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Correlation Coefficient and Path Analysis Studies in Okra (*Abelmoschus esculentus L.* Monech)

Sawant S. N.[1*], Nagre P. K.[2], Gudadhe P. S.[3] and Narkhede G. W.[4]

ABSTRACT: *In Present investigation, twenty germplasm lines of okra were evaluated in Randomized block Design with three replication. Correlation and Path coefficient analysis were carried out to study character association and contribution respectively for fourteen characters for identification of appropriate selection indices. Phenotypic and Genotypic correlation coefficient analysis revealed that plant height, leaf area, number of primary branches per plant, number of nodes per plant, number of fruits per plant, length of fruits, weight of fruit, chlorophyll content of leaves and total yield per plant had positive significant correlation while Node at which first fruit appears, diameter of fruit had significantly negative correlation on with marketable yield per plant. Genotypic path coefficient analysis revealed that number of leaves per plant, internodal length, number of fruits per plant, diameter of fruit, weight of fruit had positive high direct effect on yield per plant. Correlation and path coefficient analysis revealed that number of leaves per plant, internodal length, number of fruits per plant, diameter of fruit, weight of fruit not only had positive significant association with yield per plant but also had positive high direct effect on marketable yield per plant and are regarded as the main determinants of yield per plant. If the selection is based on these characters then improvement in yield will be efficient.*

Keywords: *Correlation, Path analysis, Okra, Yield traits, Path diagram*

INTRODUCTION

Okra is the powerhouse of variable nutrients. It is a good source of vitamin C, providing 20 per cent of daily value for a 2000 calorie diet in 100 g. It is low in calories and is fat free. Okra is surprising versatile vegetable. It also holds a high place in nutritional charts for its fibrous content and other medicinal benefits. The correlation measures the mutual relationship between different traits of a plant, it helps to access the best yield contributing traits. Path analysis deals with a close system of variables that are linearly related. It specifies the causes and generally measures their relative importance. Path analysis spilt the correlation coefficient into the measures of direct and indirect effect and determines direct and indirect contribution to the various characters towards the yield.

MATERIAL AND METHODS

The experimental material consisted of twenty genotypes okra. Seeds were sown in Randomized Block Design with three replications to study genetic variability. Sowing of seed of each genotype was done in ridges and furrows planting system with spacing 60 x 30 cm. There were 30 hills of each genotype in each replication. About 2 – 3 seeds were sown in each hill. While recording data, central five plants in each plot in each replication were selected avoiding border plants. Following observations were recorded :

(A) Pre-harvest : Plant height (cm), number of leaves per plant, number of lobe per leaf, Internodal Length (cm), Leaf area, node at which first fruit appears, number of primary branches per plant, number of nodes per plant and number of fruits per plant.

(B) Post Harvest : Length and Diameter of fruit, Weight of Fruit, number of ridges per fruit, chlorophyll content of leaves and ascorbic acid content of fruit.

* Corresponding Author, *E-mail: sawantsn09@gmail.com*

[1&3] Ph.D. Scholar, Dept. Horticulture, Dr. PDKV, Akola.

[2] Professor & Head, Dept. of Horticulture, Dr. PDKV, Akola

[4] M.Sc. Scholar, MAU, Parbhani

RESULTS

In genotypic correlation plant height, leaf area, number of primary branches per plant, number of nodes per plant, number of fruits per plant, length of fruit, weight of fruit exhibited significant and positive correlation with yield per plant while in phenotypic correlation plant height, number of nodes per plant, number of fruits per plant, length of fruit, weight of fruit exhibited significant and positive correlation with yield per plant. In genotypic correlation coefficient the characters node at which first fruit appears, diameter of fruit exhibited significant and negative correlation with yield per plant while in phenotypic correlation plant height, number of nodes per plant, number of fruits per plant, length of fruit and weight of fruit exhibited positive significant correlation with yield per plant. Rest of the characters showed non-significant but positive correlation with yield per plant. Path coefficient analysis is standardized partial regression analysis which permits the separation of correlation coefficient into the measure of direct and indirect effects. This helps in giving weightage to a particular character during selection. In path analysis, number of fruits per plant recorded highest positive direct effects at both genotypic and phenotypic level followed by weight of fruit, number of leaves per plant, internodal length, diameter of fruit and node at which first fruit appears. All the characters mentioned earlier, which contributed directly and positively to fruit yield per plant possess significant correlation suggesting that association between these traits were perfect and it was due to genetic factors only. Looking into the indirect effects, high positive indirect effects was found in plant height on yield per plant via number of fruits per plant followed by weight of fruit, number of lobes per leaf and internodal length. Therefore one can rely upon plant height, number of fruits per plant, weight of fruit, number of lobes per leaf and internodal length for selecting high fruit yielding genotypes in okra.

DISCUSSION

In the present investigation, the estimates of genotypic correlations were slightly higher than the corresponding phenotypic correlation (Table 1) indicating that genotype is superior but its expression was reduced under the influence of environment as reported by Singh *et al.*, 2007. In the present investigation, the characters exhibiting significant positive phenotypic correlation with yield were found to be, plant height, number of nodes per plant, number of fruits per plant, length of fruit, weight of fruit and chlorophyll content of leaves. These characters were also positively interlinked among themselves. Thus, it indicated the importance of these characters while selection. An examination of correlation coefficient at genotypic level revealed that leaf area showed highest positive significant association with yield per plant followed by the characters, weight of fruit, number of fruits per plant, number of nodes per plant, plant height, length of fruit, number of primary branches per plant, and leaf area. It indicated that high positive and significant correlation of these traits with yield per plant could be fruitfully exploited for increased fruit yield in okra. These findings were supported by Hazare and Basu (2000), Kale *et* al. (1989), Vijay and Manohar (1990). On the other hand, diameter of fruit showed negative and significant correlation with yield per plant. This indicated the fact that increase in one trait may generally be accompanied by corresponding decrease in the other. The observations of similar nature were reported in okra by Vijay and Manohar (1990). Among the yield contributing characters themselves, the plant height was positively and significantly correlated with internodal length, number of nodes per plant, number of fruits per plant, length of fruit, chlorophyll content of leaves and yield per plant. This indicated the importance of the character plant height in increasing the number of nodes per plant, number of fruits per plant, internodal length, length of fruit, chlorophyll content of leaves and yield per plant. Similar results were found by Singh *et al*. (2007) for plant height with internodal length, number of fruits per plant, fruit length and total yield per plant. Kale *et* al. (1989), Vijay and Manohar (1990) and Pal *et al*. (2008) also confirmed these results. The plant height was negatively and significantly correlated with number of ridges per fruit. Thus it could be concluded that direct selection procedure to increase plant height results into reduction in number of ridges per fruit which may affect fruit yield per plant. Leaf area was significantly and positively correlated with number of primary branches per plant, number of fruits per plant, weight of fruit and yield per plant. This indicated that maximum leaf area resulted into increase in number of primary branches per plant, number of fruits per plant, weight of fruit and yield per plant. The pre-requisite for realizing higher yield in crop basically depends on photosynthetic process. The rate of photosynthesis depends on solar energy and leaf area. The leaves are known to be the assimilating organ and hence yielding ability of any

crop depends upon the leaf area index as proposed by Watson (1947). These results are in consonance with the findings of Kale *et al.* (1989), who reported positive and significant correlation of leaf area with fruit length, number of fruits per plant in okra and Sreenivasulu *et al*. (1988) observed significant and positive correlation between leaf area and yield in prosomillet. Node at which first fruit appears was significantly and negatively correlated with number of primary branches per plant. The number of nodes per plant was positively and significantly correlated with number of fruits per plant, length of fruit, weight of fruit, chlorophyll content of leaves and yield per plant. The number of fruits per plant was positively and significantly correlated with length of fruit, weight of fruit, chlorophyll content of leaves and yield per plant, while it was negatively significant with number of ridges per fruit. Singh *et al*. (2007), Sharma *et al*. (2007) also found similar results in okra. The length of fruit showed significant and positive correlation with weight of fruit, chlorophyll content of leaves and yield per plant and significant and negative correlation with diameter of fruit. Weight of fruit was positively and significantly correlated with chlorophyll content of leaves at both genotypic and phenotypic level.

Path Coefficient Analysis

The diagram (Fig. 4) shows the nature of cause and effect system. It consists of sixteen characters (1) plant height, (2) number of leaves per plant, (3) number of lobes per leaf, (4) internodal length, (5) leaf area, (6) node at which first fruit appears, (7) number of primary branches per plant, (8) number of nodes per plant, (9) number of fruits per plant, (10) length of fruit, (11) diameter of fruit, (12) weight of fruit, (13) number of ridges per plant, (14) chlorophyll content of leaves, (15) ascorbic acid content of fruit and (16) yield per plant (residual factor represented by 'x'). All the components are related directly or indirectly with yield and interrelated among themselves except residual factor. The results of path analysis presented in Table 2 and 3 are discussed here under. In the integrated structure of the plant, the overall correlation observed between two attributes is a function of a series of direct and indirect association between the component characters. In order to know these specific forces in building up the total correlation, it is essential to resort to path coefficient analysis. Results obtained for path coefficient analysis at genotypic level revealed that the character plant height showed negative direct effect on yield per plant. The negative indirect effect via number of nodes per plant was highest still the correlation in this case was positive because of high positive indirect effect via number of fruits per plant, followed by weight of fruit. Plant height exhibited highest indirect positive effect on yield per plant. This results are confirmed with the findings of Ariyo *et al*.(1987) who reported largest negative direct effect of plant height on pod yield. The internodal length exhibited positive direct effect on yield per plant with positive non-significant correlation. Vijay and Manohar (1990), also reported high positive direct effect of internodal length on pod yield in okra. The positive and significant correlation was observed between leaf area and yield per plant whereas the direct effect of leaf area on yield per plant was negative. It had high positive indirect effect on yield per plant via number of fruits per plant and weight of fruit. The number of primary branches per plant had positive and significant correlation with yield per plant whereas it indicated negative direct effect on yield. The indirect effect was positive due to weight of fruit hence the correlation observed between them was positive. These results were supported by the finding of Ariyo *et al*. (1987), Vijay and Manohar (1990) and Singh *et al*. (2007).The node at which first fruit appears exhibited positive non-significant correlation with yield per plant. it showed positive direct effect on yield with negative corresponding indirect effect.. The number of nodes per plant and direct effect on yield per plant, while indirect effect via number of fruits and weight of fruit was found to be high and positive. Thus it resulted into the positive association of number of nodes per plant and yield per plant. This finding was in consonance with the findings of Jaiprakashnarayan and Mulge (2004). The character number of fruits per plant exhibited highest magnitude of direct effect. It had shown high magnitude of indirect effect via weight of fruit. Thus, it might have resulted into strong positive and significant correlation. This indicated the importance of characters number of fruits per plant and weight of fruit while selection for improvement in okra. The results of similar nature were also reported by Vijay and Manohar (1990), Shukla (1990). Pathak (1993) and Singh *et al*. (2007). Length of fruit exhibited negative direct effect on yield per plant while indirect effect via weight of fruit and number of fruits per plant was found to be high and positive. Which resulted into the positive association of length of fruit and yield per plant. Shukla (1990) reported the negative direct effect of length of fruit on yield per plant. Vijay and Manohar (1990) observed

Table 1
Estimates of Genotypic and Phenotypic Correlation Coefficients for Various Characters

Characters		*Plant height (cm)*	*No. of leaves per plant*	*No. of lobes per leaf*	*Interno-dal length (cm)*	*Leaf area (cm2)*	*Node at which first fruit appears*	*No. of primary branches per plant*	*No. of nodes per plant*	*No. of fruits per plant*	*Length of fruit (cm)*	*Dia. of fruit (cm)*	*Wt. of fruit (g)*	*No. of ridges per fruit*	*Chloro-phyll content of leaves (mg/g)*	*Ascorbic acid content (mg/ 100g*	*Yield per plant (g)*
Plant height (cm)	G	1	0.116	0.493	0.624*	0.291	0.114	0.395	0.942**	0.818**	0.697**	-0.277	0.575*	-0.592*	0.655**	0.496	0.742**
	P	1	0.045	0.343	0.494	0.248	0.082	0.247	0.688**	0.644**	0.521*	-0.083	0.484	-0.287	0.485	0.333	0.545*
No. of leaves	G		1	-0.054	-0.194	0.175	0.270	0.030	0.089	0.151	0.054	-0.032	-0.075	0.059	0.142	0.386	0.060
per plant	P		1	-0.036	-0.144	0.156	0.165	0.049	0.100	0.148	0.062	-0.063	-0.028	0.013	0.091	0.257	0.076
No. of lobes	G			1	0.299	0.233	-0.147	0.171	0.471	0.457	0.294	-0.116	0.268	-0.473	0.491	0.181	0.480
per leaf	P			1	0.220	0.074	-0.230	0.111	0.256	0.201	0.158	0.118	0.166	-0.246	0.254	0.017	0.316
Internodal	G				1	0.076	0.156	0.354	0.491	0.442	0.483	-0.405	0.292	-0.096	0.351	0.281	0.355
length (cm)	P				1	0.051	0.251	0.157	0.432	0.289	0.303	-0.243	0.202	-0.159	0.230	0.185	0.268
Leaf area (cm2)	G					1	-0.169	0.669**	0.380	0.578*	0.302	-0.301	0.531*	-0.380	0.461	0.161	0.519*
	P					1	-0.125	0.335	0.325	0.482	0.269	-0.189	0.398	-0.224	0.409	0.120	0.495
Node at which	G						1	-0.579*	0.170	0.168	0.376	-0.422	-0.061	0.483	0.336	0.252	0.102
first fruit appear	P						1	-0.176	0.175	0.038	0.179	-0.250	-0.032	0.071	0.057	0.215	0.036
No. of primary	G							1	0.361	0.283	0.491	-0.055	0.567*	-0.451	0.615*	0.228	0.662**
branches	P							1	0.256	0.264	0.197	0.013	0.332	-0.013	0.264	0.058	0.293
No. of nodes	G								1	0.914**	0.626*	-0.169	0.695**	-0.515*	0.869**	0.480	0.861**
per plant	P								1	0.766**	0.455	-0.119	0.504*	-0.334	0.663**	0.379	0.673**
No. of fruits	G									1	0.624*	-0.498	0.686**	-0.725**	0.882**	0.488	0.875**
per plant	P									1	0.467	-0.271	0.581*	-0.328	0.661**	0.345	0.693**
Length of	G										1	-0.532*	0.714**	-0.111	0.676**	0.312	0.704**
fruit (cm)	P										1	-0.203	0.586*	-0.015	0.618**	0.248	0.624**
Dia. of fruit (cm)	G											1	-0.410	0.060	-0.580*	-0.225	-0.637**
	P											1	-0.274	0.087	-0.259	-0.070	-0.291
Wt. of fruit (g)	G												1	-0.034	0.762**	0.359	0.900**
	P												1	-0.030	0.619**	0.328	0.710**
No. of ridges	G													1	-0.131	-0.320	-0.144
per fruit	P													1	-0.139	-0.100	-0.157
Chlorophyll	G														1	0.496	0.988**
content of leaves (mg/g)	P														1	0.375	0.803**
Ascorbic acid	G															1	0.389
content of fruit (mg/100g)	P															1	0.285
Yield per plant (g)	G																1
	P																1

** Significant at 1% level, * Significant at 5% level

Table 2
Path Coefficient Analysis Showing Direct (Underlined) and Indirect Effects of Various Characters on Yield

Characters	*Plant height (cm)*	*No. of leaves per plant*	*No. of lobes per leaf*	*Inter-nodal length (cm)*	*Leaf area (cm2)*	*Node at which first fruit appears*	*No. of primary branches per plant*	*No. of nodes per plant*	*No. of fruits per plant*	*Length of fruit (cm)*	*Dia. of fruit (cm)*	*Wt. of fruit (g)*	*No. of ridges per fruit*	*Chloro-phyll content of leaves (mg/g)*	*Ascorbic acid content (mg/ 100g)*
Plant height (cm)	-0.753	0.060	0.455	0.255	-0.134	0.023	-0.082	-0.454	1.223	-0.126	-0.057	0.789	0.012	-0.143	-0.326
No. of leaves per plant	-0.088	0.514	-0.036	-0.079	-0.081	0.055	-0.006	-0.043	0.225	-0.010	-0.006	-0.102	-0.001	-0.031	-0.251
No. of lobes per leaf	-0.515	-0.028	0.666	0.122	-0.107	-0.030	-0.243	-0.275	0.832	-0.053	-0.024	0.368	0.010	-0.125	-0.118
Internodal length (cm)	-0.47	-0.100	0.199	0.408	-0.035	0.032	-0.073	-0.237	0.660	-0.087	-0.084	0.400	0.002	-0.077	-0.183
Leaf area (cm2)	-0.219	0.090	0.155	0.031	-0.460	-0.034	-0.139	-0.183	0.864	-0.054	-0.062	0.728	0.007	-0.101	-0.104
Node at which first fruit appear	-0.086	0.139	-0.098	0.064	0.078	0.204	0.120	-0.082	0.250	-0.068	-0.087	-0.084	-0.010	-0.074	-0.164
No. of primary branches	-0.297	0.015	0.778	0.144	-0.308	-0.118	-0.207	-0.174	0.423	-0.089	-0.011	0.780	0.009	-0.135	-0.148
No. of nodes per plant	-0.71	0.046	0.381	0.200	-0.175	0.035	-0.075	-0.482	1.366	-0.113	-0.035	0.953	0.011	-0.190	-0.351
No. of fruits per plant	-0.616	0.078	0.372	0.180	-0.267	0.034	-0.059	-0.440	1.494	-0.113	-0.103	0.940	0.015	-0.193	-0.447
Length of fruit (cm)	-0.525	0.028	0.196	0.197	-0.139	0.076	-0.102	-0.302	0.933	-0.180	-0.110	0.980	0.003	-0.148	-0.203
Dia. of fruit (cm)	0.208	-0.016	-0.077	-0.165	0.138	-0.086	0.011	0.081	-0.744	0.096	0.207	-0.562	-0.001	0.127	0.146
Wt. of fruit (g)	-0.433	-0.038	0.178	0.119	-0.244	-0.012	-0.117	-0.335	1.024	-0.129	-0.085	1.371	0.001	-0.167	-0.233
No. of ridges per fruit	0.446	0.031	-0.315	-0.039	0.175	0.098	0.094	0.248	-1.083	0.02	0.012	-0.047	-0.021	0.029	0.208
Chlorophyll content of leaves (mg/g)	-0.493	0.073	0.380	0.144	-0.212	0.069	-0.128	-0.419	1.317	-0.122	-0.120	1.045	0.003	-0.219	-0.330
Ascorbic acid content of fruit (mg/100g)	-0.377	0.198	0.120	0.115	-0.074	0.051	-0.047	-0.260	1.028	-0.056	-0.046	0.491	0.007	-0.111	-0.650

Table 3
Total Direct and Indirect Effects of Different Characters on Yield

Sr. No.	*Characters*	*Correlation coefficient*	*Direct effect*	*Contribution (%)*	*Indirect effect*	*Contribution (%)*
1	Plant height (cm)	0.742**	-0.753	-101.48	1.495	201.48
2	Number of leaves per plant	0.060	0.514	856.67	-0.454	-756.67
3	Number of lobes per leaf	0.480	0.666	138.75	-0.186	-38.75
4	Internodal length (cm)	0.355	0.408	114.93	-0.053	-14.93
5	Leaf area (cm2)	0.519*	-0.460	-88.63	0.979	188.63
6	Node at which first fruit appear	0.102	0.204	200.00	-0.102	-100.00
7	Number of primary branches per plant	0.662**	-0.207	-31.27	0.869	131.27
8	Number of nodes per plant	0.861**	-0.482	-55.98	1.343	155.98
9	Number of fruits per plant	0.875**	1.494	170.74	-0.619	-70.74
10	Length of fruit (cm)	0.704**	-0.180	-25.57	0.884	125.57
11	Diameter of fruit (cm)	-0.637*	0.207	-32.50	-0.844	132.50
12	Weight of fruit (g)	0.900**	1.371	152.33	-0.471	-52.33
13	Number of ridges per fruit	-0.144	-0.021	14.58	-0.123	85.42
14	Chlorophyll content of leaves (mg/g)	0.988**	-0.219	-22.17	1.207	122.17
15	Ascorbic acid content of fruit (mg/100g)	0.389	-0.650	-167.10	1.039	267.10

Residual effect : 0.130 * Significant at 5% level ** Significant at 1% level

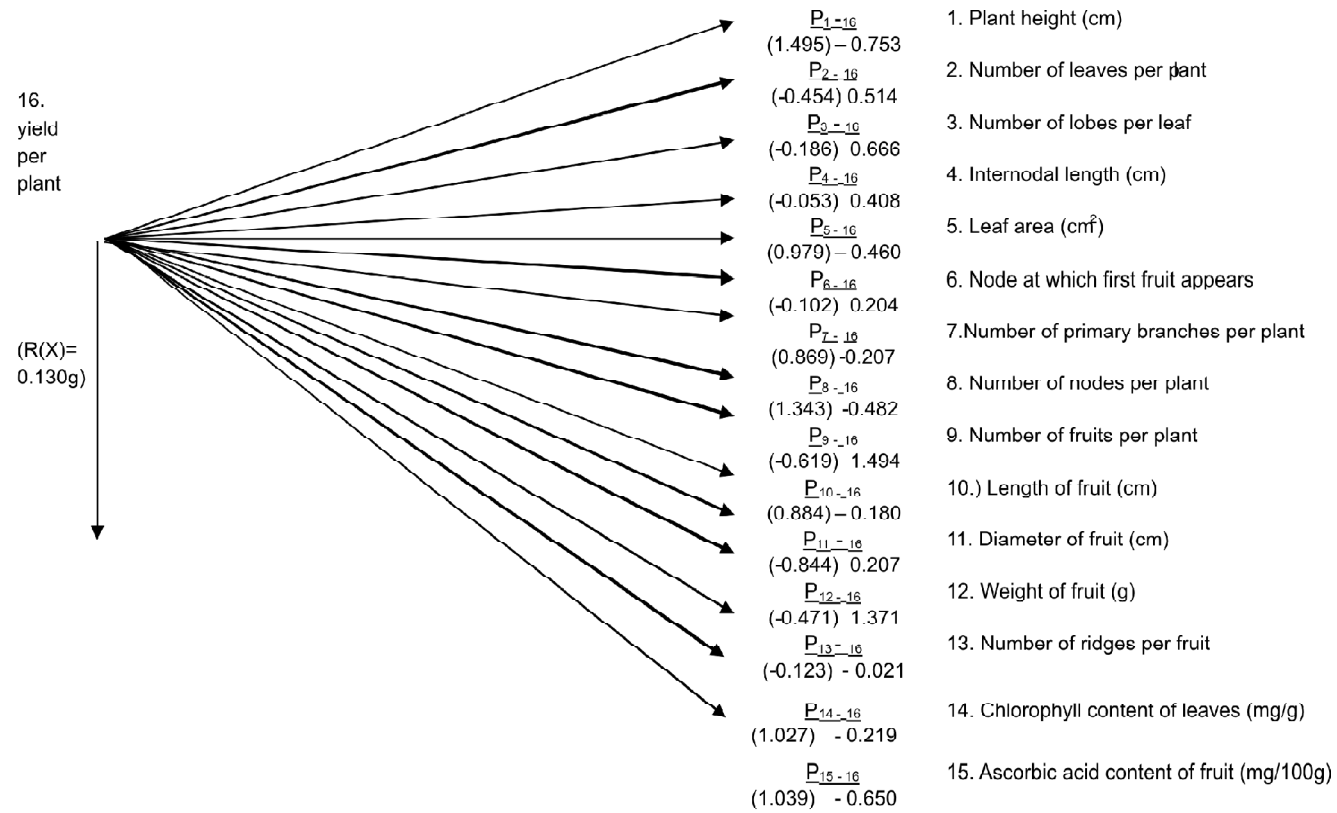

Figure 4: Path diagram and coefficient of factors influencing yield at genotypic level

indirect effect of length of fruit on yield per plant. The diameter of fruit exhibited positive direct effect on fruit yield per plant. It had shown the high negative indirect effect through via number of fruits per plant and weight of fruit. Ghate (1998), reported high direct effect of girth of fruit on pod yield in okra. Weight of fruit recorded high positive direct effect on yield per plant with positive and significant correlation the results are in consonance of findings of Ariyo *et al*. (1987), Shukla (1990). The number of ridges per fruit had negative direct effect and negative indirect effect on yield per plant. It also exhibited negative and non-significant correlation with yield per plant. The chlorophyll content of leaves exhibited negative direct effect on yield per plant. The total indirect effect of chlorophyll content of leaves was positive via number of fruits and weight of fruit. This result is supported by the findings of Saidaiah *et al*. (2008), who reported high indirect effect of chlorophyll content of leaves at 50% silking on yield in maize. The ascorbic acid content of fruit had negative direct effect and high positive indirect effect via number of fruits per plant followed by the weight of fruit. P. Usha Rani (1997) also reported that the character ascorbic acid content of chilli fruit was influenced by number of fruits through regression study. The number of leaves per plant and number of lobes per plant, exhibited positive and non-significant correlation with yield per plant whereas its direct effect was positive and indirect effect was negative. Thus the correlation studies revealed the importance of characters like number of fruits per plant, number of nodes per plant, weight of fruit, length of fruit, plant height, number of primary branches per plant, chlorophyll content of leaves and leaf area, because of their strong genotypic correlation with yield per plant. The path analysis further suggested that the number of fruits per plant, weight of fruit were most reliable and effective characters for selection when high yield is the objective.

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