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Sivakumar V
AICRP on Spices Centre, Horticultural Research Station, Dr. YSRHU, Chintapalli, Andhra Pradesh, India

Ravindrakumar K
Horticultural Research Station, Dr. YSRHU, Kovvur, West Godavari, Andhra Pradesh, India

Chandrasekhar C
AICRP on Spices Centre, Horticultural Research Station, Dr. YSRHU, Chintapalli, Andhra Pradesh, India

Bhagavan BVK
Horticultural Research Station, Dr. YSRHU, Ambajipet, East Godavari, Andhra Pradesh, India

Corresponding Author:
Sivakumar V
AICRP on Spices Centre, Horticultural Research Station, Dr. YSRHU, Chintapalli, Andhra Pradesh, India

Character association and path coefficient analysis studies on yield and yield attributing characters in Turmeric (*Curcuma longa* L.)

Sivakumar V, Ravindrakumar K, Chandrasekhar C and Bhagavan BVK

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Abstract
The Correlation and path analysis was studied for fresh rhizome yield per hectare and its component characters in 12 diverse genotypes of turmeric during *Kharif* season of 2014-15, 2015-16 and 2016-17 at Horticultural research Station, Chintapalli. The data recorded on different characters were subjected to work out correlation and path analysis to investigate the association, direct and indirect contribution of various characters on fresh rhizome yield per hectare. The resulted indicated that the strong positive genotypic correlation of plant height and yield per plant with yield per hectare. The dry recovery had a significant positive correlation with plant height, leaf length and leaf area while the significant negative correlation with the number of tillers per plant. The path analysis study revealed that the yield per plant the most important yield per hectare determinant followed by leaf length and leaf area is the another most important yield determinant thus, these characters should be given importance in selection programmes for yield improvement in turmeric.

Keywords: Turmeric, character association, correlation, path analysis

Introduction
Turmeric (*Curcuma longa* L.) is one of the important spice and also condiment crops grown in India since times immemorial. It is regarded as a symbol of well-being and widely used in ceremonies and religious functions. It is an erect, herbaceous perennial belonging to the family *Zingiberaceae.* It is originated in South East Asia and among which, India has achieved a predominant position as the largest producer of turmeric in the world. Besides India, it is cultivated in China, Taiwan, Indonesia, Sri Lanka, Thailand and other tropical countries but the highest diversity is concentrated in India and Thailand (Hikmat *et al.*, 2011) [2]. Turmeric of commerce is the dried underground rhizome, valued for its deep yellow colour and pungent aromatic flavour due to the presence of colouring matter ‘‘Curcumin’’ and a volatile oil ‘‘Termerole’’. It is also an important condiment which finds a unique place in culinary arts and as a colouring agent in textile, food, confectionary, cosmetics and drug industries in the preparation of anticancer medicines. Turmeric is either grown as a pure crop or inter/mixed crop in coconut, areca nut and coffee plantations. In India, it is being cultivated in more than 20 states in an area of 2.37 lakh ha with an annual production of 11.63 MT and earning 1241.89 crores by exporting 1.16 MT to other countries. In India, it is mainly grown in Telangana, Andhra Pradesh, Odisha, West Bengal, Tamil Nadu, Assam, Maharashtra, Karnataka, Bihar and Kerala. Among these, Telangana occupies 50,000 ha of the total area and 2.55 MT of the total production of the country. The national productivity of crop is 5 tonnes per hectare. (NHB, 2017-18).

Yield is a complex character determined by several component characters (Singh, 2005) [13]. Improvement in yield is possible only through selection for the desired component characters. For evaluating the yield potential of any variety of turmeric, it is necessary to give attention to all the yield contributing characters. It is essential to assess the degree of association of various quantitative characters in order to initiate an effective selection programme. Hence, knowledge of the association of the various plant characters with yield and among themselves is required so that a rational choice of characters for selection can be exercised. Studies on this aspect were made earlier by several workers (Lakshmi *et al*., 2017; Salimath *et al*., 2017; Singh *et al*., 2018) [7, 12, 14]. A simple measure of the correlation of characters does not

quantify the relative contribution of causal factors to the ultimate yield. Since the component traits themselves are inter-dependent, they often affect their direct relationship with yield and consequently restrict the reliability of selection indices based upon correlation coefficients. The path coefficient analysis permits the separation of direct effects from indirect effects through other related traits by partitioning the genotypic correlation coefficients. Hence, the present study was undertaken to estimate the genotypic correlations and direct and to determine the indirect effects of component characters on yield in turmeric genotypes.

Material and Methods

The experimental site was located in the Horticulture Research Station, Chinthapalli, Andhra Pradesh. The location falls under Agro-climatic zone of High Altitude and Tribal Zone with average annual rainfall from South-West monsoon of more than 1300 mm, maximum temperature range 17 to 35 ºC, minimum temperature range from 5 to 24 ºC and is located at an altitude of 933 m MSL. The geographical situation is 170.13' N latitude and 840.33' E longitudes. The experiment was laid out in Randomised Block Design with 12 treatments and 3 replications. The planting was done on raised beds spaced row to row 30 cm with the plant to plant distance of 25 cm and the net plot size was 3 x 1 m^2. The soil of the experimental field was alluvial and it was endowed with good drainage. Recommended package of practices and plant protection measures were followed to raise a healthy crop. The observations were recorded on five randomly selected plants in each plot on seven quantitative characters *viz*., plant height, number of tillers per plant, leaf length, leaf area, yield per plant, estimated yield per hectare and dry recover percentage. Genotypic and phenotypic correlation coefficients were estimated according to the formulae given by Johnson *et al*. (1955) [5]. The significance of the phenotypic and genotypic correlation coefficients was tested as given by Snedecor and Cochran (1967) [15]. Path coefficient analysis as suggested by Dewey and Lu (1959) [1] was used to partition the genotypic correlation coefficients of fruit yield into direct and indirect effects.

Results and Discussion

In the present study, the yield per hectare showed significant positive genetic correlation with plant height and yield per plant. Similar significant positive association with plant height was reported by Singh *et al*. (2018) [14], Rajyalakshmi *et al*. (2013) [10] and Jagadeeshkanth *et al*. (2018).

Dry recovery was positively correlated with plant height, leaf length and leaf area while negatively correlated with the number of tillers per plant. These results were also confirmed by the findings Kuldeep (2012) [6]. Plant height showed a significant and positive association with leaf length, leaf area, dry recovery and yield per hectare. These results were also confirmed by the findings of Jagadeeshkant *et al*. (2017) [3] for leaf length and Lakshmi *et al*. (2017) [7] for dry recovery. The number of tillers showed significant negative genotypic correlation with dry recover. Leaf length had significant positive genotypic and phenotypic correlation with leaf area and dry recovery. Similar results were reported by several workers *viz.*, Velmurugan *et al.* (2008) [16], Roy *et al.* (2011) [11], Jan *et al.* (2012) [4] and Salimath *et al*. (2017) [12].

The path coefficient analysis provides an effective means of finding out the direct and indirect effect of association and permits a critical examination of specific forces acting to produce given correlation and measure the relative importance of each factor. The direct and indirect effects of different characters on yield at the genotypic level are presented in Table 2.

The path analysis study revealed that the characters *viz*., leaf length, leaf area and yield per plant exerted a positive direct effect on yield. Similar results were reported by Singh *et al*. (2018) [14] and Velmurugan *et al*. (2008) [16].

Lenka and Mishra (1973) [8] have suggested scales for path coefficients with values 0.00 to 0.09 as negligible, 0.10 to 0.19 low, 0.20 to 0.29moderate, 0.30 to 0.99 high and more than 1.00 as very high path coefficients. Accordingly, in this study, leaf area and leaf length exhibited high positive direct effect and both the characters indirectly influence the yield per hectare through plant height. Yield per plant exhibited very high positive direct.

The results of correlation studies suggest that yield per hectare can be improved by selecting genotypes for yield per plant and plant height. Emphasis must be given for characters having high direct effects like leaf length, leaf area and yield per plant while exercising selection to improve the yield Salimath *et al*. (2017) [12] and Singh *et al*. (2018) [14].

Table 1: Estimates of phenotypic (P) and genotypic (G) correlation coefficients in turmeric

Character		Plant Height	No. of Tillers	Leaf Length	Leaf Area	Yield/ Plant	Dry Recovery	Yield/ha
Plant Height	P	1.000						
	G	1.000						
No. of Tillers	P	0.044	1.000					
	G	0.194	1.000					
Leaf Length	P	0.582**	0.064	1.000				
	G	0.879**	0.082	1.000				
Leaf Area	P	0.531**	-0.016	0.753**	1.000			
	G	0.562**	0.159	0.871**	1.000			
Yield/Plant	P	0.091	0.188	-0.300	-0.204			
	G	0.295	0.124	-0.261	-0.070	1.000		
Dry Recovery	P	0.336*	-0.260	0.593**	0.627**	-0.187	1.000	
	G	0.420*	-0.584**	0.647**	0.752**	-0.231	1.000	
Yield/ha	P	0.209	0.284	-0.084	0.027	0.715**	-0.063	1.000
	G	0.486**	0.124	-0.085	0.166	1.082**	-0.081	1.000

* - Significant at 5.0% level **- Significant at 1.0% level

Table 2: Genotypic path coefficient (direct and indirect effects) of various traits on yield per hectare in turmeric

	Plant Height	No. of Tillers	Leaf Length	Leaf Area	Yield/Plant	Dry Recovery
Plant Height	**-0.539**	-0.113	0.799	0.276	0.411	-0.348
No. of Tillers	-0.105	-0.580	0.074	0.078	0.172	0.484
Leaf Length	0.474	-0.047	0.909	0.427	-0.363	-0.536
Leaf Area	0.303	-0.092	0.791	0.491	-0.097	-0.623
Yield/Plant	-0.159	-0.072	-0.237	-0.034	1.393	0.191
Dry Recovery	-0.227	0.338	0.588	0.369	-0.321	-0.828

(Bold with underlined figures are direct effects)
Residual effect =-0.24

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