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Correlation and path coefficient analysis studies in turmeric (*Curcuma longa* L.) under low hills of Himachal Pradesh

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ABSTRACT

The research titled "Correlation and path coefficient analysis studies in turmeric (Curcuma longa L.) under low hills of Himachal Pradesh." was carried out in Dr. YSP University of Horticulture and Forestry, Solan (H.P). The experiment was laid out in randomized block design comprising of 21 diverse genotypes of turmeric, to ascertain the correlation and path analysis for yield and other horticultural traits among the genotypes. The correlation coefficient studies showed that yield per plot had positive and significant association with number of leaves per plant, number of tillers per plant, length of mother rhizome, weight of mother rhizome, length of primary rhizome, girth of primary rhizome, length of secondary rhizome and girth of secondary rhizome. Path coefficient showed that the weight of the mother rhizome, girth of the primary rhizome, girth of mother rhizome, leaf length, number of leaves per plant, dry matter, number of secondary fingers per plant and girth of secondary rhizome had a high positive direct effect on yield per plot. Hence, these characteristics should be given more helpful in the selection program of high-yielding genotypes in turmeric.

Keywords: *Correlation, Curcuma longa, Genotypes, Path coefficient, Selection, Rhizome*

I. INTRODUCTION

Turmeric (*Curcuma longa* L.) belongs to Zingiberaceae family, which is indigenous to Southeast Asia, particularly India. Rhizomes are used to propagate this plant [9],[14]. Turmeric is considered auspicious and is used in religious ceremonies. It is often used in traditional Hindu medicine to alleviate sprains and inflammation induced by injuries [8]. Turmeric oleoresin is used in brine pickles and to some extent in non-alcoholic beverages, gelatins, butter and cheese, etc. [15],[10]. Curcumin extracted from turmeric is used as a colorant which has antioxidant [1], anti-inflammatory, antifungal and antitumoral activities [16]. India is the largest producer, consumer and exporter of turmeric in the world. India dominates the world production scenario contributing 80% followed by China (8%), Myanmar (4%), Nigeria (3%) and Bangladesh (3%). In 2020–21, India exported 1.71 lakh tones of turmeric compared to 1.37 lakh tones in the previous year [3].

Path coefficient analysis was used for analyzing the direct and indirect contribution of various independent characters to a dependent character. The correlation coefficient on the other hand indicates the degree and direction of the relationship between two variables but does not provide an insight into the amount of contribution of a trait on another. In turmeric, rhizome yield cannot be improved by direct selection of high-yielding genotypes alone but, it also requires a complete study of yield contributing traits and thus path and correlation coefficient are two major statistical techniques to quantify the relation between two traits and for improving rhizome yield [7].

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II. MATERIALS AND METHODS

The present investigation was carried out in the Department of Vegetable Science, College of Horticulture and Forestry, Neri, Hamirpur, Dr Yashwant Singh Parmar University of Horticulture and Forestry, Nauni, Solan, HP during 2018-2019 and 2019-20. The experimental material comprised of turmeric rhizomes (Local). 21 genotypes including check cultivar (*Table I*) were grown under open field conditions. The experiment was conducted under a randomized Complete Block Design (RCBD) with three replications of each genotype. Rhizomes of different genotypes were planted at a spacing of 30×20 cm in a plot size of 1×1 m which accommodate 16 plants/plot. The standard cultural practices as recommended in the package of practices for vegetable crops were followed to ensure a healthy crop stand [2].

The observations were recorded for plant height (cm), leaf length (cm), leaf breadth (cm), number of leaves per plant, number of tillers per plant, length of mother rhizomes (cm), girth of mother rhizome (cm), weight of mother rhizome (g), length of primary rhizomes (cm), girth of primary rhizomes (cm), number of primary fingers per plant, length of secondary rhizomes (cm), girth of secondary rhizomes (cm), number of secondary rhizomes per plant, yield per plot (kg) and yield per hectare (q), dry matter content (%) and curcumin content (%) from five randomly selected plants in each replication for all characters.

III. RESULTS AND DISCUSSION

Correlation studies

Correlation is defined as the direction of association between two or more characters.

The effectiveness of any breeding program largely depends upon the nature of the association between yield and other component characters. The more directly a character is associated with yield, the more success will be in the selection program. Therefore, it is also important to collect information on association of yield with other characters and among themselves, and their basis to identify characters for increasing the efficiency of both direct and indirect selection and thereby defining an ideal plant type (*Table II and III*). The correlation coefficients among the different characters were worked out at both phenotypic and genotypic levels.

The results revealed that yield per plot significant association at both genotypic and phenotypic levels, and also exhibited positive correlations with the number of leaves per plant (0.500, 0.412) and number of tillers per plant (0.929, 0.430), indicating their strong contribution to yield. Similarly, traits related to rhizome structure show significant positive correlations, including the length of the mother rhizome (0.358, 0.281), girth of the mother rhizome (0.350, 0.212), weight of the mother rhizome (0.415, 0.285), length of the primary rhizome (0.457, 0.295), girth of the primary rhizome (0.422, 0.281), stem length of the secondary rhizome (0.489, 0.127), and girth of the secondary rhizome (0.353, 0.215), highlighting their importance in yield improvement. However, yield per plot (YPP) exhibits a significant negative correlation with curcumin content (-0.328, -0.258), suggesting that higher yield may be associated with lower curcumin levels. These results are similar to the findings of [5],[18],[17] and [11].

Path coefficient analysis

Correlation study only provides information about the linear relationship between the traits under study but does not give any idea about the cause of this relation and therefore sometimes the information obtained is misleading with respect to the identification of yield components. Path coefficient analysis determines the effects of different independent traits individually as well as in combination with other traits on the dependent variable i.e. yield per plot. The estimates of the path coefficient representing direct and indirect effects of various horticultural traits over yield. The path coefficient analysis (*Table IV*) revealed that the highest positive direct effect on yield per plot was recorded for the weight of mother rhizome (3.275) followed by girth of the primary rhizome (1.717), girth of mother rhizome (1.305), leaf length (1.152), number of leaves per plant (0.434), dry matter (0.355), number of secondary fingers per plant (0.306) and girth of secondary rhizome (0.218). [4] and [12] observed that a number of leaves per plant, the weight of mother rhizome and the number of secondary fingers per plant had positive direct effects on yield.

The highest negative direct effect on yield per plot was observed for length of mother rhizome (-2.700), number of primary fingers per plant (-1.825), leaf breadth (-1.325), curcumin content (-1.161), length of primary rhizome (-1.018), length of secondary rhizome (-0.341), number of tillers per plant (-0.312) and plant height (-0.213). Similar findings were observed by [6] and [13] number of tillers per plant, length of the mother rhizome and length of the primary rhizome. Hence, the number of tillers per plant, weight of mother rhizome, number of primary fingers per plant and number of secondary fingers per plant for direct improvement of yield per plot.

IV. CONCLUSION

The present study on correlation and path coefficient analysis in turmeric (*Curcuma longa* L.) has provided valuable insights into the association between various morphological and yield-related traits. The correlation analysis revealed that yield per plot exhibited a significant positive association with key agronomic traits such as the number of leaves per plant, number of tillers per plant, length and weight of mother rhizome, length and girth of primary rhizome, and length and girth of secondary rhizome at both genotypic and phenotypic levels. These findings suggest that selection based on these traits can effectively enhance yield potential in turmeric.

Compliance with ethical standards

Conflict of interest: The authors declare that they have no conflict of interest.

Acknowledgement

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Author's contribution

M (Meenakshi) conducted the experiment and analyzed the data; B.S.D. (Balbir Singh Dogra) conceptualized the research and guided throughout the experiment; J.K. (Jasdeep Kaur) and N.T. (Nikhil Thakur) helped in main manuscript writing and forming tables; R. (Rishabh) helped in data curation.

Table I. List of turmeric genotypes studied along with their sources

Genotypes	Source
LC-T-1-18, LC-T-2-18, LC-T-3-18, LC-T-4-18, LC-T-5-18, LC-T-6-18, LC-T-7-18, LC-T-8-18, LC-T-9-18, LC-T-10-18, LC-T-11-18, LC-T-12-18, LC-T-13-18, LC-T-14-18, LC-T-15-18, LC-T-16-18, LC-T-17-18, LC-T-18-18, LC-T-19-18, LC-T-20-18	Department of Vegetable Science, COHF, Neri, Hamirpur dr Y S Parmar University of Horticulture and Forestry, Nauni, Solan (HP)
Palam Pitamber	CSKHPKV, Palampur (HP)

Table II: Phenotypic coefficients of correlation among different traits in turmeric

Traits	PH	LL	LB	NLP	NTP	LMR	GMR	WMR	LPR	GPR	NPFP	LSR	GSR	NSFP	DM	CC	YPP
PH	1.000																
LL	0.423**	1.000															
LB	0.307*	0.918**	1.000														
NLP	0.008	0.269*	0.222	1.000													
NTP	0.118	0.101	0.014	0.489**	1.000												
LMR	0.181	-0.038	0.144	0.356**	0.199	1.000											
GMR	0.214	-0.003	0.094	0.299*	0.191	0.888**	1.000										
WMR	0.129	0.123	-0.194	0.359**	0.236	0.883**	0.861**	1.000									
LPR	-0.005	-0.000	-0.085	0.194	0.315*	0.144	0.028	0.051	1.000								
GPR	0.108	0.260*	0.239	0.128	0.254*	0.085	0.018	-0.092	0.613**	1.000							
NPFP	0.201	0.189	0.250*	0.003	-0.171	-0.187	-0.079	-0.052	-0.537**	-0.035	1.000						
LSR	-0.064	-0.031	0.047	0.085	-0.073	-0.135	-0.169	-0.236	0.159	0.261*	0.003	1.000					
GSR	-0.103	0.036	0.055	0.092	-0.003	-0.139	0.126	-0.301*	0.292*	0.329**	-0.060	0.671**	1.000				
NSFP	0.473**	0.289*	0.175	-0.019	0.005	-0.222	-0.198	-0.185	-0.142	0.048	0.501**	0.026	-0.080	1.000			
DM	-0.043	0.056	-0.003	0.337**	-0.013	0.524**	0.557**	0.496**	-0.079	-0.092	0.352**	0.023	-0.034	0.140	1.000		
CC	0.080	-0.176	-0.196	-0.310*	-0.098	-0.575**	-0.589**	-0.489**	0.081	-0.102	-0.308*	0.165	0.204	-0.060	-0.637**	1.000	
YPP	0.065	0.026	-0.068	0.412**	0.430**	0.281*	0.212	0.285*	0.295*	0.281*	0.220	0.127*	0.215*	0.114	-0.030	-0.258*	1.000

**Significant at 5% level of significance*
***Significant at 1% level of significance Where,*
PH = Plant height, LL = Leaf length, LB = Leaf breadth, NLP = Number of leaves per plant, NTP = Number of tillers per plant, LMR = Length of mother rhizome, GMR = Girth of mother rhizome, WMR = Weight of mother rhizome, LPR = Length of primary rhizome, GPR = Girth of primary rhizome, NPFP = Number of primary fingers per plant, LSR = Stem Length of secondary rhizome, GSR = Girth of secondary rhizome, NSFP = Number of secondary fingers per plant, DM = Dry matter, CC = Curcumin content and YPP = Yield per plot.

Table III: Genotypic coefficients of correlation among different traits in turmeric

Traits	PH	LL	LB	NLP	NTP	LMR	GMR	WMR	LPR	GPR	NPFP	LSR	GSR	NSFP	DMC	CC	YPP
PH	1.000																
LL	0.436**	1.000															
LB	0.331**	0.976**	1.000														
NLP	-0.003	0.307*	0.261*	1.000													
NTP	0.149	0.180	-0.031	0.626**	1.000												
LMR	0.207	0.042	0.130	0.376**	0.431**	1.000											
GMR	0.224	0.028	0.098	0.417**	0.351**	1.048**	1.000										
WMR	0.135*	0.127	0.211	0.399**	0.382**	0.944**	0.970**	1.000									
LPR	0.024	0.015	0.085	0.299*	0.625**	0.149**	0.053	0.060*	1.000								
GPR	0.132	0.300*	0.260*	0.155	0.560**	0.079	0.031	-0.104	0.727**	1.000							
NPFP	0.229	0.200	0.267*	-0.022	0.338**	-0.167	-0.106	-0.061	0.602**	0.044	1.000						
LSR	-0.027	0.095	0.076	0.103	0.031	0.214**	0.199	0.371**	0.401**	0.383**	0.050	1.000					
GSR	-0.117	0.033	0.062	0.088	0.067	-0.182	-0.214	-0.329**	0.426**	0.403**	-0.089	1.260**	1.000				
NSFP	0.603**	0.320**	0.210	-0.022	0.017	-0.306*	-0.321**	-0.221	-0.130	0.156	0.658**	0.019	-0.070	1.000			
DMC	-0.039	0.053	-0.008	0.390**	0.051	0.572**	0.629**	0.507**	-0.135	-0.111	0.378**	0.030	-0.016	0.186	1.000		
CC	0.080	-0.181	-0.202	-0.335**	-0.139	-0.610**	-0.650**	-0.497**	0.098	-0.110	-0.330**	0.250*	0.232	-0.078	-0.656**	1.000	
YPP	0.107	0.047	-0.032	0.500**	0.929**	0.358**	0.350**	0.415**	0.457**	0.422**	0.291*	0.489**	0.353**	0.110	-0.052	-0.328**	1.000

**Significant at 5% level of significance*
***Significant at 1% level of significance*
Where,
PH = Plant height, LL = Leaf length, LB = Leaf breadth, NLP = Number of leaves per plant, NTP = Number of tillers per plant, LMR = Length of mother rhizome, GMR = Girth of mother rhizome, WMR = Weight of mother rhizome, LPR = Length of primary rhizome, GPR = Girth of primary rhizome, NPFP = Number of primary fingers per plant, LSR = Stem Length of secondary rhizome, GSR = Girth of secondary rhizome, NSFP = Number of secondary fingers per plant, DMC = Dry matter content, CC = Curcumin content and YPP = Yield per plot

Table IV: Path coefficient analysis showing the direct and indirect effect of seventeen characters on yield per plot genotypic at level

Traits	PH	LL	LB	NLP	NTP	LMR	GMR	WMR	LPR	GPR	NPFP	LSR	GSR	NSFP	DM	CC	YPP
PH	-0.213	0.502	-0.439	-0.001	-0.046	0.560	0.292	-0.443	0.024	0.227	-0.418	0.009	-0.026	0.185	-0.014	-0.093	0.107
LL	-0.093	1.152	-1.293	0.133	-0.056	0.114	0.037	-0.415	0.015	0.516	-0.365	-0.032	0.007	0.098	0.019	0.210	0.047
LB	-0.070	1.123	-1.325	0.113	0.010	0.351	0.128	-0.689	0.086	0.446	-0.487	-0.026	0.013	0.064	-0.003	0.234	-0.032
NLP	0.001	0.354	-0.346	0.434	-0.195	-1.016	-0.544	1.306	-0.305	0.266	0.040	-0.035	0.019	-0.007	0.139	0.389	0.500**
NTP	-0.032	0.207	0.041	0.272	-0.312	-1.163	-0.459	1.252	-0.636	0.961	0.617	0.011	-0.015	0.005	0.018	0.162	0.929**
LMR	0.044	-0.048	0.172	0.163	-0.134	-2.700	-1.368	3.091	-0.152	0.135	0.305	0.073	-0.040	-0.094	0.203	0.708	0.358**
GMR	0.048	-0.033	0.130	0.181	-0.110	-2.831	1.305	3.176	-0.054	0.053	0.194	0.068	-0.047	-0.098	0.223	0.755	0.350**
WMR	0.029	-0.146	0.279	0.173	-0.119	-2.548	-1.265	3.275	0.061	-0.179	0.111	0.126	-0.072	-0.068	0.180	0.577	0.415**
LPR	0.005	-0.018	0.112	0.130	-0.195	-0.403	-0.070	-0.196	-1.018	1.249	1.099	-0.137	0.093	-0.040	-0.048	-0.108	0.457**
GPR	-0.028	0.346	-0.344	0.067	-0.175	-0.212	-0.040	-0.341	-0.740	1.717	0.080	-0.130	0.088	0.048	-0.040	0.128	0.422**
NPFP	-0.049	0.230	-0.353	-0.010	0.105	0.451	0.139	-0.200	0.613	-0.075	-1.825	-0.017	-0.019	0.201	0.134	0.383	0.291*
LSR	0.006	0.110	-0.101	0.045	0.010	0.579	0.260	-1.214	-0.408	0.657	-0.091	-0.341	0.275	0.006	0.011	-0.291	0.489**
GSR	0.025	0.038	-0.082	0.038	0.021	0.492	0.280	-1.078	-0.434	0.691	0.162	-0.429	0.218	-0.022	-0.006	-0.269	0.353**
NSFP	-0.128	0.369	-0.278	-0.010	-0.005	0.826	0.419	-0.723	0.132	0.268	-1.201	-0.006	-0.015	0.306	0.661	0.908	0.11
DM	0.008	0.061	0.011	0.169	-0.016	-1.543	-0.821	1.660	0.138	-0.191	-0.689	-0.010	-0.004	0.057	0.355	0.762	-0.052
CC	-0.017	-0.208	0.267	-0.145	0.044	1.646	0.849	-1.630	-0.095	-0.189	0.602	-0.085	0.051	-0.024	-0.233	-1.161	-0.328**

Residual effect: 0.09050

Where

PH = Plant height, LL = Leaf length, LB = Leaf breadth, NLP = Number of leaves per plant, NTP = Number of tillers per plant, LMR = Length of mother rhizome, GMR = Girth of mother rhizome, WMR = Weight of mother rhizome, LPR = Length of primary rhizome, GPR = Girth of primary rhizome, NPFP = Number of primary fingers per plant, LSR = Stem Length of secondary rhizome, GSR = Girth of secondary rhizome, NSFP = Number of secondary fingers per plant, DM = Dry matter, CC = Curcumin content and YPP = Yield per plot.

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