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Character association studies for yield and its attributing traits in elephant foot yam [*Amorphophallus paeoniifolius* (Dennst.) Nicolson]

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Abstract
Elephant foot yam is an important tuber crop of the tropical and sub-tropical countries. The present experiment was conducted to know the association of various characters with corm yield in 21 germplasm of elephant foot yam. Study of correlation between different quantitative characters provides a thought of association that would be effectively exploited to formulate selection strategies for improving yield components. Correlation coefficient studies indicated that the characters like pseudostem girth, pseudostem length, chlorophyll content and leaf canopy diameter had highly significant and positive correlation with corm weight per plant. Path analysis revealed that chlorophyll content had high positive direct effect on corm weight per plant. While, psuedostem length and calcium oxalate had moderate positive direct effect on corm weight per plant. Thus, these characters have to be given importance in selection process for improvement in corm yield.

Keywords: Correlation coefficient, path analysis, elephant foot yam

Introduction
Tuber crops are the third most important food crop of man after cereals and grain legumes. Among them elephant foot yam is an important tuber crop of the tropical and sub-tropical countries, because of its higher yield potential, culinary properties, medicinal utility and therapeutic values. It referred as "King of tuber crops" (Sengupta *et al.*, 2008) [13] and also known as "Money spinning tuber crop" due to high mean profit associated with it. Elephant foot yam is a member of family Araceae and with diploid chromosome number 2n =26, 28. It is originated in South East Asia and having a wide distribution. It is a cross pollinated and vegetatively propagated tuber crop. It is propagated by corms as such or by cut corm pieces having a part of apical meristem. In India, it is commonly known as Suran or Zimmikand and it is traditionally cultivated on commercial scales in the states of Bihar, Uttar Pradesh, Andhra Pradesh, Tamil Nadu, West Bengal and Kerala.
Improvements made in crop varieties are mainly concentrated on increasing yield and yield attributing characters. A study of correlation between different quantitative characters provides an idea of association. It could be effectively exploited to formulate selection strategies for improving yield and quality. Correlation study does not reveal the direct and indirect contribution of individual character towards yield. In order to have a clear cut picture of yield components for effective selection programme, it would be desirable to consider the relative magnitude of various characters contributing towards yield. The path coefficient technique helps in estimating direct and indirect contribution of various components in building up the correlation towards yield.

Materials and Methods
The present investigation was carried-out to assess the character association in 21 germplasm of elephant foot yam, obtained from germplasm collections maintained at Tirhut College of Agriculture, Dholi including Gajendra variety as National check. The experiment was conducted in Randomized Block Design in two replications at T.C.A., Dholi Research Farm of DRPCAU, Pusa, Samastipur, Bihar. Standard cultural practices were applied during the crop period. The observations were recorded on five randomly selected plants in each entry and replication and their mean values were used for statistical analysis. Data were collected for ten characters *viz*., days to sprouting, pseudostem length (cm), pseudostem girth (cm), leaf canopy diameter (cm), chlorophyll content (SPAD), calcium oxalate (mg/100gm), dry matter (%),

days to maturity, no. of cormels per plant and corm weight per plant (kg.). Phenotypic and genotypic correlation coefficients were calculated from the variance and covariance component as suggested by Johnson *et al*. (1955) [7]. Path coefficient analysis was carried out according to the procedure suggested by Dewy and Lu (1959) [4].

Results and Discussions

Correlation coefficient analysis

Correlation coefficient was worked out at phenotypic and genotypic level for all possible combination of yield and its attributing traits in elephant foot yam (Table 1). Results indicated that the genotypic coefficient of correlation was higher in magnitude than the corresponding phenotypic coefficient of correlation. In the present investigation, corm weight per plant was found to have strong positive correlation with pseudostem girth, pseudostem length, chlorophyll content, leaf canopy diameter, days to maturity and calcium oxalate. Cheema *et al*. (2007) [2]; Chattopadhyay (2009) [1]; Singh and Tripathi (2012) [14]; Paul and Bari (2013) [10] have also reported similar findings. However, corm weight per plant showed strong negative correlation with days to sprouting, no. of cormels per plant and dry matter.

Days to sprouting and days to maturity had negative association at genotypic level is an important component in identifying and deciding the duration of the crop. The days to sprouting had significant and negative correlation with corm weight per plant indicating that early germination will yield more corm weight.

No. of cormels per plant exhibited significant positive association with days to sprouting and non-significant positive association with calcium oxalate, dry matter and days to maturity. It exhibited highly significant and negative association with corm weight per plant, pseudostem length, pseudostem girth and chlorophyll content. While, it had negative association with leaf canopy diameter at both genotypic and phenotypic level indicating the positive and negative effect of these characters in deciding crop yield.

Days to maturity had positive correlation with corm weight per plant, pseudostem girth, calcium oxalate, leaf canopy diameter, chlorophyll content, pseudostem length and dry matter. While, it had a negative correlation with days to sprouting at both genotypic and phenotypic level.

Dry matter exhibited negative correlation with leaf canopy diameter and chlorophyll content but, positively correlation to pseudostem girth at genotypic level. On other hand, a positive correlation of dry matter with leaf canopy diameter and chlorophyll content was found along with negative correlation with pseudostem girth at phenotypic level. Besides, it was also founded that dry matter had negative correlation with corm weight per plant, days to sprouting, pseudostem length as well as calcium oxalate both at phenotypic and genotypic level.

Calcium oxalate had a positive correlation with corm weight per plant, days to sprouting, leaf canopy diameter and pseudostem girth but, it had negative correlation with chlorophyll content at both genotypic and phenotypic level. On other hand, a calcium oxalate had positive correlation with pseudostem length at genotypic level, while it had negative correlation with pseudostem length at phenotypic level.

Chlorophyll content showed strong positive and significant correlation with corm weight per plant, pseudostem length, pseudostem girth and leaf canopy diameter. While, on other hand it had a highly negative and significant correlation with days to sprouting at both genotypic and phenotypic level.

Leaf canopy diameter exhibited highly significant and positive correlation with corm weight per plant, pseudostem girth and pseudostem length. Whereas, it had negative and non-significant correlation with days to sprouting at both genotypic and phenotypic level.

Pseudostem girth showed highly significant and positive correlation with corm weight per plant and pseudostem length. While, it was highly significant and negative correlation with days to sprouting at both genotypic and phenotypic level.

Pseudostem length showed highly significant and positive correlation with corm weight per plant and pseudostem girth. While, it was highly significant and negative correlation with days to sprouting at both genotypic and phenotypic level.

Path coefficient analysis

Path coefficient analysis is simply a standardized partial regression coefficient which splits correlation coefficients into the measure of direct and indirect contributions of various independent characters on a dependent character. The correlation coefficients between corm weight per plant and its attributing traits were divided into the corresponding direct and indirect effects through cause and effect analysis and the results were presented in Table 2 & 3.

Table 1: Genotypic and phenotypic correlation coefficient among ten quantitative characters in elephant foot yam

Sl. No	Characters		Days to sprouting	Pseudostem length (cm)	Pseudostem girth (cm)	Leaf canopy diameter (cm)	Chlorophyll content (SPAD)	Calcium oxalate (mg/100gm)	Dry matter (%)	Days to maturity	No. of cormels per plant	Corm weight per plant (kg)
1	Days to sprouting	r_g	1.0000									
		r_p	1.0000									
2	Pseudostem length (cm)	r_g	-0.6047**	1.0000								
		r_p	-0.5188**	1.0000								
3	Pseudostem girth (cm)	r_g	-0.5855**	0.9214**	1.0000							
		r_p	-0.4751**	0.6544**	1.0000							
4	Leaf canopy diameter (cm)	r_g	-0.3032	0.6210**	0.9779**	1.0000						
		r_p	-0.2801	0.4918**	0.6615**	1.0000						
5	Chlorophyll content (SPAD)	r_g	-0.7496**	0.7298**	0.8507**	0.4996**	1.0000					
		r_p	-0.5242**	0.4393**	0.4385**	0.3290*	1.0000					
6	Calcium oxalate (mg/100gm)	r_g	0.2212	0.0005	0.1347	0.2754	-0.3136*	1.0000				
		r_p	0.2174	-0.0613	0.1200	0.1755	-0.2825	1.0000				
7	Dry matter	r_g	-0.0919	-0.2530	0.0956	-0.0558	-0.1927	-0.0558	1.0000			

	(%)	r_p	-0.0322	-0.1269	-0.0724	0.0787	0.0167	-0.0842	1.0000			
8	Days to maturity	r_g	-0.1022	0.2786	0.4940**	0.5363**	0.0914	0.4624**	0.3046*	1.0000		
		r_p	-0.0760	0.0971	0.2846	0.2551	0.1379	0.2723	0.0075	1.0000		
9	No. of cormels per plant	r_g	0.3991*	-0.6343**	-0.5882**	-0.1255	-0.4052**	0.3004	0.1549	0.1467	1.0000	
		r_p	0.3636*	-0.5450**	-0.4627**	-0.0410	-0.3256*	0.2893	0.1595	0.1003	1.0000	
10	Corm weight per plant (kg)	r_g	-0.6062**	0.8826**	1.0124**	0.6122**	0.7430**	0.0862	-0.2824	0.3388*	-0.5928**	1.0000
		r_p	-0.4862**	0.7005**	0.6328**	0.5246**	0.6795**	0.0302	-0.0243	0.1649	-0.4713**	1.0000

*, ** significant at 5% and 1% level, respectively

Table 2: Genotypic path coefficient analysis of different characters on corm weight per plant in elephant foot yam

Sl. No.	Characters	Days to sprouting	Pseudostem length (cm)	Pseudostem girth (cm)	Leaf canopy diameter (cm)	Chlorophyll content (SPAD)	Calcium oxalate (mg/100gm)	Dry matter (%)	Days to maturity	No. of cormels per plant
1	Days to sprouting	-0.0033	0.0020	0.0020	0.0010	0.0025	-0.0007	0.0003	0.0003	-0.0013
2	Pseudostem length (cm)	-0.1296	0.2143	0.1975	0.1331	0.1564	0.0001	-0.0542	0.0597	-0.1360
3	Pseudostem girth (cm)	0.1270	-0.1999	-0.2170	-0.2122	-0.1846	-0.0292	-0.0207	-0.1072	0.1276
4	Leaf canopy diameter (cm)	-0.0497	0.1018	0.1603	0.1639	0.0819	0.0451	-0.0063	0.0879	-0.0206
5	Chlorophyll content (SPAD)	-0.4250	0.4137	0.4823	0.2832	0.5669	-0.1778	-0.1092	0.0518	-0.2297
6	Calcium oxalate mg/100gm)	0.0626	0.0001	0.0382	0.0780	-0.0888	0.2832	-0.0158	0.1309	0.0851
7	Dry matter (%)	0.0064	0.0177	-0.0067	0.0027	0.0135	0.0039	-0.0699	-0.0213	-0.0108
8	Days to maturity	-0.0205	0.0559	0.0991	0.1076	0.0183	0.0928	0.0611	0.2006	0.0294
9	No. of cormels per plant	-0.1742	0.2769	0.2567	0.0548	0.1769	-0.1311	-0.0676	-0.0640	-0.4365
10	Corm weight per plant (kg)	-0.6062**	0.8826**	1.0124**	0.6122**	0.7430**	0.0862	-0.2824	0.3388*	-0.5928**

Residual effect = 0.368

*, ** significant at 5% and 1% level, respectively

Table 3: Phenotypic path coefficient analysis of different characters on corm weight per plant in elephant foot yam

Sl. No.	Characters	Days to sprouting	Pseudostem length (cm)	Pseudostem girth (cm)	Leaf canopy diameter (cm)	Chlorophyll content (SPAD)	Calcium oxalate (mg/100gm)	Dry matter (%)	Days to maturity	No. of cormels per plant
1	Days to sprouting	0.0026	-0.0014	-0.0012	-0.0007	-0.0014	0.0006	-0.0001	-0.0002	0.0009
2	Pseudostem length (cm)	-0.1679	0.3236	0.2118	0.1591	0.1421	-0.0198	-0.0411	0.0314	-0.1763
3	Pseudostem girth (cm)	0.0130	-0.0179	-0.0273	-0.0181	-0.0120	-0.0033	0.0020	-0.0078	0.0127
4	Leaf canopy diameter (cm)	-0.0486	0.0852	0.1147	0.1733	0.0570	0.0304	0.0136	0.0442	-0.0071
5	Chlorophyll content (SPAD)	-0.2566	0.2150	0.2146	0.1610	0.4894	-0.1382	0.0082	0.0675	-0.1594
6	Calcium oxalate mg/100gm)	0.0500	-0.0141	0.0276	0.0403	-0.0649	0.2298	-0.0193	0.0626	0.0665
7	Dry matter (%)	-0.0015	-0.0059	-0.0034	0.0037	0.0008	-0.0039	0.0468	0.0004	0.0075
8	Days to maturity	0.0009	-0.0011	-0.0033	-0.0030	-0.0016	-0.0032	-0.0001	-0.0116	-0.0012
9	No. of cormels per plant	-0.0781	0.1171	0.0994	0.0088	0.0700	-0.0622	-0.0343	-0.0216	-0.2149
10	Corm weight per plant (kg)	-0.4862**	0.7005**	0.6328**	0.5246**	0.6795**	0.0302	-0.0243	0.1649	-0.4713**

Residual effect =0.5130

*, ** significant at 5% and 1% level, respectively

The phenotypic path coefficient analysis revealed that chlorophyll content and psuedostem length exhibited high positive direct effect and their respective correlation coefficient value was also high and positive indicating the true relationship with corm weight per plant, suggesting improvement in corm weight through selection of these characters. Leaf canopy diameter exhibited positive low direct effect but respective correlation coefficient value was high

and positive due to positive indirect effect via chlorophyll content and pseudostem length. Calcium oxalate also had a moderate direct effect on corm weight per plant but respectively correlation coefficient value was low and positive due to nullifying indirect effect via chlorophyll content and no. of cormels per plant. No of cormels per plant had moderate negative direct effect on corm weight per plant, while it corresponding correlation value was highly negative due to indirect effect of others characters like chlorophyll content and pseudostem length.

At genotypic level, chlorophyll content had highly significant and positive direct effect and their respective correlation coefficient value was also high. Whereas, pseudostem length, leaf canopy diameter, calcium oxalate and days to maturity had moderate positive direct effect on corm weight per plant resulting more yield. However, no. of cormels per plant exhibited high negative and significant direct effect effect and their respective correlation coefficient value was also highly negative. While, pseudostem girth had medium negative direct effect on corm weight per plant, displaying reduction of yield due to more number of side tubers. Similar approach as mentioned in the above discussion was considered by Cheema *et al.* (2007) [2]; Mukherjee *et al.* (2016) [8]; Eze and Nwofia (2016) [5] in taro, Singh and Tripathi (2012) [14]; Paul and Bari (2013) [10] in elephant foot yam, Tsegaye *et al.* (2007) [16]; Solankey *et al.* (2015) [15]; Sahu *et al.* (2017) [12]; Dash *et al.* (2015) [3]; Yahaya *et al.* (2015) [17] in sweet potato, Rao *et al.* (2017) [11]; Mulualem *et al.* (2013) [9] in cassava, Fantwah *et al.* (2014) [6] in tannia.

Conclusion

On the basis of correlations and path analysis we concluded that the characters, pseudostem girth, pseudostem length, chlorophyll content, leaf canopy diameter, days to maturity were proved to be the outstanding characters influencing corm weight in elephant foot yam and they can serve as marker indicator characters for improvement in corm weight and need to be given importance in selection to achieve the higher corm weight.

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