Kashi Satdhari (14.77 %) followed by Kashi Vardan (16.38 %) whereas maximum YVMV incidence % was recorded in 151-10-1-2-3 (79.17 %) followed by Larem-1 (75.31 %).

Conclusion:A very strong positive and significant correlation was recorded between Days to First Flowering with Days to 50% Flowering and Fruit Weight with Fruit Yield/plant. Negative and significant association of YVMV Incidence % with Fruit Yield/plant (g) indicates that fruit yield/plant decreases with increase in YVMV incidence %.Fruit weight showed maximum positive direct effect on fruit yield per plant at both genotypic and phenotypic level indicating that effective improvement through these characters could be achieved in okra.

Comment [UC2]: How can you place conclusion before introduction?
That's so silly

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Introduction

Vegetables are getting increasingly higher importance in India as well as in the world due to their relevance in achieving nutritional security from mal nutrition in human beings. Okra [*Abelmoschus esculentus* (L.) (Moench)] is an economically important vegetable crop grown in tropical and sub-tropical parts of the world. Okra has captured a prominent position among vegetables. It is choicest fruit vegetable grown extensively in tropical and subtropical parts of the world. Its tender green fruits are used as a vegetable and are generally marketed in fresh form, but sometimes in canned or dehydrated form. Major areas of cultivation in India are Uttar Pradesh, Bihar, Orissa, West Bengal, Andhra Pra desh, Karnataka and Assam West Bengal and Karnataka are major producers of okra (Anon., 2006).

This vegetable is largely a self-pollinating crop, but because of its spectacular corolla, the possibility of insect cross-pollination cannot be completely ruled out. As a

result, cross pollination is observed with insect assisted pollination to a degree of 4.0–19.0% (Purewell and Randhawa, 1947) and up to 42.2% (Mitrideri and Vencovsky, 1974 and Kumar, 2006). This explains a large amount of diversity in fruit output and its related features. The cultivar itself is crucial to the performance of the plant in terms of earliness, disease resistance, and yield in addition to soil and climate considerations.

A statistical tool for determining the strength and direction of a relationship between two or more variables is the correlation coefficient. Correlation coefficient analysis, used in plant breeding, assesses the interrelationships between various plant characteristics and determines the character components that selection can be based on for genetic yield improvement.

The plant breeder benefits from a positive correlation between desirable traits since it aids in the simultaneous development of both traits. On the other hand, a negative correlation will prevent two characters with high values from expressing themselves simultaneously. It is possible to improve dependent traits genetically by applying strong selection on a character who is genetically related to the dependent character (Al-Jibouri et al., 1958). The genetic relationship between the features to be chosen and other attributes has a significant impact on the selection process (Falconer and Mackay, 1996). The route coefficient analysis divides correlation coefficients into direct and indirect effects to emphasise the significance of accidental causes. The main goals of the current research are to comprehend genetic variation, the relationships between various features, and the direct and indirect contributions of each feature to the overall pea yield.

Materials and methods

The present investigation was carried out at the Horticulture Research Farm, Department of Horticulture, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj. The experiment will be conducted in Randomized Block Design having 25 genotypes collected from IIVR, Varanasi. The allocations of treatments in the individual plots are done by using random number using three replications.

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The site is located between 25.87°N latitude and 81.15° E longitude at 78 m above the sea level. The soils of the study areas are sandy to sandy loam in texture and moderately well to well drained with ground water irrigation facility. Soils are medium in fertility status. Climate of the district is characterized by dry summer and cool winter with average rainfall is 1013.4 mm during *kharif* season.Good agricultural practices were done to grow the crop.The observations on 5 randomly selected plants from each genotypes in each replication were recorded for 15 quantitative and qualitative traits viz. plant height (cm), no. of branches/plant, no of leaves/plant, days to first flowering, days to 50% flowering, first flowering node, fruit length (cm), fruit diameter (cm), fresh fruit weight (g), no. of fruits/plant, fruit yield/plant (g), fruit yield/plot (g), YVMV incidence (%) YVMV severity (%) and crude fibre content (%).The data were subjected to statistical analysis to estimate the genetic correlation coefficient analysis.Genotypic and phenotypic correlation coefficients were calculated according to the formula given by *Miller et al.* (1958)

Results and Discussion

The degree of association between two characters is measured by character association or correlation. A measure of the intrinsic relationship between the genes governing any two features is provided by genotypic correlation. The degree of the observed association between two features is shown by the phenotypic correlations. Therefore, the genotypic correlation coefficients for okra fruit production and its components were calculated for the current study. The correlation coefficients between the characters at genotypic and phenotypic level were presented in Table 1. In general magnitude of genotypic correlation coefficient was higher than phenotypic correlation coefficients.

Comment [UC3]: Results and discussion to come at the end of the paper before conclusions

Correlation analysis

Comment [UC4]: Explain corealtion analysis graphically

Character associationor correlation is a measure of the degree of association betweentwo characters.The phenotypic correlations indicate the extent of theobserved relationship between two characters. This does not givetrue genetic picture of the relationship because it includeshereditary as well as environmental influences. Genotypiccorrelation provides an estimate of inherent association betweengenes controlling any two characters. Hence, it is of greatersignificance and could be effectively utilized in formulating aneffective selection scheme.

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Therefore, in the present study, the genotypic correlation coefficients were workedout for cluster bean for vegetable fruit yield and its components.

Correlation studies on vegetable fruit yield andits component traits revealed that the values of genotypiccorrelation coefficients were higher than phenotypiccorrelationcoefficient this was in confirmation with Patel and Chaudhary (2001). This suggests the strong inherent association among thetraits.The correlation coefficients between the characters atgenotypic and phenotypic level were presented in Table1. In general magnitude of genotypic correlation coefficient washigher than phenotypiccorrelation coefficients.

Genotypic level correlation

Fruit yield per plot (kg) showed (Table)significant and positive correlation with fruit weight (gm) (0.91), fruits/plant (0.46), and leaves/plant (0.40) while it showed non-significant and positive correlation with fruit yield per plant (g) (1.00),branches/plant (0.29), first flowering node (0.27), days to first flowering (0.03) and days to 50% flowering (0.01). It showed non-significant and negative correlation with fruit diameter (cm) (0.25), fruit length (cm) (0.06) and and plant height (cm) (0.06). These results were similar to those found by Guddadamath*et al.* (2011); Nwangburuka*et al.* (2012) and Celestin *et al.* (2012).

Comment [UC5]: Explain more at depth about genotypic and phenotypic correaltion

Phenotypic Correlation

Fruit yield per plot (kg) showed (Table1) significant and positive correlation with fruits/plant (0.68), fruit weight (gm) (0.67) and leaves/plant (0.28) while it showed non-significant and positive correlation with fruit yield per plant (g) (1.00), first flowering node (0.11), branches/plant (0.09), days to first flowering (0.04), days to 50% flowering (0.03)and plant height (cm) (0.03). It showed non-significant and negative correlation with fruit length (cm) (0.09) andfruit diameter (cm) (0.02). These results were similar to those found by Guddadamath*et al.* (2011); Nwangburuka*et al.* (2012) and Celestin *et al.* (2012).

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Table 1: Genotypic and Phenotypic Correlation Coefficient (r_g&r_p) of fruit yield and its contributing traits of okra

S.N.	Character		PH	LP	BP	DFF	DF	FNN	FP	FL	FD	FW	FYP	FPP	YVMI	YVMS	CFC
1	PH	r_g	**1.00**	0.39**	0.17	-0.30	-0.33	0.30	0.05	-0.30*	-0.26	-0.10	-0.06	-0.06	0.20	0.07	-0.24*
		r_p	**1.00**	0.37**	0.04	-0.19	-0.23	0.21	0.09	-0.29*	-0.20	-0.06	0.03	0.03	0.19	0.06	-0.23*
2	LP	r_g		**1.00**	0.18	0.18	0.29*	0.06	0.01	-0.14	0.09	0.09	0.09	-0.21	-0.32**	0.27*	0.27*
		r_p		**1.00**	0.26*	-0.12	-0.16	0.41**	0.09	-0.25*	-0.01	0.33**	0.28*	0.28*	-0.06	-0.20	0.03
3	BP	r_g			**1.00**	0.18	0.18	0.29*	0.06	0.01	-0.14	0.09	0.09	0.09	-0.21	-0.32**	0.27*
		r_p			**1.00**	0.18	0.18	0.29*	0.06	0.01	-0.14	0.09	0.09	0.09	-0.21	-0.32**	0.27*
4	DFF	r_g				**1.00**	0.94**	-0.25	-0.23	0.76**	0.47	0.17	0.03	0.03	-0.30	-0.07	0.27
		r_p				**1.00**	0.90**	-0.10	-0.01	0.52**	0.17	0.05	0.04	0.04	-0.20	-0.02	0.19
5	DF	r_g					**1.00**	-0.43	-0.20	0.79**	0.37	0.12	0.01	0.01	-0.18	-0.03	0.14
		r_p					**1.00**	-0.21	-0.04	0.56**	0.13	0.06	0.03	0.03	-0.13	-0.02	0.12
6	FNN	r_g						**1.00**	0.16	-0.16	-0.14	0.20	0.27	0.27	-0.01	0.04	0.33**
		r_p						**1.00**	0.08	-0.10	-0.21	0.09	0.11	0.11	-0.03	0.08	0.27*
7	FP	r_g							**1.00**	-0.24	-0.18	-0.03	0.46**	0.46**	-0.48**	-0.48**	-0.12
		r_p							**1.00**	-0.17	0.01	-0.05	0.68**	0.68**	-0.30**	-0.30**	-0.08
8	FL	r_g								**1.00**	0.17	0.08	-0.06	-0.06	-0.05	0.11	0.47**
		r_p								**1.00**	0.14	0.03	-0.09	-0.09	-0.04	0.08	0.44**
9	FD	r_g									**1.00**	-0.14	-0.25	-0.25	0.19	0.21	-0.08
		r_p									**1.00**	-0.08	-0.02	-0.02	0.15	0.11	-0.05
10	FW	r_g										**1.00**	0.91**	0.91**	-0.37**	0.40**	0.29*
		r_p										**1.00**	0.67**	0.67**	-0.35**	-0.38**	0.28*
11	FYP	r_g											**1.00**	1.00	-0.61**	0.65**	0.18
		r_p											**1.00**	1.00	-0.42**	-0.45**	0.13
12	FPP	r_g												**1.00**	-0.61**	-0.65**	0.18
		r_p												**1.00**	-0.42**	-0.45**	0.13
13	YVMI	r_g													**1.00**	0.84**	-0.22
		r_p													**1.00**	0.80**	-0.21
14	YVMS	r_g														**1.00**	-0.14
		r_p														**1.00**	-0.23
15	CFC	r_g															**1.00**
		r_p															**1.00**

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

Plant Height (cm), LP: Leaves/ Plant, BP Branches/ Plant, DFF: **Days to First Flowering, DF: Days to 50 % Flowering, FFN:First Flowering Node, FP: Fruits/ Plant, FL: Fruit Len:gth (cm), FD: Fruit Diameter (cm), FW Fruit Weight (g, FYP): Fruit Yield/ FPP: Fruit Yield/ Plot (kg Plant (g) YVMI: YVMV Incidence (%), YVMS:YVMV Severity (%), CFC:CrudeFibre Content (%)**

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Table: 2Direct (diagonal) and indirect effects of component characters contributing to yield in okra at genotypic level:

Character	PH	LP	BP	DFF	DF	FNN	FP	FL	FD	FW	YVMI	YVMS	CFC
PH	**0.0061**	0.0024	0.0007	-0.0018	-0.0020	0.0018	0.0003	-0.0018	-0.0016	-0.0006	0.0012	0.0004	-0.0015
LP	-0.0172	**-0.0437**	-0.0186	0.0080	0.0117	-0.0274	-0.0073	0.0121	0.0041	-0.0149	0.0031	0.0088	-0.0012
BP	-0.0082	-0.0299	**-0.0704**	-0.0302	-0.0176	-0.0323	-0.0275	-0.0041	0.0106	-0.0043	0.0214	0.0384	-0.0283
DFF	0.0763	0.0461	-0.1077	**-0.2510**	-0.2370	0.0635	0.0580	-0.1902	-0.1177	-0.0430	0.0754	0.0164	-0.0684
DF	-0.1372	-0.1106	0.1039	0.3917	**0.4149**	-0.1771	-0.0819	0.3265	0.1548	0.0497	-0.0742	-0.0105	0.0588
FNN	0.0599	0.1237	0.0907	-0.0500	-0.0844	**0.1978**	0.0325	-0.0323	-0.0269	0.0400	-0.0028	0.0074	0.0643
FP	0.0183	0.0659	0.1541	-0.0913	-0.0780	0.0648	**0.3949**	-0.0957	-0.0719	-0.0118	-0.1897	-0.1908	-0.0462
FL	0.0330	0.0304	-0.0064	-0.0830	-0.0862	0.0179	0.0266	**-0.1096**	-0.0190	-0.0090	0.0056	-0.0119	-0.0517
FD	0.0080	0.0029	0.0046	-0.0145	-0.0115	0.0042	0.0056	-0.0054	**-0.0309**	0.0043	-0.0057	-0.0063	0.0025
FW	-0.0851	0.2838	0.0504	0.1426	0.0998	0.1683	-0.0249	0.0685	-0.1148	**0.8322**	-0.3044	-0.3354	0.2412
YVMI	-0.0018	0.0007	0.0028	0.0028	0.0017	0.0001	0.0044	0.0005	-0.0017	0.0034	**-0.0092**	-0.0078	0.0020
YVMS	-0.0111	0.0318	0.0866	0.0104	0.0040	-0.0060	0.0767	-0.0172	-0.0326	0.0640	-0.1339	**-0.1588**	0.0230
CFC	0.0034	-0.0004	-0.0057	-0.0039	-0.0020	-0.0046	0.0017	-0.0067	0.0011	-0.0041	0.0031	0.0021	**-0.0142**
Fruit Yield/ Plant (g)	**-0.0558**	**0.4030**	**0.2850**	**0.0297**	**0.0131**	**0.2712**	**0.4591**	**-0.0554**	**-0.2466**	**0.9058**	**-0.6100**	**-0.6480**	**0.1803**
Partial R^2	-0.0003	-0.0176	-0.0201	-0.0075	0.0054	0.0537	0.1813	0.0061	0.0076	0.7538	0.0056	0.1029	-0.0026

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

Plant Height (cm), LP: Leaves/ Plant, BP Branches/ Plant, DFF: **Days to First Flowering, DF: Days to 50 % Flowering, FFN:First Flowering Node, FP: Fruits/ Plant, FL: Fruit Len:gth (cm), FD: Fruit Diameter (cm), FW: Fruit Weight (g), YVMI: YVMV Incidence (%), YVMS:YVMV Severity (%), CFC:CrudeFibre Content (%)**

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Table3: Direct (diagonal) and indirect effects of component characters contributing to yield in okra at phenotypic level:

Character	PH	LP	BP	DFF	DF	FNN	FP	FL	FD	FW	YVMI	YVMS	CFC
PH	**0.0245**	0.0091	0.0010	-0.0045	-0.0055	0.0051	0.0023	-0.0070	-0.0048	-0.0016	0.0047	0.0014	-0.0057
LP	-0.0125	**-0.0335**	-0.0088	0.0041	0.0055	-0.0137	-0.0031	0.0083	0.0003	-0.0112	0.0022	0.0068	-0.0011
BP	-0.0004	-0.0023	**-0.0089**	-0.0016	-0.0016	-0.0026	-0.0006	-0.0001	0.0013	-0.0008	0.0018	0.0029	-0.0024
DFF	0.0026	0.0017	-0.0025	**-0.0138**	-0.0124	0.0014	0.0002	-0.0071	-0.0024	-0.0007	0.0027	0.0003	-0.0027
DF	-0.0078	-0.0057	0.0061	0.0310	**0.0345**	-0.0074	-0.0014	0.0190	0.0046	0.0020	-0.0044	-0.0006	0.0042
FNN	0.0010	0.0020	0.0014	-0.0005	-0.0010	**0.0049**	0.0004	-0.0005	-0.0010	0.0004	-0.0001	0.0004	0.0013
FP	0.0670	0.0675	0.0464	-0.0082	-0.0304	0.0561	**0.7270**	-0.1245	0.0061	-0.0373	-0.2154	-0.2214	-0.0599
FL	0.0026	0.0023	-0.0001	-0.0047	-0.0050	0.0009	0.0016	**-0.0091**	-0.0013	-0.0003	0.0004	-0.0007	-0.0040
FD	-0.0053	-0.0003	-0.0038	0.0047	0.0036	-0.0056	0.0002	0.0038	**0.0270**	-0.0021	0.0040	0.0031	-0.0012
FW	-0.0468	0.2444	0.0630	0.0363	0.0419	0.0641	-0.0376	0.0255	-0.0568	**0.7330**	-0.2536	-0.2788	0.2025
YVMI	0.0055	-0.0019	-0.0060	-0.0058	-0.0037	-0.0008	-0.0086	-0.0013	0.0044	-0.0101	**0.0292**	0.0234	-0.0062
YVMS	0.0008	-0.0027	-0.0043	-0.0003	-0.0002	0.0010	-0.0041	0.0011	0.0015	-0.0051	0.0108	**0.0134**	-0.0018
CFC	-0.0021	0.0003	0.0024	0.0017	0.0011	0.0024	-0.0007	0.0039	-0.0004	0.0025	-0.0019	-0.0012	**0.0089**
Fruit Yield/ Plant (g)	**0.0293**	**0.2809**	**0.0859**	**0.0384**	**0.0267**	**0.1057**	**0.6754**	**-0.0879**	**-0.0215**	**0.6688**	**-0.4197**	**-0.4512**	**0.1319**
Partial R^2	0.0007	-0.0094	-0.0008	-0.0005	0.0009	0.0005	0.4910	0.0008	-0.0006	0.4903	-0.0122	-0.0060	0.0012

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

Plant Height (cm), LP: Leaves/ Plant, BP Branches/ Plant, DFF: **Days to First Flowering, DF: Days to 50 % Flowering, FFN:First Flowering Node, FP: Fruits/ Plant, FL: Fruit Len:gth (cm), FD: Fruit Diameter (cm), FW Fruit Weight (g), YVMI: YVMV Incidence (%), YVMS:YVMV Severity (%), CFC:CrudeFibre Content (%)**

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Path coefficient analysis

Path coefficient analysis is an important tool for partitioning the correlated coefficients into the direct and indirect effects of independent variables on a dependent variable with the inclusion of more variables in correlated study. Their indirect association becomes more complex. Two characters may show correlated, just because they are correlated with a common third one. In such circumstances, path coefficient analysis provides an effective means of a critical examination of specific forces action to produce a given correlated and measure the relative importance of each factor. Path coefficient analysis can explain the extent of relative contribution. In this analysis, fruit yield per plant was taken as dependent variable and the rest of the characters were considered as in dependable variables.

Genotypic path analysis

The path coefficient analysis (presented in table 2) which splits total correlated coefficient of different characters into direct and indirect effects on fruit yield per plant in such a manner that the sum of direct and indirect effects is equal to total genotypic correlated.Data revealed that fruit weight (0.83) showed the highest direct positive effect on green pod yield per plant followed by days to 50 % flowering (0.41), fruits per plant (0.39), first flowering node (0.19), plant height (0.00) While other traits like days to firs flowering (-0.25), YVMV severity (-0.15), fruit length (-0.10), branches per plant (-0.07), leaves per plant (-0.04), fruit diameter (-0.03), crude fibre content % (-0.01) and YVMV incidence (-0.00) showed direct negative effect on fruit yield per plant at genotypic level.These finding are conformity of the findings of Patil, et al. (2016) Kumar and Reddy (2016), Kerure et al. (2017).

Comment [UC6]: Speeling errors are to be corrected

Phenotypic path analysis

Data revealed that fruit weight (0.73) showed (Table3) the highest direct positive effect on green pod yield per plant followed by fruits per plant (0.72), YVMV incidence (0.02), fruit diameter (0.02), plant height (0.02), YVMV severity (0.01), crude fibre content % (0.00) and first flowering node (0.00) While other traits leaves per plant (-0.03), days to first flowering (-0.01), fruit length (-0.00) and branches per plant (0.00) showed direct negative effect on fruit yield per plant at phenotypic level.

Comment [UC7]: Coorect all punctuation errors

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Conclusion:A very strong positive and significant correlation was recorded between Days to First Flowering with Days to 50% Flowering and Fruit Weight with Fruit Yield/plant. Negative and significant association of YVMV Incidence % with Fruit Yield/plant (g) indicates that fruit yield/plant decreases with increase in YVMV incidence %.Fruit weight showed maximum positive direct effect on fruit yield per plant at both genotypic and phenotypic level indicating that effective improvement through these characters could be achieved

Comment [UC8]: Conclusion is poor and does not complete the summary of the whole paper

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Comment [UC9]: References could be increased in number

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