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Correlation and path analysis for yield contributing characters in spine gourd (*Momordica dioica* Roxb.) genotypes

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Abstract
In cucurbits crop, the studies on spine gourds is under exploited crop. The performance of crop regards with yield and quality is not uniform because of its dioecious nature. The systemic and scientific research work to explore the path analysis and correlation in this crop is lacking. To understand the correlation factors related to yield and quality of crop is needed to be investigated hence present work was carried out. Eighteen promising spine gourd genotypes were obtained from various locations of Maharashtra and evaluated during kharif season of 2022-23. The experiment was set up in randomized block design replicated thrice with plant spacing of 1 m x 0.9 m. The correlation studies revealed that, fruit yield ha^{-1} revealed highly significant difference and positive correlation both in genotypic and phenotypic level with fruit yield plant^{-1}, no. of fruit plant^{-1}, fruit diameter, pedicel length, average fruit weight. Direct and indirect effects were analyzed using path analysis so as to obtain mechanisms of interrelationship between fruit yield ha^{-1} and its parameters. The genotypic and phenotypic path analysis showed that fruit yield plot^{-1}, average fruit weight, fruit length, fruit yield plant^{-1}, no. of fruit plant^{-1}, fruit diameter revealed direct positive effects on fruit yield ha^{-1}. From present investigation, it was concluded that for selecting superior genotypes main emphasis is should be given to fruit yield plant^{-1}, no. of fruit plant^{-1}, fruit diameter, average fruit weight.

Keywords: Correlation, path analysis, yield, spine gourd

Introduction
Spine gourd (*Momordica dioica* Roxb.) is nutritionally important dioceious, perennial and underutilized vegetable crop. It belongs to the Cucurbitaceae family having chromosome number (2n = 28), in the genus Momordica (Raj *et al*., 1993) [9].

The major constraints to commercial cultivation of spine gourd has a various problems which includes lack of improved varieties, low marketable yield, reduced marketability of fruits due to hard spines and yellow colour, low rate of seed germination or inability to germinate due to presence of hard seed coat, low rate of tuber development, fruits become non edible at maturity due to aging of seeds and become hard, effect of dormancy on propagation by seeds and tubers and uncertain sex ratio in seedling progeny (Ali *et al*., 1991) [14] in spine gourd. The correlation studies revealed the nature and extent of relationship between various characters and help in improving the yield contributing characters in spine gourd.

Yield of crop is a dependent character which is linked with a number of component characters. Hence, direct selection for yield is not effective. The genetic enhancement in dependent traits was obtained by applying strong selection procedure to characters which are generally associated with the dependent character. Partitioning of total correlation into direct and indirect effects by path coefficient analysis aids in making the selection procedure more effective. The path analysis points out the association of component traits with yield is due to their direct effect on yield, or it is a consequence of their indirect effect through some other characters. The steps of improving the crop by involving indigenous germplasm has showed new way in breaking the yield barriers. Therefore, the present investigation was aimed to determine the association of different yield contributing parameters with yield, direct and indirect effects of traits towards yield to identify high yielding spine gourd genotypes (Triveni *et al*., 2021 in bitter gourd) [13].

Materials and Methods
Experimental site
The field experiment was set up at Research Farm, Department of Horticulture, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani. The experimental site was geographically located at latitude: 19°16′0″N and longitude: 76°47′0″E with at an altitude of about 408m from mean sea level. Parbhani district comes under semi-arid climate, with a dry and hot summer, humid monsoon and cold winter.

Experimental material
Eighteen promising spine gourd genotypes were obtained from various locations of Maharashtra and evaluated in *kharif* season of 2022-23. The source of all the germplasms which were utilized in the study are given in Table1.

Table 1: Details of genotypes used for study

Sr. No	Genotypes	Source	Sr. No	Genotypes	Source
1.	MDW-1	Mandwa, Dist. Beed	10.	DHD-1	Dhadgaon, Dist. Nandurbar
2.	MDW-2	Mandwa, Dist. Beed	11.	DHD-2	Dhadgaon, Dist. Nandurbar
3.	MDW-3	Mandwa, Dist. Beed	12.	DHD-4	Dhadgaon, Dist. Nandurbar
4.	YLD-1	Yelda, Dist. Beed	13.	DHD-5	Dhadgaon, Dist. Nandurbar
5.	YLD-2	Yelda, Dist. Beed	14.	KKD-1	Kakardi, Dist. Nandurbar
6.	PGK-1	Pimplegaon Gadhe, Dist. Beed	15.	KKD-3	Kakardi, Dist. Nandurbar
7.	PGK-2	Pimplegaon Gadhe, Dist. Beed	16.	NDB-1	Nandurbar
8.	ZDG-1	Zodga, Dist. Washim	17.	NDB-2	Nandurbar
9.	ZDG-2	Zodga, Dist. Washim	18.	NDB-3	Nandurbar

Experimental details and observations recorded
The experiment was set up in randomized block design replicated thrice with plant spacing of 1 m x 0.9 m. To produce a healthy crop, all cultural operations and plant protection techniques were uniformly applied to each treatment. The data were recorded on five randomly selected uniform plants from each treatment on seventeen traits *viz*, plant height (cm), no. of primary branches plant^{-1}, internodal length, days to first flowering, days to 50% flowering, days to first harvest, days to last harvest, fruit length (cm), fruit diameter (cm), fruit pedicel length (cm), no. of fruits plant^{-1}, ascorbic acid content (mg/100 gm), total soluble solids (TSS), average fruit weight (g), fruit yield plant^{-1} (g), fruit yield plot^{-1} (kg), fruit yield ha^{-1} (q).

Statistical analysis
The correlation coefficients were compared with table value of correlation coefficient at 1 percent and 5 percent level of significance (Snedecor and Cochran, 1967) [12]. The coefficients genotypic and phenotypic correlations were used to determine their direct and indirect path as suggested by Dewey and Lu (1959) [3].

Results
Correlation coefficients analysis: The data represented in Table 2, clearly showed that fruit yield ha^{-1} of spine gourd had showed that positive significant relation at both genotypic and phenotypic level with no. of primary branches plant^{-1} (0.036** G and 0.039** P), fruit diameter (0.781** G and 0.574** P), pedicel length (0.746** G and 0.669** P), average fruit weight (0.837** G and 0.651** P), no. of fruits plant^{-1} (0.99** G and 0.853**), fruit yield plant^{-1} (0.976** G and 0.889** P) and fruit yield plot^{-1} (0.987** G and 0.904** P). Hence, these traits indicating to improve yield (Sandliya *et al*., 2020) [10] in spine gourd. It had also recorded that positive but non-significant relation with fruit length (0.138 G and 0.07 P), ascorbic acid (0.116 G and 0.11) and total soluble solids (0.129 G and 0.116 P) at both the levels. Fruit yield ha^{-1} had showed negative significant relation at both genotypic and phenotypic level with days to first flowering (-0.722** G and-0.538** P), days to first harvest (-0.774** G and-0.488** P) and days to last harvest (-0.545* G and-0.296* P). It had also recorded that negative but non-significant relation with plant height (-0.088 G and-0.06 P), internodel length (-0.234 G and-0.206 P), days to 50% flowering (-0.064 G and-0.079 P) at both the levels. Hence, those traits show non-significant and negatively correlated with yield revealed that improvement of this traits shall reduce the yield. The results obtained from this study were in agreement with those obtained by Sandliya *et al*., (2020) [10], Aliya *et al*., (2014) [2], Patil *et al*., (2022) [8] in spine gourd and Sinha *et al*., (2024) [11] in pointed gourd.

Path coefficient analysis: Results of Path analysis are presented in Table 3 and 4. Path analysis showed that, the traits viz. fruit yield ha.$^{-1}$ was exhibited with plant height (0.0640 G and 0.0764 P), days to first harvest (0.0207 G and 0.0143 P), fruit length (0.2061 G and 0.0297 P), average fruit weight (0.2874 G and 0.1780 P), no. of fruit plant^{-1} (0.08154 G and 0.2632 P), fruit yield plant^{-1} (0.1523 G and 0.1613 P), fruit yield plot^{-1} (0.5359 G and 0.3780 P) and total soluble solids (0.1997 G and 0.0568 P) had showed positive direct effect on fruit yield ha.$^{-1}$. Similar results were found by Patil *et al.* (2022) [8] in spine gourd, Sinha *et al.*, (2024) [11] in pointed gourd and Aishwarya *et al*., (2024) in bitter gourd. So, the genotypes which exhibited better performance for these characters can be used in further improvement of spine gourd (Triveni *et al*., 2021) [13] in bitter gourd. Whereas no. of primary primary branches plant^{-1} (-0.2174 G and-0.1249 P), internodel length (-0.1284 G and-0.1063 P), days to last harvest (-0.2817 G and-0.0892 P) and ascorbic acid (-0.0312 G and-0.1093 P) had showed negative direct effect on fruit yield ha.$^{-1}$ at both genotypic and phenotypic level. Thus, these findings showed that trait was neglected duration selection, as it did not contribute in production.

Discussion
Correlation coefficients analysis: The correlation coefficient indicated the relation between two traits and forms basis for selecting a desirable plant type. It helps to identify traits or combination of traits which might be useful as an indicator of high yield. Study on correlation of components traits with yield help in planning of an effective selection programme (Triveni *et al*., 2021) [13] in bitter gourd and Mane *et al*., 2024. In the present investigation, genotypic and phenotypic correlation coefficient between yield and its sixteen component characters are presented in

table 2. In general, genotypic correlation were greater than phenotypic correlation, which revealed that the association was largely due to genetic basis and masked efficiently by environment effects which had to the expression of the characters thereby reduced the phenotypic expression at a bit of lesser extent (Islam *et al*., 2014) [5] in snake gourd.
In general, the relation of the characters could be shown in a way that total change in yield is controlled mainly by changing in one or more components; though all changes in the components as in each of cases were not expressed in yield due to decisive ratings of desirable and undesirable relation of the components with yield/plant (Graffius, 1964) [4]. Moreover, the knowledge of nature and extent of association between yield and its components is quite necessary for effective selection procedure in advance generation. Correlations between pairs of characters were brought up due to either linkage of genes or pleiotropic gene action (Narolia *et al*., 2012) [7] in tomato. So, focus for selection of the components in positive direction for higher fruit yield ha^{-1} might be suggested for effective yield enhancement in spine gourd.

Path coefficient analysis: Path coefficient analysis divide the correlation coefficients into direct and indirect effects to access the relative impact on each character. Yield being a complex polygenic character, direct selection may not be an appropriate approach on account of being highly affected by environmental factors. So, it becomes imperative to identify the component characters through which yield improvement could be achieved. Even Tough correlations reflect about the components of a complex character like yield, but it laid to generate correct picture of relative importance of the direct and indirect of the component characters to yield. Hence, correlation in addition with path analysis would project a better insight into cause-and-effect relationship between different pairs of characters (Triveni *et al*., 2021) [13] in bitter gourd.

Table 3: Genotypic path coefficient analysis of the yield and its components in spine gourd.

Traits	PH	NPBPP	IL	DFF	D50%F	DFH	DLH	FL	FD	PL	AFW	NFPP	FYPP	FYPP	AA	TSS
PH	0.0640	-0.0296	-0.0797	0.0017	-0.0309	-0.0019	-0.0635	-0.0132	0.0030	0.0418	0.0792	-0.00997	-0.0226	-0.0642	0.0174	0.0205
NPBPP	0.0087	-0.2174	0.0189	-0.0010	0.0220	-0.0103	0.0756	0.1476	0.0108	-0.0588	-0.0506	0.00643	0.0232	0.1249	-0.0445	-0.0195
IL	0.0398	0.0321	-0.1284	0.0017	-0.0336	0.0030	-0.0226	-0.1089	-0.0163	0.0555	-0.0618	-0.00806	-0.0352	-0.1355	0.0523	0.1326
DFF	0.0251	0.0474	-0.0483	0.0044	-0.0620	0.0139	-0.2206	-0.0283	-0.0191	0.1761	-0.1161	-0.05722	-0.1180	-0.3701	0.0556	-0.0046
D50%F	0.0279	0.0673	-0.0609	0.0038	-0.0710	0.0025	-0.0452	-0.1733	-0.0144	0.0815	0.0492	0.00377	-0.0395	-0.0277	0.0624	0.0696
DFH	-0.0058	0.1081	-0.0183	0.0029	-0.0086	0.0207	-0.2008	-0.0296	-0.0211	0.1310	-0.1536	-0.06106	-0.1210	-0.4330	0.0326	-0.0160
DLH	0.0144	0.0583	-0.0103	0.0034	-0.0114	0.0147	-0.2817	0.0592	-0.0030	0.1404	-0.1185	-0.04545	-0.0757	-0.3084	0.0337	-0.0144
FL	-0.0041	-0.1557	0.0678	-0.0006	0.0596	-0.0030	-0.0810	0.2061	0.0210	-0.0401	-0.0011	0.00227	0.0310	0.1321	-0.0684	-0.0289
FD	0.0060	-0.0739	0.0661	-0.0027	0.0322	-0.0138	0.0263	0.1368	0.0317	-0.1637	0.2504	0.05239	0.1384	0.4398	-0.0593	-0.0863
PL	-0.0120	-0.0570	0.0316	-0.0034	0.0258	-0.0121	0.1765	0.0368	0.0231	-0.2240	0.1825	0.05601	0.1260	0.4127	-0.0505	0.0331
AFW	0.0176	0.0382	0.0276	-0.0018	-0.0122	-0.0111	0.1161	-0.0008	0.0276	-0.1423	0.2874	0.05212	0.1145	0.3815	-0.0192	-0.0384
NFPP	-0.0078	-0.0172	0.0127	-0.0031	-0.0033	-0.0155	0.1571	0.0057	0.0204	-0.1539	0.1837	0.08154	0.1458	0.5158	0.0001	0.0676
FYPP	-0.0095	-0.0331	0.0296	-0.0034	0.0184	-0.0164	0.1401	0.0419	0.0288	-0.1854	0.2161	0.07807	0.1523	0.5224	-0.0212	0.0168
FYPP	-0.0078	-0.0516	0.0331	-0.0031	0.0037	-0.0170	0.1652	0.0518	0.0265	-0.1758	0.2085	0.07998	0.1512	0.5259	-0.0208	0.0168
AA	-0.0102	-0.0886	0.0613	-0.0022	0.0405	-0.0061	0.0868	0.1289	0.0172	-0.1035	0.0505	-0.00007	0.0296	0.1001	-0.1093	-0.0788
TSS	0.0066	0.0213	-0.0852	-0.0001	-0.0247	-0.0017	0.0203	-0.0298	-0.0137	-0.0371	-0.0553	0.02758	0.0128	0.0442	0.0431	0.1997

Bold numbers indicate direct effects and remaining all indirect effects of particular character; Residual effect:-0.0428
PH-Plant height (cm), NPBPP-No. of primary branches $plant^{-1}$, IL-Internodal length (cm), DFF-Days to first flowering, D50% F-Days to 50% flowering, DFH-Days to first harvest, DLH-Days to last harvest, FL-Fruit length (cm), FD-Fruit diameter (cm), PL-Pedicel length (cm), AFW-Average fruit weight (g), NFPP-No. of fruit $plant^{-1}$, FYPP-Fruit yield $plant^{-1}$ (g), FYPP-Fruit yield $plot^{-1}$ (kg), AA-Ascorbic acid (Mg/100 g), TSS-Total soluble soiled (%) and FYPH-Fruit yield $ha.^{-1}$ (q)

Table 4: Phenotypic path coefficient analysis of the yield and its components in spine gourd.

Traits	PH	NPB	IL	DFFO	D50.F	DFH	DLH	FL	FD	PL	AFW	NFP	FYP	FYPL	AA	TSS
PH	0.0764	-0.0150	-0.0532	-0.0142	0.0043	-0.0004	-0.0144	-0.0003	0.0052	-0.0023	0.0303	-0.031	-0.0221	-0.0338	0.0051	0.0058
NPB	0.0092	-0.1249	0.0136	0.0078	-0.0045	-0.0038	0.0197	0.0110	0.0137	0.0039	-0.0194	0.0152	0.0228	0.0906	-0.0112	-0.0051
IL	0.0382	0.0160	-0.1063	-0.0145	0.0069	0.0009	0.0038	-0.0075	-0.0145	-0.0032	-0.0198	-0.0265	-0.0342	-0.0898	0.0123	0.0326
DFFO	0.0176	0.0157	-0.0250	-0.0618	0.0059	0.0053	-0.0356	-0.0051	-0.0172	-0.0086	-0.0406	-0.1261	-0.0887	-0.1858	0.0126	0.0003
D50.F	0.0165	0.0285	-0.0369	-0.0184	0.0198	0.0012	-0.0035	-0.0085	-0.0110	-0.0036	-0.0122	-0.0269	-0.0236	-0.0188	0.0102	0.0082
DFH	-0.0019	0.0335	-0.0065	-0.0227	0.0017	0.0143	-0.0346	-0.0053	-0.0172	-0.0061	-0.0411	-0.1496	-0.0897	-0.1660	0.0073	-0.0039
DLH	0.0123	0.0275	0.0045	-0.0246	0.0008	0.0056	-0.0892	0.0053	-0.0049	-0.0049	-0.0210	-0.0496	-0.0430	-0.1199	0.0059	-0.0004
FL	-0.0007	-0.0463	0.0270	0.0106	-0.0057	-0.0025	-0.0158	0.0297	0.0096	0.0032	-0.0076	0.0330	0.0176	0.0349	-0.0101	-0.0077
FD	0.0087	-0.0377	0.0341	0.0235	-0.0048	-0.0055	0.0096	0.0063	0.0453	0.0080	0.0873	0.1123	0.0990	0.2198	-0.0134	-0.0187
PL	-0.0114	-0.0312	0.0217	0.0339	-0.0046	-0.0056	0.0279	0.0061	0.0231	0.0156	0.0682	0.1572	0.1162	0.2552	-0.0128	0.0085
AFW	0.0130	0.0136	0.0118	0.0141	-0.0014	-0.0033	0.0105	-0.0013	0.0222	0.0060	0.1780	0.1069	0.0882	0.2046	-0.0031	-0.0097
NFP	-0.009	-0.0072	0.0107	0.0296	-0.0020	-0.0082	0.0168	0.0037	0.0194	0.0093	0.0723	0.2632	0.1352	0.3012	-0.0009	0.0186
FYP	-0.0105	-0.0177	0.0226	0.034	-0.0029	-0.0080	0.0236	0.0032	0.0278	0.0113	0.0974	0.2206	0.1613	0.3269	-0.0063	0.0052
FYPL	-0.0068	-0.0299	0.0253	0.0304	-0.0010	-0.0063	0.0283	0.0026	0.0264	0.0106	0.0964	0.2097	0.1395	0.3780	-0.0042	0.0050
AA	-0.0126	-0.0446	0.0418	0.0250	-0.0064	-0.0034	0.0169	0.0096	0.0194	0.0064	0.0179	0.0078	0.0326	0.0508	-0.0312	-0.0204
TSS	0.0078	0.0111	-0.0609	-0.0003	0.0029	-0.0010	0.0006	-0.0040	-0.0149	0.0023	-0.0303	0.0858	0.0147	0.0333	0.0111	0.0568

Bold numbers indicate direct effects and remaining all indirect effects of particular character; Residual effect: 0.0696
PH-Plant height (cm), NPBPP-No. of primary branches $plant^{-1}$, IL-Internodal length (cm), DFF-Days to first flowering, D50% F-Days to 50% flowering, DFH-Days to first harvest, DLH-Days to last harvest, FL-Fruit length (cm), FD-Fruit diameter (cm), PL-Pedicel length (cm), AFW-Average fruit weight(g), NFPP-No. of fruit $plant^{-1}$, FYPP-Fruit yield $plant^{-1}$ (g), FYPP-Fruit yield $plot^{-1}$ (kg), AA-Ascorbic acid (Mg/100 g), TSS-Total soluble soiled (%) and FYPH-Fruit yield $ha.^{-1}$ (q).

Conclusion

Based on findings of present studies on correlation and path analysis, it may be concluded that the fruit yield plant^{-1}, no. of fruit plant^{-1}, fruit yield plot^{-1}, fruit diameter, average fruit weight, fruit length these traits being easily observable should be given primary focus during the selecting of superior genotypes for improving the genetic yield potential of spine gourd.

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