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GENETIC VARIABILITY AND ASSOCIATION STUDIES IN SWEET POTATO [*IPOMOEA BATATAS* (L.) LAM]

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ABSTRACT
Sweet potato is nutritionally and economically very important crop. It is highly heterozygous; there is extensive variability within the species, which is available for exploitation by plant breeders. Therefore, the present experiment was conducted in Randomized Block Design with three replications comprising twenty nine germplasm plus one check variety of sweet potato for the purpose. The results showed that the mean sum of square due to treatments was highly significant for all the characters studied. High estimate of PCV (33.67) and GCV (33.35) were observed for the characters leaf area followed by yield per plant and leaves per vine. High heritability coupled with high genetic advance were recorded in leaf area (98% and 68%) followed by dry matter (97% and 22.64%) and yield per plant (78% and 35%), considerable variability exists within the genotypes of sweet potato and length of tuber, tubers per plant and length of vine showed positive correlations with maximum direct effect while girth of tuber, length of vine exerted highest indirect positive effect via length of tuber on tuber yield. Therefore, these characters can be considered for selection of high yielding genotypes on the basis of their phenotypic data.

INTRODUCTION

Sweet potato [*Ipomoea batatas* (L.) Lam], is nutritionally and economically very important crop belonging to family convolvulaceae. It is cultivated largely for its starchy roots, which can provide nutrition and energy. This plant has assumed great significance in recent year as a health food due to various bioactive principles in the roots. Due to high heterozygosity and cross pollination, this crop shows continuous variation in many traits. Since it is highly heterozygous, there is extensive variability within the species, which is available for exploitation by plant breeders (Jones, 1986). Collection of genotypes and estimation of genetic variability is a basic step in each crop improvement program. Knowledge of variability in the germplasm will allow breeders to better understand the evolutionary relationships between germplasm, and to develop strategies to incorporate desirable traits in breeding programs (Bretting and Widrlencher, 1995; Jadeja *et al.,* 2016). Correlation studies give an idea about the positive and negative associations of different characters with yield and also among themselves. However, the nature and extent of contribution of these characters towards yield is not obtained. Hence, path coefficient analysis was used to make partition of the correlation coefficient of the different characters studied to know direct and indirect effects on yield. The information obtained helps in giving proper weightage to the various characters during selection or other breeding programme so that the improvement of desirable traits can be achieved effectively (Meena and Bahadur, 2015). Since the success of any breeding programme depends upon the availability of information on genetic variability, association between any two characters, and in their direct and indirect effects on yield. Therefore, the present study assumes importance considering very few reports available in tuber crop like sweet potato on the aspect of genetic variability and association studies.

MATERIALS AND METHODS

Experiment was conducted at Main Experimental Station of Vegetable Science, Narendra Nagar (Kumarganj), Faizabad (U.P.) during last week of October, 2015 to 1st week of March, 2016. The soil type is sandy loam. The annual rainfall is about 1270 mm. The climate of district Faizabad is semi-arid with hot summer and cold winter.

The experimental materials for the present investigation comprised 30 genotypes (NDSP-58, NDSP -59, NDSP -60, NDSP -61, NDSP-62, NDSP-63, NDSP-64, NDSP-65, NDSP -66, NDSP -67, NDSP -68, NDSP -69, NDSP -70, NDSP -71, NDSP -72, NDSP -73, NDSP -74, NDSP -75, NDSP -76, NDSP -77, NDSP -78, NDSP -79, NDSP -80, NDSP -81, NDSP -82, NDSP -83, NDSP -84, NDSP -85, NDSP -86) of sweet potato including one check variety NDSP-9 collected from different places of India and maintained at main experimental station of the Department of Vegetable Science, N.D. University of Agriculture & Technology, Narendra Nagar, (Kumarganj), Faizabad (U.P.). Each genotype was planted on 2.4 m long and 1.8 m wide plot consisting five rows which accommodated six plants per row and thirty plants per plot. A distance of 60 cm maintained between the plots. Vine cutting of 25 cm upper portions (Rajendran *et al.,* 2001) from sweet potato nursery were taken and vertically planted on in the well prepared field at 60 cm × 30 cm spacing on the ridges. The intercultural operations were done timely to raise a good crop.

For each character under study, data were recorded on five randomly taken plants from each plot and expressed on plant basis. The mean of five plants used for statistical analyses. Observation of important characters *viz*., days to sprouting, leaf area (cm^2), length of vine (cm), number of vine per plant, number of leaves per vine, internodal length (cm), length of tubers (cm), girth of tubers (cm), number of tubers per plant, yield per plant (g), yield per hectare (q), dry matter in tuber (%), total soluble solids (TSS) were recorded.

The nature of association among different characters was studied by using analysis of variance by Panse and Sukhatme (1967). Genetic variability by Burton and de Vane (1953), Heritability in broad sense (Hanson *et al.,* 1956), Correlation coefficient by Al-Jibouri *et al*., 1958, Path coefficient analysis by Dewey and Lu (1959).

RESULTS AND DISCUSSION

Highly significant results of analysis of variance were recorded for all the characters studied (Table 1). The results of estimates of genetic variability, heritability, genetic advance for tubers yield per plant and other characters are presented in Table 2. The PCV was higher than GCV for all the characters studied showing that all the traits were highly influenced by environment. However differences between them were not of high magnitude. A high estimates of genotypic and phenotypic coefficient of variation were observed for leaf area (33.67, 33.35) followed by yield per plant (21.78, 19.26), leaves per vine (20.53, 18.13). Earlier similar findings were reported in sweet potato by Teshome *et al*., 2004. While, low PCV (8.04) and GCV (3.91) were noticed for days to sprouting, suggesting this trait to be least different among genotypes.

The effectiveness of selection for any character depends not only the extent of genetic variability but also in the extent to

Table 1: Analysis of variance (mean sum of squares) for 13 characters in sweet potato

S.No	Characters	Source of variation (Mean sum of squares) Replication	Treatment	Error
	d.f.	2	29	58
1	Days to Sprouting	0.05	0.60**	0.31
2	Leaf area (cm^2)	1.98	319.80**	2.10
3	Length of vine (cm)	46.16	405.36**	35.29
4	Vines per plant	0.32	0.56**	0.14
5	Leaves per vine	16.75	602.09**	51.75
6	Internodal length (cm)	0.01	0.24**	0.04
7	Length of tuber (cm)	0.99	9.66**	0.75
8	Girth of tuber (cm)	1.37	3.92**	0.51
9	Tubers per plant	0.09	1.42**	0.10
10	Yield per plant (g)	403.46	13929.12**	1182.02
11	Yield per hectare (q)	126.04	4368.81**	370.77
12	Dry Matter (%)	0.20	30.02**	0.34
13	T.S.S.	0.01	3.09**	0.08

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

Table 2: Estimates of range, grand mean, phenotypic (PCV), genotypic (GCV), environmental (ECV) coefficient of variation, heritability in broad sense, genetic advance and genetic advance in percent of mean for thirteen character in sweet potato

S.No.	Characters	Range Min.	Max.	Grand mean	Variability PCV (%)	GCV (%)	ECV (%)	Heritability in broad sense (%) (h^2_{bs})	Genetic Advance	Genetic advance in per cent of mean
1	Days to sprouting	7.33	8.67	7.91	8.04	3.91	7.02	24.0	0.31	3.92
2	Leaf area (cm^2)	18.10	57.50	30.87	33.67	33.35	4.69	98.0	20.99	68.02
3	Length of vine (cm)	46.33	102.50	68.14	18.48	16.30	8.72	78.0	20.18	29.61
4	Vines per plant	4.33	6.33	5.64	9.37	6.60	6.65	50.0	0.54	9.59
5	Leaves per vine	51.33	113.67	74.71	20.53	18.13	9.63	78.0	24.64	32.98
6	Internodal length (cm)	2.60	3.60	2.99	11.06	8.61	6.94	61.0	0.14	13.98
7	Length of tuber (cm)	12.00	19.37	14.24	13.55	12.10	6.08	80.0	3.17	22.28
8	Girth of tuber (cm)	8.13	13.77	11.03	11.64	9.67	6.48	69.0	1.82	16.54
9	Tubers per plant	3.67	6.67	5.06	14.55	13.13	6.27	81.0	1.23	24.40
10	Yield per plant (g)	258.23	534.0	338.41	21.78	19.26	10.16	78.0	118.78	35.10
11	Yield per hectare (q)	144.60	299.03	189.50	21.78	19.26	10.16	78.0	66.52	35.10
12	Dry matter (%)	21.77	34.00	28.14	11.36	11.18	2.06	97.0	6.37	22.64
13	T.S.S.	9.20	12.60	10.78	9.66	9.29	2.65	92.0	1.98	18.41

Table 3: Estimates of phenotypic(p) correlation coefficients among different characters in sweet potato

Characters		Leaf area (cm^2)	Length of vine (cm)	Vines per plant	Leaves per vine	Internodal length (cm)	Length of tuber (cm)	Girth of tuber (cm)	Tubers per plant	Dry matter (%)	T.S.S.	Correlation with yield per plant (g)
Days to sprouting	P	-0.245	-0.129	-0.107	0.099	-0.120	-0.162	-0.002	0.084	0.172	0.019	0.060
	G	-0.473	-0.416	-0.468	0.179	-0.478	-0.406	-0.130	0.096	0.269	-0.005	-0.081
Leaf area (cm^2)	P		0.183	0.008	-0.013	0.006	0.375*	0.024	0.134	-0.048	-0.104	0.365*
	G		0.217	0.025	-0.005	0.019	0.431	0.042	0.152	-0.047	-0.108	0.419
Length of vine (cm)	P			0.183	0.433*	0.531**	0.492**	0.345	-0.027	-0.250	-0.283	0.372*
	G			0.152	0.345	0.608	0.557	0.456	-0.093	-0.307	-0.327	0.460
Vines per plant	P				0.105	0.045	0.101	0.210	0.112	-0.179	-0.392*	0.202
	G				0.023	0.118	0.231	0.393	-0.025	-0.256	-0.574	0.376
Leaves per vine	P					0.376*	0.376*	0.177	-0.047	0.094	-0.241	0.349
	G					0.439	0.439	0.251	-0.149	0.094	-0.282	0.462
Internodal length (cm)	P						0.292	0.121	0.152	-0.087	-0.038	0.239
	G						0.319	0.082	0.209	-0.111	-0.066	0.294
Length of tuber (cm)	P							0.509**	-0.306	-0.069	-0.178	0.571**
	G							0.613	-0.345	-0.077	-0.192	0.664
Girth of tuber (cm)	P								-0.322	-0.252	-0.360*	0.450*
	G								-0.291	-0.298	-0.430	0.632
Tubers per plant	P									0.001	0.149	0.227
	G									-0.002	0.171	0.291
Dry matter (%)	P										0.459**	-0.006
	G										0.494	-0.019
T.S.S.	P											-0.282
	G											-0.317

*, ** - significant at 5 % and 1 % probability level, respectively.

Table 4: Direct (diagonal) and indirect effect of different characters on yield per plant (g) at phenotypic level in sweet potato

Characters	Days to sprouting	Leaf area (cm^2)	Length of vine (cm)	Vines per plant	Leaves per vine	Inter-nodal length (cm)	Length of tuber (cm)	Girth of tuber (cm)	Tubers per plant	Dry matter (%)	T.S.S.	Yield per plant (g)
Days to sprouting	0.085	-0.028	0.001	0.002	0.007	0.003	-0.079	-0.006	0.042	0.032	-0.004	0.059
Leaf area (cm^2)	-0.021	0.115	-0.001	-0.000	-0.001	-0.002	0.183	0.008	0.067	-0.009	0.023	0.364
Length of vine (cm)	-0.011	0.021	-0.007	-0.004	0.029	-0.012	0.241	0.112	-0.014	-0.047	0.063	0.371
Vines per plant	-0.009	0.001	-0.001	-0.021	0.007	-0.001	0.049	0.068	0.056	-0.034	0.087	0.202
Leaves per vine	0.008	-0.001	-0.003	-0.002	0.067	-0.008	0.184	0.058	-0.023	0.018	0.053	0.349
Internodal length (cm)	-0.010	0.008	-0.004	-0.001	0.025	-0.022	0.143	0.039	0.076	-0.016	0.008	0.238
Length of tuber (cm)	-0.014	0.043	-0.004	-0.002	0.025	-0.006	0.489	0.165	-0.153	-0.013	0.039	0.570
Girth of tuber (cm)	-0.000	0.003	-0.003	-0.005	0.012	-0.003	0.249	0.325	-0.161	-0.048	0.080	0.450
Tubers per plant	0.007	0.016	0.000	-0.002	-0.003	-0.003	-0.149	-0.105	0.501	0.000	-0.033	0.227
Dry matter (%)	0.015	-0.006	0.002	0.004	0.006	0.002	-0.035	-0.082	0.0006	0.188	-0.103	-0.006
T.S.S.	0.002	-0.012	0.002	0.008	-0.016	0.0001	-0.087	-0.117	0.0744	0.087	-0.223	-0.281

Residual effect = 0.5840

which it will be transferred from one generation to the other generation. In this context, the heritability was estimated in the present study, a high heritability was observed for leaf area (98%), dry matter (97%), total soluble solid (92%), tuber per plant (81%) and length of tuber (80%). This finding is also supported by the findings of Thiyagu *et al.* (2013). However, days to sprouting like PCV and GCV recorded low heritability (24%). While, high and low genetic advance was observed for yield per plant (118.78) and days to sprouting (0.14). High heritability coupled with high genetic advance was recorded for leaf area (98% and 68%) followed by dry matter (97% and 22.64%), yield per plant (78% and 35%) and length of vine (78% and 29%) in sweet potato were reported earlier (Sastry *et al.*, 2007, Chaudhary *et al.*, 2011, Madawal *et al.*, 2015), that revealed a role of additive gene action for the characters, and thus phenotypic selection for these characters will be effective in breeding programme. The phenotypic and genotypic correlation coefficient among various yield and its attributing characters (Table 3) revealed that tuber yield per plant was significantly positively correlated with length of tuber (0.571), girth of tuber (0.450), length of vine (0.372) and leaf area (0.365). Sahu *et al.* (2005) reported that tuber yield positive correlated with girth of tuber. Thus our findings suggest that selection of genotypes for the traits like length of tuber, girth of tuber, vine length and leaf area could be appropriate for higher yield.

Other traits like length of vine showed highly significant positive correlation with internodal length (0.531) and length of tuber (0.492). Length of tuber showed highly significant and positive correlation with girth of tuber (0.509). In our biochemical analysis, we found that T.S.S. was significantly positively correlated with dry matter (0.459), while a negative significant correlation was observed with vines per plant (-0.392) and girth of tuber (-0.360) (Table 3).

Path coefficient analysis is a tool to partition the observed correlation into direct and indirect effects on yield to components on tuber yield provides clearer picture of character association for formulating efficient selection strategy. Path coefficient analysis differs from simple correlation in that, it point out the cause and their relative importance, whereas, the later measures simply the mutual association ignoring the causation. In the present study, the path coefficient analysis

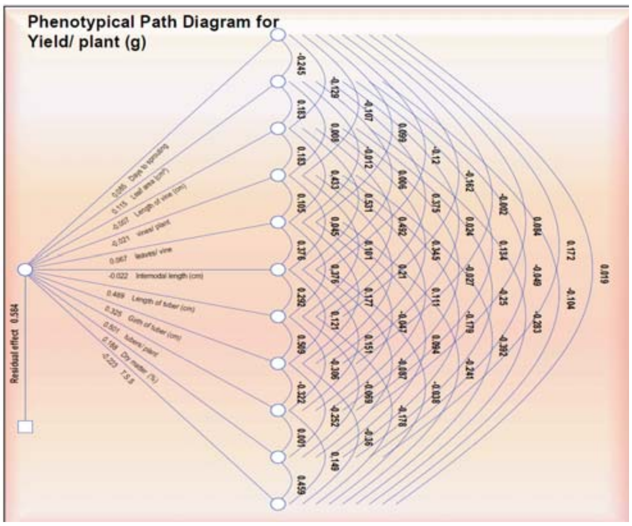

Figure 1: Direct and indirect effects of different characters on yield per plant (g) at phenotypic level in sweet potato

was estimated at phenotypic and genotypic level of thirty genotypes for different characters. At phenotypic levels, tuber per plant (0.501) followed by length of tuber (0.489) and girth of tuber (0.325) exerted high positive direct effect on tuber yield per plant which indicated that these are the main contributors to the tuber yield (Table 4). This finding was supported by the findings of Alam *et al*. (1998), Jha (2011) and Sasmal *et al*. (2015). Whereas, T.S.S (-0.223) showed maximum negative direct effect on tuber yield per plant followed by internodal length (-0.022), vines per plant (-0.021) and length of vine (-0.007). The other characters such as dry matter, leaf area, days to sprouting, and leaves per vine showed positively direct effect on yield per plant. Similar observation has also been reported by Yun *et al*. (2010) for leaves per vine. Girth of tuber (0.249) followed by length of vine (0.241), leaf area (0.183) and leaves per vine (0.184), exerted highest indirect positive effect on tuber yield per plant via length of tuber (Table 4; Figure 1). Similar findings had also been reported by Sahu *et al*. (2005) and Yun *et al*. (2010).

Hence this could be concluded that a considerable amount of variability exists within the genotypes of sweet potato investigated in the present study. The traits like length of tuber, tubers per plant and length of vine which showed positive correlations with maximum direct effect while girth of tuber, length of vine exerted highest indirect positive effect on tuber yield per plant, could be considered for selection of high yielding genotypes on the basis of their phenotypic data because these character were least influenced by environment.

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