

Assessment of Genetic Variability, Correlation and Path Coefficient Analysis In Taro (*Colocasia Esculenta* L. Schott. Var. *Antiquorum*) Germplasm

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Abstract

For getting the maximum productivity, detailed information about genetic variability, heritability, genetic advance, correlation and path coefficient of various quantitative traits and their contribution towards yield is essential. Therefore, an investigation was conducted to evaluate 45 germplasms of *Colocasia* for 19 quantitative traits. The field experiment was conducted at Govind Ballabh Pant University of Agriculture and Technology during March to October 2016. Intercultural practices were carried out as per recommendation. Observations were recorded for nineteen qualitative and quantitative characters. The data were analyzed statistically using proper statistical techniques for the different parameters i.e. their heritable variation, genetic advance, GCV, PCV, correlation and path coefficient. GCV and PCV were found maximum for weight of corms per plant. Length of corms showed maximum heritability whereas genetic gain was found highest for width of cormels. Cormels count per plant and weight of cormels plant⁻¹ showed highly positive significant correlation with yield. Cormels count per plant exerted maximum direct effect on yield. The cormels count, weight of cormels, weight of corms and leaf area index are the most important yield contributing characters so improvement in these characters will directly lead to increase in yield.

Keywords: Coefficient of variation, genetic advance, heritability, path coefficient, phenotypic correlation

Introduction

Taro (*Colocasia esculenta* (L.) Schottvar. antiquorum), $2n=28$, family Araceae is one of the important tuber crops which is grown for its edible corms and leaves (Coates *et al.*, 1998). In world it holds fifth rank in consumption. It is believed that the origin of domesticated taro is from 'wild type' *Colocasia esculenta* var. aquatilis, which is from North East India or South East Asia (Matthews, 1991). It is a vegetatively propagated crop and cultivation is through the corms and cormels. It is grown widely in Bihar, Punjab, Uttar Pradesh, WB, Assam, Uttarakhand, Orissa, AP and Tamil Nadu. The parts of taro i.e. corms, leaves and petioles is consumed in form of vegetable. It is considered as a rich source of carbohydrates, proteins, minerals (copper, iron, phosphorus, potassium, manganese, zinc) and different vitamins (ascorbic acid, niacin, pyridoxine, riboflavin thiamin) respectively (Coursey, 1968). Corm of taro is rich source of easily digestible starch and due to this its flour is considered as a good baby food. It helps in constipation problems and supplements of iron (Onwueme, 1999). In spite of its importance as a favoured edible tuber crop and large morphological variability in nature, very little research has been done on this crop in Uttarakhand, India. Nature and magnitude of variability and heritability of any character is a useful indicator to initiate the crop improvement programme (Dudley and Moll, 1969). For a given character, the major determining factors are the genetic variability, heritability and genetic advance in a population (Burton, 1952, Johnson *et al.* 1955) which in turn decides the strategy to be followed for further improvement of a trait in a particular population. Yield which displays a chain of positive and negative correlation among yield components is a complex trait with varying degree of effects. Knowledge of this relationship is must because it finally leads to choice of elite genotypes and finally ways to increased yield through inter related characters. Degree of correlation as well as path coefficient between the various characters contributory to total corm yield holds an important place in formulating suitable breeding strategy. The aim of this present study was to measure genetic variation, heritable variation, genetic advance, correlation and path coefficient of various quantitative and qualitative traits and their contribution towards yield in *Colocasia*.

Material and methods

The site of experiment is G.B.P.U.A. & T. during March to October 2016 located at Pantnagar, U.S. Nagar, Uttarakhand. Pantnagar is situated in the Tarai region (humid subtropical climate) of Shivalik hills of Himalayan region. The location of experimental site is of 29.5°N Lat., 79.3°E

long and 243.84 meters MSL is altitude. The soil having pH 7.0 is clay-loam in nature. The maximum temperature in area ranged from 32°C to 42°C and minimum temperature from 3°C to 14°C.

A total of 45 genotypes including three checks collected from different parts of North India (Uttarakhand, Bihar, Uttar Pradesh and Himanchal Pradesh) and maintained at Vegetable Research Centre (Table 1) laid out in Augmented block design (This design is very useful in testing of a huge number of germplasm when the amount of planting material is very limited and due to this replication is not practically possible) having 6 blocks. In each block there were 7 genotypes along with three checks and each plot having 1 row of 3 meter long.

Normal cultivation practices were adopted to raise the healthy crops. Observations were recorded on nineteen yield and yield contributing traits, namely, days to sprouting, diameter of plants (cm), leaf area index, leaf breadth (cm), leaf length (cm), length of corms (cm), length of cormels (cm), number of leaves per plant, plant height (cm), cormels count, weight of corms (g), weight of cormels (g), width of corms (cm), width of cormels (cm), yield (t/ha), specific gravity (g/cm^3), starch content (%), dry matter (%) and vitamin C content (mg/100g). The mean of the data on different characteristics were used for further analysis. The data were examined statistically for their mean, range, heritable variation and genetic advance, genotypic and phenotypic coefficient of variability, correlation and path coefficient analysis using OPSTAT software. The analysis of data was carried out to compute the variance components and coefficient of variation as per Burton and DeVane, (1952). Heritability was interpreted by formula given by Hanson *et al.* (1956). The genetic advance at 5% level of significance was performed by formula given by Robinson *et al.* (1949). In the present study Genotypic and phenotypic correlations between all the characters were done according to method given by Searle (1961).

Results and Discussion

Coefficient of variability: A significant difference was reported for all the traits (Table 1) which can be confirmed by findings of Kumar *et al.* (2017). The higher value of phenotypic coefficient of variation was reported for all the traits in comparison to the equivalent genotypic coefficient of variation (GCV) (Table 3). This was because of the both genotypic and environmental variability included at level of phenotypic variability and environment plays an important part in performance of these traits. This result shows similarity with Kumar *et al.* (2001), Pandey *et al.*

(2009), Sarma *et al.* 2010, Raichal Anil *et al.* (2011) for elephant foot yam, Alam *et al.* (2014) for greater yam and Poddar *et al.* (2015), Kumar *et al.* (2017) in taro. High GCV and PCV was observed for weight of corms per plant (34.39 and 41.13), respectively whereas, leaf length showed lowest GCV and PCV (5.95 and 10.35) respectively. High GCV and PCV was reported for weight of corms plant⁻¹ (Sarma *et al.* 2010), weight of cormels plant⁻¹ (Singh *et al.* 2003; Pandey *et al.* 2009), cormels count per plant (Pandey *et al.* 2009; Poddar *et al.* 2015; Mukherjee *et al.* 2016). The lowest value of GCV and PCV was reported for leaf length, leaf breadth and dry matter content. This result was also observed by Mulualet *et al.* (2013). Result revealed that traits such as weight of cormels plant⁻¹, weight of corms plant⁻¹ and number of cormels plant⁻¹ had quite high GCV and PCV values and indicate sample variability available with a scope for selection to operate in these traits. This present findings are in conformity with the findings of Mukherjee *et al.* 2016. Higher PCV together with lower ECV than GCV for characters indicates the presence of genetic variability. Environment as well as interactions at different levels was moderately influenced by the phenotypic variations. This result is in accordance with Paul *et al.* (2011).

Heritability and genetic advance: With the help of genotypic and phenotypic coefficient of variation alone, it is not possible to determine the heritable variation (Johnson *et al.*, 1955 and Panse, 1957). So Broad sense heritability provides a good mean for determining the effect of selection on phenotypic expression of characters. Broad sense heritability and genetic gain was given in Table 3. Length of corms (98.14) showed maximum heritability followed by dry matter content (97.72). Genetic gain was found highest for width of cormels (66.02) followed by length of corms (60.39). In general, heritability gives the idea whether the trait is under strong or partial genetic control and further will the selection will be effective or partitioning of variance needs to be done for selecting better segregants. Dry matter content showed the high heritability. This observation supported by Mukherjee *et al.* (2016). High genetic advance as percentage of mean was found for cormels count per plant. Present observations support the results of Singh *et al.*, (2003); Cheema *et al.* (2007). Notable improvement could be made in characters by prediction of traits having high heritability combined with high genetic advance and it gives better information rather than the heritability alone and on basis of which selection of best individual is done. It is mentioned by Johnson *et al.* (1955) and Saha *et al.* (1990). High heritability and high

genetic advance was reported for days to sprouting, length of corms, length of cormels, width of corms, width of cormels, dry matter content and starch content. Therefore, germplasm which comprised maximum value of these characters could be evaluated in different trials held in different locations and after that directly introduced as a variety or include in crossing programmes as a parent for trait specific breeding. Those traits governed by additive genetic components having high heritability and high genetic advance could be improved more easily through selection in spite of characters governed by non-additive components having low heritability and low genetic advance (Sarma *et al.* 2010). Those characters which are greatly affected by the environment, showed high heritability followed by low genetic advance as well as low heritability and low genetic advance and for these characters selection is ineffective. Leaf length showed low heritability and low genetic advance (33.01 cm, 7.04 cm). It means that selection for leaf length would be ineffective. Similar studies have been reported by Mukherjee *et al.* (2016) in *Colocasia*. Corm length showed maximum heritability and high genetic advance. Similar result supports the findings of Paul *et al.* (2011) and Mulua and Weldemichael (2013) in yam. Similar finding was for days to sprouting in yam (Alam *et al.* 2014).

Correlation analysis: For a plant breeder, correlation between different characters is very important as it gives knowledge about the effect of different characters on phenotypic selection. Furthermore, once the highly significant positive correlation is established between yield and yield contributing characters, it would make selection process easier (Table 4). Weight of cormels plant⁻¹ (0.5910**) Cormels count per plant (0.5768**), indicates a highly positive correlation with yield. In present study, plant height showed highly significant positive correlation with plant diameter indicates that the gene controlling both parameters are closely related which is similar to results obtained by Orji and Ogbonna (2015). Cormels count per plant and weight of cormels plant⁻¹ showed positive correlation with yield. This implies that an increase in cormels count per plant or weight of cormels plant⁻¹ increases the yield and selection of plants with improved no. of cormels and weight of cormels will result in a variety with increased yield. Similar study is supported by Singh *et al.* (1992); Dwivedi and Sen (1999); Cheema *et al.* (2007) and Pandey *et al.* (2009). Number of leaves per plant showed negative correlation with yield. This result is supported by Velayudhan *et al.* (2000). Weight of corms plant⁻¹ one of the important characters, showed highly positive significant correlation with length

of corms. This result is favoured by Velayudhan *et al.* (2000) and Yadav *et al.* (2007). Cormels count per plant demonstrates significant correlation with weight of corms plant⁻¹. This study is also supported by Sarma *et al.* (2010).

Path Analysis: The knowledge of correlation causes confusion in the minds of plant breeder as correlation between two characters is affected by third common character. In such cases path analysis provides an option of direct and indirect effects of various characters through correlation coefficient (Table 5). Direct effect: Cormels count per plant followed by exerted maximum direct effect on yield. Cormels count per plant (0.4099), weight of corms per plant (0.4063), weight of corms plant⁻¹ (0.3738), leaf area index (0.1832) has direct positive effect on yield. This finding is supported with result of Velayudhan *et al.* (2000), Yadav *et al.* (2007), Sarma *et al.* (2010) respectively. Therefore, attention should be paid on selection based on these traits for total yield improvement in *Colocasia*.

Indirect effect: Days to sprouting, number of leaves per plant, cormels count per plant, length of corms and length of cormels via weight of cormels per plant (0.0440), (0.0080), (0.1430), (0.0490), and (0.0035), respectively exerted indirect effect on yield. Diameter of plant, weight of corms plant⁻¹ and width of corms made positive indirect effect on yield via length of corms (0.0040), (0.1587) and (0.0489) respectively. Leaf breadth, leaf area index, cormels count per plant, width of corms exerted indirect negative effect on yield via days to sprouting (-0.0128), (-0.0205), (-0.1096) and (-0.0145) respectively while plant height and leaf length exerted indirect effect towards yield via leaf breadth (-0.0671) and (-0.0071) respectively. Correlation and direct effects values were almost equal with the traits, plant height, diameter of plant, number of leaves per plant, LAI, Cormels count per plant, weight of cormels per plant, length of corm, specific gravity and vitamin C content which indicated the true relationship of these traits with yield exists and direct selection for these traits will be useful for selection. The value of residual effect was fairly low *i.e.* 0.509 at phenotypic level which supports the statement of Yadav *et al.* (2010). The contribution of residual factors at phenotypic level was quite low indicating that most of variation in yield was explained by these variables and the effect of other factors was almost negligible.

Conclusion

Based on variability, correlation and path coefficient study, it can be concluded that cormels count per plant, weight of cormels per plant, weight of corms per plant and leaf area index are the important characters that plays an important role in increasing the yield of Taro, soimprovement in these traits plays an important role in for yield improvement.

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Table 1: List of forty-five taro germplasm under study along with checks

S.No.	Genotypes	Place of Origin	S.No.	Genotypes	Place of Origin
1.	PA-1	Lucknow, U.P.	23.	PA-42	Chakrata, Dehradun, Uttarakhand
2.	PA-3	Rudrapur, Uttarakhand	24.	NDC-6	Kumarganj, Faizabad, U.P.
3.	PA-4	Dharchula, Pithoragarh, Uttarakhand	25.	NDC-7	Kumarganj, Faizabad, U.P.
4.	PA-5	Suyalbadi, Nanital,	26.	NDC-9	Kumarganj,

		Uttarakhand			Faizabad, U.P.
5.	PA-8	Kiccha, Uttarakhand	27.	NDC-15	Kumarganj, Faizabad, U.P.
6.	PA-9	Dehradun, Uttarakhand	28.	NDC-18	Kumarganj, Faizabad, U.P.
7.	PA-10	Lalkuan, Uttarakhand	29.	NDC-26	Kumarganj, Faizabad, U.P.
8.	PA-12	Nagina, Uttarakhand	30.	NDC-44	Kumarganj, Faizabad, U.P.
9.	PA-16	PantaSahib, Himanchal Pradesh	31.	NDC-54	Kumarganj, Faizabad, U.P.
10.	PA-20	Tehri Garhwal, Uttarakhand	32.	NDC-68	Kumarganj, Faizabad, U.P.
11.	PA-22	Haldwani, Uttarakhand	33.	NDC-71	Kumarganj, Faizabad, U.P.
12.	PA-23	Kaladhungi, Haldwani, Uttarakhand	34.	NDC-85	Kumarganj, Faizabad, U.P.
13.	PA-24	Ramnagar, Uttarakhand	35.	Saatmukhi	Kumarganj, Faizabad, U.P.
14.	PA-28	Rudrapur, Uttarakhand	36.	KCS-2	Kumarganj, Faizabad, U.P.
15.	PA-29	Nakot, Pithoragarh, Uttarakhand	37.	KCS-3	Kumarganj, Faizabad, U.P.
16.	PA-30	Dholi, Bihar	38.	PKS-1	Kumarganj, Faizabad, U.P.
17.	PA-33	Pithoragarh, Uttarakhand	39.	Aryan CA-1	Kumarganj, Faizabad, U.P.
18.	PA-35	Okhapani, Pithoragarh, Uttarakhand	40.	MuktaKeshi	Dholi, RAU, Bihar
19.	PA-38	Rudrapur, Uttarakhand	41.	Saharasmukhi	Dholi, RAU, Bihar
20.	PA-39	Pantnagar, Uttarakhand	42.	Taliya	Dholi, RAU, Bihar
21.	PA-40	Varanasi, U.P.	43.	NDC-1 (Check)	Kumarganj, Faizabad, U.P.
22.	PA-41	Chakrata, Dehradun,	44.	NDC-2 (Check)	Kumarganj,

		Uttarakhand			Faizabad, U.P.
			45.	Rajendra Arabi (Check)	Dholi, RAU, Bihar

Table 2: Analysis of variance for nineteen quantitative characters in taro

S.No.	Characters	Mean sum of square		
		Block (5)	Check (2)	Error (10)
1.	Days to sprouting	3.47	468.41**	106.12
2.	Plant height (cm)	3.84	68.43**	2.27
3.	Diameter of plant (cm)	0.48	9.64**	4.05
4.	No. of leaves per plant	6.81	1.89**	0.53
5.	Leaf length (cm)	1251.69	16.39*	8.26
6.	Leaf breadth (cm)	110.39	20.96**	3.81
7.	Leaf area index	1645865.0	40811.73*	21736.44
8.	Cormels count per plant	3.15	40.21*	22.56
9.	Weight of corms per plant (g)	30960.43	8661.46**	1534.56
10.	Weight of cormels plant ⁻¹ (g)	20773.91	21367.39**	4490.72
11.	Length of corms (cm)	0.08	6.23**	0.06
12.	Width of corms (cm)	0.18	1.72**	0.09
13.	Length of cormels (cm)	1.18	4.58**	0.25
14.	Width of cormels (cm)	0.51	0.32**	0.02
15.	Specific gravity(gm/cm ³)	0.03	0.12**	0.03
16.	Dry matter content (%)	0.96	38.55**	0.44
17.	Starch content (%)	0.95	26.41**	0.32
18.	Vitamin C content (mg/100g)	5.04	4.78**	2.25
19.	Yield (t/ha)	145.64	55.48**	14.66

Table 3: Estimation of coefficient of variation and other genetic parameters in taro

S.No.	Characters	General mean	Range	Coefficient of variation			Heritability (%)	Genetic advance	G.A. as % of mean
				GCV	PCV	ECV			
1.	Days to sprouting	27.97	18.06-43.72	20.56	21.26	5.39	93.57	11.46	40.97
2.	Plant height (cm)	119.94	76.49-151.11	11.22	14.13	8.59	63.06	22.02	18.36
3.	Diameter of plants (cm)	11.50	7.58-16.55	14.53	22.75	17.51	40.79	2.19	19.12
4.	No. of leaves per plant	6.54	4.19-8.49	12.47	16.69	11.09	55.85	1.26	19.21
5.	Leaf length (cm)	33.93	25.91-37.96	5.95	10.35	8.47	33.01	2.39	7.04
6.	Leaf breadth (cm)	30.17	23.03-36.91	9.71	11.66	6.47	69.25	5.02	16.64
7.	Leaf area index	779.00	404.28-1043.42	12.54	22.70	18.93	30.50	111.10	14.26
8.	Cormels count per plant	14.68	7.09-25.34	20.23	38.15	32.35	28.12	3.24	22.09
9.	Weight of corms per plant (g)	173.58	75.63-368.74	34.39	41.13	22.57	69.90	102.81	59.23
10.	Weight of cormels plant ⁻¹ (g)	330.13	164.76-610.35	27.83	34.44	20.29	65.27	152.88	46.31
11.	Length of corms (cm)	5.94	3.13-9.97	29.59	29.87	4.07	98.14	3.58	60.39
12.	Width of corms (cm)	4.31	2.03-6.25	20.95	22.14	7.16	89.55	1.76	40.84
13.	Length of cormels (cm)	5.29	3.40-13.03	27.81	29.36	9.41	89.73	2.87	54.27
14.	Width of cormels (cm)	1.73	0.32-1.97	34.24	36.59	12.88	87.61	0.75	66.02
15.	Specific gravity(gm/cm ³)	1.37	1.06-2.36	15.35	19.73	12.39	60.57	0.34	24.61
16.	Dry matter content (%)	27.85	21.18-41.70	15.67	15.86	2.39	97.72	8.89	31.92
17.	Starch content (%)	21.65	16.09-33.15	16.68	16.89	2.62	97.58	7.35	33.94
18.	Vitamin C content (mg/100g)	6.33	2.87-9.31	17.77	29.63	23.70	36.00	1.39	21.97
19.	Yield (t/ha)	27.99	15.34-40.72	16.14	21.15	13.68	58.21	7.10	25.37

Table 4: Phenotypic correlation coefficient between different characters

	X ₁	X ₂	X ₃	X ₄	X ₅	X ₆	X ₇	X ₈	X ₉	X ₁₀	X ₁₁	X ₁₂	X ₁₃	X ₁₄	X ₁₅	X ₁₆	X ₁₇	X ₁₈	X ₁₉
X ₁	1.0000	0.0046	-0.0379	0.1717	-0.0821	-0.1483	-0.1120	-0.2674*	0.0928	-0.2982**	0.2420*	-0.1024	0.0269	-0.1885	0.0280	-0.0352	-0.0324	-0.0070	-0.4333
X ₂		1.0000	0.4486**	0.0524	0.2680*	0.4838**	0.3633**	-0.1932	0.0815	0.0115	0.1934	0.1006	-0.0157	0.1366	0.0563	0.2596*	0.2618	0.0022	-0.1253
X ₃			1.0000	0.0997	0.1522	0.1888	0.1481	-0.0624	-0.0127	0.0455	-0.0996	0.0792	0.0150	0.1596	-0.0204	0.2950**	0.2909	-0.0160	-0.0657
X ₄				1.0000	0.2467*	-0.0007	0.1511	0.0377	0.1621	-0.0794	0.0003	-0.0031	0.1377	-0.1123	0.1461	-0.0428	-0.0399	-0.0445	-0.0767
X ₅					1.0000	0.6910**	0.9344**	-0.0731	-0.0124	0.2720**	-0.0658	0.0753	0.0550	0.2599*	-0.0333	0.0855	0.0878	-0.1243	0.2385
X ₆						1.0000	0.8672**	-0.1095	-0.1054	0.2512*	0.0320	0.1326	0.0111	0.1953	-0.0905	0.1096	0.1070	-0.0765	0.1994
X ₇							1.0000	-0.0686	-0.0162	0.2707**	-0.0216	0.1137	0.0446	0.2518*	-0.0364	0.1110	0.1114	-0.1048	0.2671
X ₈								1.0000	-0.1529	0.3489**	-0.2105*	0.0638	-0.1575	0.1362	0.1297	-0.0985	-0.0976	0.1161	0.5768**
X ₉									1.0000	-0.2903**	0.3906**	0.1293	0.0164	-0.3670**	0.1417	0.2436*	0.2476	-0.0075	0.1183
X ₁₀										1.0000	-0.3348**	0.0173	-0.1792	0.2213*	-0.1509	-0.0676	-0.0684	0.0440	0.5910**
X ₁₁											1.0000	0.3439**	0.1104	-0.2207*	0.1125	-0.1035	-0.0947	0.1012	-0.2036
X ₁₂												1.0000	0.1199	0.3166**	0.0330	-0.0621	-0.0576	0.2468*	0.2387
X ₁₃													1.0000	-0.0731	0.1510	-0.0691	-0.0703	-0.0417	-0.1631
X ₁₄														1.0000	-0.1931	-0.0016	0.0014	0.0589	0.1754
X ₁₅															1.0000	-0.1068	-0.1091	-0.1435	-0.0755
X ₁₆																1.0000	0.9991**	-0.1252	-0.0218
X ₁₇																	1.0000	-0.1245	-0.0211
X ₁₈																		1.0000	0.1928
X ₁₉																			1.0000

X₁= Days to sprouting X₂ = Plant height (cm), X₃ = Diameter of plant (cm), X₄= No. of leaves per plant, X₅= Leaf length (cm), X₆= Leaf breadth (cm), X₇=Leaf area index, X₈= cormels count per plant, X₉= Weight of corms per plant (g), X₁₀= Weight of cormels plant⁻¹(g), X₁₁ = Length of corms (cm), X₁₂= Width of corms (cm), X₁₃= Length of cormels (cm), X₁₄= Width of cormels (cm), X₁₅= Specific gravity(gm/cm³), X₁₆ = Dry matter content (%), X₁₇= Starch content (%), X₁₈= Vitamin C content (mg/100g), X₁₉= Yield (t/ha)

**= Significant at 1% level of significance

*= Significant at 5% level of significance

Table 5: Path coefficient analysis for different pairs on yield

	X ₁	X ₂	X ₃	X ₄	X ₅	X ₆	X ₇	X ₈	X ₉	X ₁₀	X ₁₁	X ₁₂	X ₁₃	X ₁₄	X ₁₅	X ₁₆	X ₁₇	X ₁₈
X ₁	-0.1474	-0.0007	0.0056	-0.0253	0.0121	0.0219	0.0165	0.0394	-0.0137	0.0440	-0.0357	0.0151	-0.0040	0.0278	-0.0041	0.0052	0.0048	0.0010
X ₂	-0.0006	-0.1387	-0.0622	-0.0073	-0.0372	-0.0671	-0.0504	0.0268	-0.0113	-0.0016	-0.0268	-0.0139	0.0022	-0.0189	-0.0078	-0.0360	-0.0363	-0.0003
X ₃	0.0015	-0.0181	-0.0404	-0.0040	-0.0062	-0.0076	-0.0060	0.0025	0.0005	-0.0018	0.0040	-0.0032	-0.0006	-0.0064	0.0008	-0.0119	-0.0118	0.0006
X ₄	-0.0173	-0.0053	-0.0100	-0.1005	-0.0248	0.0001	-0.0152	-0.0038	-0.0163	0.0080	0.0000	0.0003	-0.0138	0.0113	-0.0147	0.0043	0.0040	0.0045
X ₅	0.0008	-0.0027	-0.0016	-0.0025	-0.0102	-0.0071	-0.0095	0.0007	0.0001	-0.0028	0.0007	-0.0008	-0.0006	-0.0027	0.0003	-0.0009	-0.0009	0.0013
X ₆	-0.0128	0.0417	0.0163	-0.0001	0.0595	0.0861	0.0747	-0.0094	-0.0091	0.0216	0.0028	0.0114	0.0010	0.0168	-0.0078	0.0094	0.0092	-0.0066
X ₇	-0.0205	0.0665	0.0271	0.0277	0.1712	0.1589	0.1832	-0.0126	-0.0030	0.0496	-0.0040	0.0208	0.0082	0.0461	-0.0067	0.0203	0.0204	-0.0192
X ₈	-0.1096	-0.0792	-0.0256	0.0155	-0.0300	-0.0449	-0.0281	0.4099	-0.0627	0.1430	-0.0863	0.0262	-0.0646	0.0558	0.0531	-0.0404	-0.0400	0.0476
X ₉	0.0377	0.0331	-0.0051	0.0659	-0.0050	-0.0428	-0.0066	-0.0621	0.4063	-0.1180	0.1587	0.0525	0.0067	-0.1491	0.0576	0.0990	0.1006	-0.0031
X ₁₀	-0.1115	0.0043	0.0170	-0.0297	0.1017	0.0939	0.1012	0.1304	-0.1085	0.3738	-0.1252	0.0065	-0.0670	0.0827	-0.0564	-0.0253	-0.0256	0.0165
X ₁₁	-0.0354	-0.0283	0.0146	0.0000	0.0096	-0.0047	0.0032	0.0308	-0.0571	0.0490	-0.1462	-0.0503	-0.0161	0.0323	-0.0164	0.0151	0.0138	-0.0148
X ₁₂	-0.0145	0.0143	0.0113	-0.0004	0.0107	0.0188	0.0162	0.0091	0.0184	0.0025	0.0489	0.1421	0.0170	0.0450	0.0047	-0.0088	-0.0082	0.0351
X ₁₃	-0.0005	0.0003	-0.0003	-0.0027	-0.0011	-0.0002	-0.0009	0.0031	-0.0003	0.0035	-0.0021	-0.0023	-0.0194	0.0014	-0.0029	0.0013	0.0014	0.0008
X ₁₄	-0.0027	0.0020	0.0023	-0.0016	0.0037	0.0028	0.0036	0.0020	-0.0053	0.0032	-0.0032	0.0045	-0.0010	0.0143	-0.0028	0.0000	0.0000	0.0008
X ₁₅	-0.0017	-0.0034	0.0012	-0.0088	0.0020	0.0055	0.0022	-0.0078	-0.0086	0.0091	-0.0068	-0.0020	-0.0091	0.0117	-0.0604	0.0065	0.0066	0.0087
X ₁₆	0.0074	-0.0548	-0.0623	0.0090	-0.0181	-0.0231	-0.0234	0.0208	-0.0514	0.0143	0.0218	0.0131	0.0146	0.0003	0.0225	-0.2112	-0.2110	0.0264
X ₁₇	-0.0054	0.0435	0.0483	-0.0066	0.0146	0.0178	0.0185	-0.0162	0.0411	-0.0113	-0.0157	-0.0096	-0.0117	0.0002	-0.0181	0.1658	0.1660	-0.0207
X ₁₈	-0.0008	0.0003	-0.0018	-0.0051	-0.0142	-0.0087	-0.0120	0.0133	-0.0009	0.0050	0.0116	0.0282	-0.0048	0.0067	-0.0164	-0.0143	-0.0142	0.1142
X ₁₉	-0.4333	-0.1253	-0.0657	-0.0767	0.2385	0.1994	0.2671	0.5768	0.1183	0.5910	-0.2036	0.2387	-0.1631	0.1754	-0.0755	-0.0218	-0.0211	0.1928

X₁= Days to sprouting X₂ = Plant height (cm), X₃ = Diameter of plants (cm), X₄= No. of leaves per plant, X₅= Leaf length (cm), X₆= Leaf breadth (cm), X₇=Leaf area index, X₈= Cormels count per plant, X₉= Weight of corms per plant (g), X₁₀= Weight of cormels plant⁻¹(g), X₁₁ = Length of corms (cm), X₁₂= Width of corms (cm), X₁₃= Length of cormels (cm), X₁₄= Width of cormels (cm), X₁₅= Specific gravity(gm/cm³), X₁₆ = Dry matter content (%), X₁₇= Starch content (%), X₁₈= Vitamin C content (mg/100g), X₁₉= Yield (t/ha)

Residual effect=0.5019