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CORRELATION AND PATH STUDIES TO DEFINE TRAITS FOR IMPROVING MARKETABLE TUBER YIELD IN ADVANCED CLONAL PROGENIES OF POTATO (*SOLANUM TUBEROSUM* L)

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ABSTRACT

A field evaluation of clonal population was conducted under AICRP on potato, in Indira Gandhi Krishi vishwavidalaya, Raipur, (C.G.) to assess interrelationship among various yield and quality attributes in clonal progenies (bulk, F_1C_1, F_1C_2, & F_1C_3) of potato. Association analysis revealed that marketable tuber yield plant^{-1} exhibited highly significant and positive association with number of tubers plant^{-1}, tuber weight plant^{-1}, number of leaves plant^{-1} number of branches plant^{-1}, number of eyes tuber^{-1}, plant emergence percentage at 30 DAP, number of shoots, dry matter content of shoots and plant height. Path analysis revealed that, characters such as number of tubers plant^{-1}, tuber weight plant^{-1} and starch content revealed that the components showing high correlations with marketable tuber yield also had the high and positive direct effect on marketable tuber yield. This suggests that, the direct selection for number of tubers and tuber weight would likely to be effective in increasing marketable tuber yield.

KEYWORDS: Correlation, Path Coefficient Analysis, Clones, Potato

INTRODUCTION

Potato (*Solanum tuberosum* L.) belonging to family Solanaceae is one of the major crops of the world, especially in Europe and America; and the most important commercial food crop of India, ranked the fourth largest food-providing commodity, after maize, rice and wheat. Thus improving marketable yield is of utmost important. It is an important horticultural product used by both rich and poor. For planning a programme for genetic improvement of a crop plant, knowledge of inheritance of economic traits is vital, but, owing to a highly heterozygous autotetraploid nature of potato, and the possibility of identification of a potential clone at the F_1 and its further multiplication without the hazards of segregation have deterred potato geneticists, in elucidating the genetics of important economic traits. Limited information is available on genetics of important traits in potato. Correlation coefficient analysis measures the mutual relationship between two plant characters and determined component characters in which selection can be based for genetic improvement in yield (Roy and Singh, 2006). Whether the association of these characters due to their direct effect on yield or is a consequence of their indirect effects via other component characters may be answered through path coefficient analysis. The present study was therefore, undertaken to find out the relative importance of degree of association different yield contributing traits and their direct and indirect effects on the yield.

MATERIALS AND METHODS

The present study was undertaken at Horticultural Research farm, Department of Genetics and Plant Breeding, Indira Gandhi Krishi vishwavidayala, Raipur, (C.G.). The experimental material was grown under two experiments. (i)

Experiment I (18 bulks, 39 F_1C_1 and 86 F_1C_2 clonal progenies) was grown during *Rabi* 2007-08 and (ii) Experiment II (18 bulks, 43 F_1C_2 and 90 F_1C_2 clonal progenies) was grown during *Rabi* in 2008-09. The field layout was done in Randomized Complete Block design with three replications. The crop was raised with recommended cultural practices. Observations were recorded on five randomly selected plants for twelve yield attributing traits in Experiment I and for twelve yield attributing and four quality parameters in Experiment II. Finally the mean data was subjected to statistical analysis is using software SPAR-1 to perform analysis of variance, genotypic and phenotypic correlation coefficients as per Miller *et al*. (1958) and path coefficient per Singh and Choudhary (1985).

RESULTS AND DISCUSSIONS

The analysis of variance carried out for all the characters separately for clonal bulks and progenies revealed existence of substantial variability for all the characters except for dry matter content of shoots and tubers in bulks and F_1C_2 clonal progenies and dry matter content of tubers in F_1C_2 progenies of Experiment-I and unmarketable tuber yield plant^{-1} in clonal bulks, plant emergence per cent and unmarketable tuber yield plant^{-1} in F_1C_2 progenies and plant emergence per cent in F_1C_3 clonal progenies of Experiment-II suggesting substantial variability created for carrying out various analysis and inference in potato.

Correlation among marketable tuber yield and other yield components computed at both phenotypic and genotypic levels in experiment-I are presented in (Table 1). In experiment-I correlation coefficient analysis revealed that marketable tuber yield plant^{-1} exhibited a significant and positive association with number of tubers plant^{-1}, tuber weight plant^{-1} and number of leaves plant^{-1} in bulks, F_1C_1 and F_1C_2 clonal progenies; with number of branches plant^{-1} and number of eyes tuber^{-1} in bulks and F_1C_1 progenies; plant emergence in F_1C_1 and F_1C_2 progenies, number of shoots plant^{-1} and dry matter content of shoots in bulks and F_1C_2 clonal progenies; plant emergence and dry matter content of tubers in F_1C_2 clonal progenies. Similarly, in Experiment-II (Table-2), marketable tuber yield plant^{-1} exhibited positive significant association with number of tubers plant^{-1} and tuber weight plant^{-1} in bulks, F_1C_2 and F_1C_3 clonal progenies; with plant emergence, number of leaves plant^{-1} and number of branches plant^{-1} in F_1C_2 and F_1C_3 progenies; plant height in F_1C_2 progenies; number of shoots plant^{-1}, dry matter content of shoots and starch content in F_1C_3 progenies. These findings are in agreement with the findings of Roy and Singh (2006) and Patel *et al.* (2003) for tuber weight plant^{-1}, number of tubers plant^{-1} and number of leaves plant^{-1}; Verma *et al.* (2006) for plant emergence and dry matter content of tubers.

In clonal bulks of Experiment-I (Table-3), number of tubers plant^{-1} recorded the highest positive direct effect on marketable tuber yield plant^{-1} followed by plant height, number of eyes tuber^{-1}, number of shoots plant^{-1}, number of branches plant^{-1} and unmarketable tuber yield plant^{-1}. While, tuber weight plant^{-1}, dry matter content of shoots, plant emergence and number of leaves plant^{-1} negatively influenced the marketable tuber yield plant^{-1} in clonal bulks, suggesting true relationship among traits.

Table 1: Genotypic (G) and Phenotypic (P) Correlation Coefficients for Tuber Yield and its Components in Bulk Population, F_1C_1 and F_1C_2 Clones of Potato of Experiment-I (2007-08)

Character	Clones		(X_2)	(X_3)	(X_4)	(X_5)	(X_6)	(X_7)	(X_8)	(X_9)	(X_{10})	(X_{11})	(X_{12})
Plant emergence at 30 DAP (%) (X_1)	bulks	P	0.189	0.320	0.168	0.237	0.311	0.039	0.207	0.238	-0.451	0.205	0.284
		G	0.383	0.437	0.650**	0.364	0.775**	0.965**	0.321	0.263	-0.683**	0.253	0.288
	F_1C_1	P	0.058	0.118	0.174	0.139	0.135	0.158	0.129	0.139	-0.360*	-0.109	0.249
		G	0.272	0.345*	0.640**	0.152	0.514**	0.906**	0.413**	0.325*	-0.861**	0.266	0.416**
	F_1C_2	P	0.123	0.042	-0.042	0.101	-0.046	-0.001	0.144	0.100	0.123	0.035	0.130
		G	0.378**	0.281**	0.034	0.370**	0.819**	0.929**	0.496**	0.490**	0.317**	0.359**	0.433**
Plant height (cm) (X_2)	bulks	P	-	0.058	0.029	-0.077	-0.018	0.215	-0.001	0.080	-0.251	0.079	0.115
		G	-	0.153	0.123	0.068	0.399	0.970**	-0.004	0.125	-0.304	0.104	0.127
	F_1C_1	P	-	0.081	0.044	0.047	-0.036	0.158	0.136	0.128	-0.209	0.039	0.176
		G	-	0.130	0.080	0.068	0.414**	0.985**	0.259	0.159	-0.463**	0.507**	0.219
	F_1C_2	P	-	0.522**	0.241*	0.293**	0.092	0.010	0.373**	0.288**	0.010	0.021	0.244*
		G	-	0.999**	0.530**	0.609**	0.192	0.963**	0.643**	0.514**	0.184	0.213*	0.458**
Number of leaves plant^{-1} (X_3)	bulks	P		-	0.656**	0.460	0.269	0.111	0.432	0.403	-0.187	0.534*	0.387
		G		-	0.970**	0.944**	0.907**	0.773**	0.524*	0.559**	-0.246	0.620**	0.598**
	F_1C_1	P		-	0.513**	0.533**	0.067	0.026	0.300	0.388*	-0.004	0.108	0.364*
		G		-	0.948**	0.736**	0.643**	0.932**	0.380*	0.446**	-0.108	0.229	0.443**
	F_1C_2	P		-	0.393**	0.349**	0.119	0.080	0.325**	0.282**	0.124	-0.013	0.216*
		G		-	0.650**	0.652**	0.239*	0.968**	0.579**	0.497**	0.252*	-0.077	0.423**
Number of branches plant^{-1} (X_4)	bulks	P			-	0.321	0.293	-0.076	0.349	0.403	-0.097	0.276	0.183
		G			-	0.756**	0.950**	0.966**	0.729**	0.625**	-0.210	0.603**	0.862**
	F_1C_1	P			-	0.384*	0.070	0.147	0.252	0.434**	0.019	0.061	0.375*
		G			-	0.769**	0.901**	0.756**	0.372*	0.749**	-0.333*	-0.174	0.741**
	F_1C_2	P			-	0.350**	0.111	0.048	0.235*	0.065	0.098	-0.014	0.102
		G			-	0.657**	0.098	0.930**	0.381**	0.107	0.038	-0.246*	0.131
Number of shoots plant^{-1} (X_5)	bulks	P				-	0.640**	-0.063	0.264	0.330	-0.187	0.543*	0.206
		G				-	0.433	-0.914**	0.261	0.394	-0.397	0.937**	0.570*
	F_1C_1	P				-	0.216	-0.021	0.027	0.176	0.119	-0.061	0.131
		G				-	0.856**	0.680**	0.053	0.303	0.248	0.545**	0.247
	F_1C_2	P				-	0.240	0.066	0.317**	0.259*	0.066	0.088	0.260*
		G				-	0.750**	0.846**	0.516**	0.372**	0.117	0.151	0.375**
Dry matter content of shoots (%) (X_6)	bulks	P					-	-0.096	0.160	0.282	-0.178	0.295	0.131
		G					-	-0.967**	0.304	0.316	-0.745**	0.982**	0.655**
	F_1C_1	P					-	0.005	0.046	0.037	0.010	0.009	0.037
		G					-	0.851**	0.150	0.177	-0.231	0.916**	0.170
	F_1C_2	P					-	0.119	0.080	0.102	0.030	-0.004	0.145
		G					-	0.809**	0.271*	0.227*	0.524**	0.031	0.317**
Dry matter content of tuber (%) (X_7)	bulks	P						-	-0.147	-0.121	0.024	-0.064	-0.089
		G						-	-0.989**	-0.915**	-0.671**	-0.901**	-0.888**
	F_1C_1	P						-	-0.091	-0.151	0.084	-0.041	-0.157
		G						-	-0.990**	-0.929**	-0.905**	-0.989**	-0.706**
	F_1C_2	P						-	0.033	0.092	0.017	-0.060	0.041
		G						-	0.929**	0.962**	0.860**	-0.921**	0.998**
Number of tubers plant^{-1} (X_8)	bulks	P							-	0.753**	-0.267	0.478*	0.738**
		G							-	0.986**	-0.511*	0.562*	0.928**
	F_1C_1	P							-	0.396*	-0.132	0.139	0.396*
		G							-	0.590**	-0.540**	0.658**	0.635**
	F_1C_2	P							-	0.165	0.016	-0.002	0.151
		G							-	0.309**	0.248*	0.059	0.283**
Tuber weight plant^{-1} (kg)	bulks	P								-	-0.294	0.500*	0.737**
		G								-	-0.417	0.673**	0.996**

(X_9)	F_1C_1	P								-	-0.111	0.110	0.942**
		G								-	-0.284	0.856**	0.992**
	F_1C_2	P								-	0.084	0.023	0.903**
		G								-	0.116	0.160	0.957**
Unmarketable tuber yield plant[-1] (kg) (X_{10})	bulks	P									-	-0.210	-0.355
		G									-	-0.172	-0.545*
	F_1C_1	P									-	-0.089	-0.322*
		G									-	-0.376*	-0.469**
	F_1C_2	P									-	-0.088	0.071
		G									-	-0.510**	0.192
Number of eyes tuber[-1] (X_{11})	bulks	P											0.495*
		G											0.676**
	F_1C_1	P											0.102
		G											0.872**
	F_1C_2	P											0.045
		G											0.121

: Significant at 1% level; *: Significant at 5% level **(X_{12}) = Marketable tuber yield plant^{-1} (kg)

Table 2: Genotypic (G) and Phenotypic (P) Correlation Coefficients for Tuber Yield and its Components in Bulk Population, F_1C_2 and F_1C_3 Clones of Potato of Experiment-II (2008-09)

Character	Clones		(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})
Plant emergence (%) (X_1)	bulks	P	0.053	0.200	-0.215	0.118	-0.369	0.107	0.016	-0.315	-0.052	0.010	0.295	-0.043	0.044	0.038	0.010
		G	0.031	0.220	-0.699**	-0.178	-0.598**	0.902**	0.062	-0.814**	-0.025	0.094	0.377	-0.022	0.172	0.153	0.018
	F_1C_2	P	0.115	0.085	0.117	0.095	0.034	0.012	0.160	0.006	0.237	0.058	-0.075	0.060	0.041	-0.106	0.209
		G	0.999**	0.978**	0.984**	0.968**	-0.903**	0.944**	0.947**	-0.914**	0.990**	0.972**	-0.971**	0.933**	0.774**	0.913**	0.937**
	F_1C_3	P	0.041	0.117	0.096	0.078	0.076	0.065	0.022	-0.082	0.072	0.007	0.057	0.043	0.071	-0.079	0.109
		G	0.996**	0.771**	0.650**	0.810**	0.971**	0.997**	0.966**	-0.990**	0.994**	-0.514**	0.813**	0.806**	0.955**	0.894**	0.953**
Plant height (cm) (X_2)	bulks	P	-	0.356	0.469*	-0.045	0.141	0.093	0.228	-0.106	0.221	0.101	0.052	-0.070	0.141	-0.032	0.237
		G	-	0.472*	0.843**	-0.121	0.250	0.472*	0.216	-0.957**	0.240	0.047	0.167	-0.118	0.098	-0.061	0.282
	F_1C_2	P	-	0.450**	0.099	0.210	0.155	-0.035	0.048	-0.064	0.179	0.273	0.321*	-0.200	-0.065	-0.001	0.299
		G	-	0.638**	0.095	0.337*	0.300	0.080	0.059	-0.155	0.390**	0.495**	0.414**	-0.240	-0.015	-0.046	0.554**
	F_1C_3	P	-	0.352**	0.099	0.105	0.097	0.091	0.039	0.017	0.198	0.049	0.108	0.044	-0.151	0.088	0.165
		G	-	0.415**	0.129	0.200	0.201	0.289**	0.030	0.066	0.238*	0.035	0.171	0.045	-0.187	0.120	0.198
Number of leaves plant[-1] (X_3)	bulks	P		-	-0.038	-0.033	-0.133	0.086	0.178	0.026	0.194	-0.143	0.033	0.006	0.120	0.052	0.189
		G		-	0.090	-0.130	-0.164	0.459	0.196	0.293	0.224	-0.258	0.040	0.030	0.124	0.093	0.214
	F_1C_2	P		-	0.347*	0.295	0.139	0.090	0.135	-0.006	0.222	0.166	0.266	-0.195	0.074	0.097	0.248
		G		-	0.642**	0.816**	0.236	0.174	0.353*	-0.148	0.422**	0.276	0.390**	-0.232	0.057	0.075	0.480**
	F_1C_3	P		-	0.465**	0.304**	0.389**	0.108	0.247*	-0.082	0.458**	-0.074	0.018	-0.040	-0.112	0.113	0.403**
		G		-	0.635**	0.474**	0.608**	0.230*	0.366**	-0.152	0.567**	-0.128	0.015	-0.032	-0.147	0.160	0.552**
Number of branches plant[-1] (X_4)	bulks	P			-	0.039	0.336	-0.235	-0.182	-0.075	-0.145	0.026	0.128	0.052	0.210	-0.374	-0.139
		G			-	0.210	0.691**	-0.583*	-0.320	-0.950**	-0.210	0.468*	0.090	0.202	0.499*	-0.436	-0.182
	F_1C_2	P			-	0.360*	-0.113	0.159	0.085	0.017	0.151	0.248	0.069	-0.103	0.007	-0.008	0.153
		G			-	0.753**	0.040	0.434**	-0.028	0.070	0.571**	0.411**	0.145	-0.162	0.073	0.202	0.351*
	F_1C_3	P			-	0.247*	0.210	0.110	0.198	0.020	0.300**	0.021	0.016	0.057	-0.092	0.033	0.290**
		G			-	0.567**	0.382**	0.161	0.352**	0.148	0.458**	-0.106	0.051	0.097	-0.111	0.062	0.545**
Number of shoots plant[-1] (X_5)	bulks	P				-	0.239	-0.033	-0.025	-0.166	-0.095	-0.088	0.224	0.017	0.027	-0.203	-0.062
		G				-	0.869**	-0.943**	-0.065	-0.223	-0.118	0.057	0.306	0.007	0.179	-0.380	-0.121
	F_1C_2	P				-	0.090	0.079	0.228	-0.048	0.048	0.120	0.250	-0.160	-0.088	0.088	0.065
		G				-	0.140	0.842**	0.198	0.151	0.323*	0.668**	0.802**	-0.385*	-0.200	0.540**	0.017
	F_1C_3	P				-	0.166	0.088	0.106	0.205	0.279**	0.050	0.036	-0.123	-0.081	0.022	0.245*
		G				-	0.218*	0.285**	0.278**	0.227*	0.450**	0.014	0.183	-0.253*	-0.221*	0.118	0.438**
Dry matter content of shoots (%) (X_6)	bulks	P					-	-0.172	-0.032	-0.092	-0.058	-0.010	0.125	0.006	0.030	-0.164	-0.048
		G					-	-0.303	0.162	-0.716**	-0.063	0.036	0.275	0.073	0.125	-0.363	-0.050
	F_1C_2	P					-	0.000	0.020	-0.012	0.039	0.056	0.117	0.057	0.183	-0.108	0.150
		G					-	-0.031	0.089	-0.168	0.034	0.186	0.105	0.051	0.208	-0.079	0.300
	F_1C_3	P					-	0.097	0.163	-0.100	0.273**	-0.102	0.139	0.051	0.079	-0.005	0.237*
		G					-	0.056	0.328**	-0.143	0.361**	-0.139	0.159	0.097	0.212*	-0.042	0.399**
Dry matter content of tuber (%) (X_7)	bulks	P						-	0.263	-0.211	0.136	-0.330	0.148	-0.545*	-0.391	0.418	0.167
		G						-	0.595**	-0.218	0.350	-0.926**	0.975**	-0.996**	-0.999**	0.921**	0.356
	F_1C_2	P						-	0.028	0.026	0.051	-0.088	0.204	-0.257	-0.198	0.275	0.037
		G						-	0.130	-0.118	0.048	-0.430**	0.273	-0.514**	-0.439**	0.509**	0.003
	F_1C_3	P						-	0.012	0.015	0.052	-0.224*	-0.060	-0.215*	-0.287**	0.129	0.017
		G						-	0.132	0.207*	0.157	-0.883**	-0.079	-0.377**	-0.579**	0.398**	0.022
Number of tubers	bulks	P							-	-0.059	0.729**	-0.147	-0.246	-0.188	-0.260	0.306	0.728**
		G							-	-0.527*	0.894**	-0.342	-0.209	-0.215	-0.349	0.410	0.900**
	F_1C_2	P							-	-0.086	0.232	-0.072	0.152	-0.075	-0.190	0.119	0.303*

plant^{-1} (X_8)		G							-	-0.094	0.469**	-0.007	0.161	-0.159	-0.229	0.349*	0.499**
	F_1C_3	P							-	0.110	0.412**	-0.107	0.104	-0.185	-0.211*	0.202	0.317**
		G							-	0.424**	0.631**	-0.191	0.161	-0.309**	-0.321**	0.342**	0.602**
Unmarketable tuber yield plant^{-1} (kg) (X_9)	bulks	P								-	0.012	0.085	-0.180	0.033	0.021	-0.007	-0.140
		G								-	-0.378	-0.346	-0.780**	0.087	-0.473*	-0.400	-0.432
	F_1C_2	P								-	-0.049	-0.018	-0.064	0.023	0.090	-0.032	-0.211
		G								-	-0.064	0.038	-0.090	0.026	0.020	0.002	-0.093
	F_1C_3	P								-	0.014	-0.059	-0.097	-0.172	-0.128	0.143	-0.085
		G								-	-0.010	-0.151	-0.044	-0.376**	-0.413**	0.459**	-0.140
Tuber weight plant^{-1} (kg) (X_{10})	bulks	P									-	-0.190	-0.524*	-0.056	-0.218	0.326	0.987**
		G									-	-0.347	-0.548*	-0.051	-0.286	0.420	0.999**
	F_1C_2	P									-	0.170	0.011	0.013	0.078	-0.040	0.692**
		G									-	0.391**	-0.010	0.104	0.078	0.106	0.977**
	F_1C_3	P									-	-0.067	0.092	-0.136	-0.114	0.146	0.836**
		G									-	-0.206	0.140	-0.182	-0.185	0.189	0.970**
Number of eyes tuber^{-1} (X_{11})	bulks	P										-	-0.269	0.639**	0.632**	-0.592**	-0.196
		G										-	-0.267	0.867**	0.794**	-0.968**	-0.321
	F_1C_2	P										-	0.005	0.142	0.130	-0.177	0.165
		G										-	-0.005	0.199	0.242	-0.425**	0.171
	F_1C_3	P										-	0.013	0.344**	0.267*	-0.182	-0.057
		G										-	0.034	0.644**	0.520**	-0.443**	-0.177
Starch content (%) (X_{12})	bulks	P											-	-0.385	-0.049	0.050	-0.492*
		G											-	-0.464	-0.012	0.800	-0.514*
	F_1C_2	P											-	-0.403**	-0.202	0.032	0.053
		G											-	-0.463**	-0.249	0.090	0.066
	F_1C_3	P											-	-0.066	-0.080	0.081	0.182
		G											-	-0.066	-0.111	0.096	0.285**
Reducing sugar (mg/100 g FW) (X_{13})	bulks	P												-	0.757**	-0.550*	-0.052
		G												-	0.848**	-0.780**	-0.050
	F_1C_2	P												-	0.708**	-0.159	-0.040
		G												-	0.822**	-0.380*	0.006
	F_1C_3	P												-	0.529**	-0.391**	-0.118
		G												-	0.640**	-0.541**	-0.167
Chip colour (X_{14})	bulks	P													-	-0.695**	-0.214
		G													-	-0.967**	-0.262
	F_1C_2	P													-	-0.280	0.030
		G													-	-0.603**	-0.034
	F_1C_3	P													-	-0.492**	-0.079
		G													-	-0.751**	-0.198
Specific gravity (X_{15})	bulks	P															0.329
		G															0.424
	F_1C_2	P															0.041
		G															0.139
	F_1C_3	P															0.073
		G															0.086

**: Significant at 1% level; *: Significant at 5% level (X16) = Marketable tuber yield plant-1 (kg)

Table 3: Estimation of path Coefficient in Bulk Population, F_1C_1 and F_1C_2 Clones of Potato of Experiment-I based on Genotypic Correlation Coefficients (2007-08)

S. No.	Character	Clones	(X_1)	(X_2)	(X_3)	(X_4)	(X_5)	(X_6)	(X_7)	(X_8)	(X_9)	(X_{10})	Correlation (r) with Marketable Yield
1.	Plant emergence (%) (X_1)	bulks	**-0.473**	0.356	-0.170	0.167	0.219	-0.455	1.413	-0.975	-0.018	0.224	0.288
		F_1C_1	**0.257**	0.001	0.130	-0.071	-0.073	0.032	-0.053	0.312	-0.162	0.043	0.416**
		F_1C_2	**0.673**	-0.184	0.188	-0.011	-0.083	0.094	0.295	0.610	0.272	-0.074	0.433**
2.	Plant height (cm) (X_2)	bulks	-0.181	**0.930**	-0.060	0.032	0.041	-0.234	-0.018	-0.465	-0.008	0.092	0.127
		F_1C_1	0.070	**0.002**	0.049	-0.009	-0.033	0.026	-0.033	0.152	-0.087	0.081	0.219
		F_1C_2	0.254	**-0.487**	0.668	-0.174	-0.136	0.022	0.381	0.641	-0.158	-0.044	0.458**
3.	Number of leaves plant^{-1} (X_3)	bulks	-0.207	0.142	**-0.389**	0.301	0.569	-0.591	0.305	0.973	-0.006	0.547	0.598**
		F_1C_1	0.089	0.001	**0.378**	-0.105	-0.355	0.040	-0.049	0.428	-0.020	0.037	0.443**
		F_1C_2	-0.189	-0.487	**0.668**	-0.214	-0.146	0.027	0.343	0.619	-0.216	0.016	0.423**
4.	Number of branches plant^{-1} (X_4)	bulks	-0.307	0.114	-0.456	**0.257**	0.456	-0.616	0.205	-0.818	-0.005	0.532	0.862**
		F_1C_1	0.164	0.001	0.358	**-0.111**	-0.371	0.063	-0.048	0.719	-0.006	-0.028	0.741**
		F_1C_2	-0.023	-0.258	0.435	**-0.329**	-0.147	0.011	0.226	0.133	0.032	0.051	0.131
5.	Number of shoots plant^{-1} (X_5)	bulks	-0.172	0.063	-0.367	0.194	**0.602**	-0.254	1.150	-0.963	-0.010	0.827	0.570*
		F_1C_1	0.039	0.002	0.278	-0.085	**-0.482**	0.079	-0.007	0.291	0.047	0.087	0.247
		F_1C_2	-0.249	-0.297	0.435	-0.216	**-0.224**	0.086	0.306	0.463	0.101	-0.031	0.375**
6.	Dry matter content of shoots (%) (X_6)	bulks	-0.367	0.371	-0.392	0.270	0.261	**-0.587**	1.338	-0.976	-0.019	0.955	0.655**
		F_1C_1	0.132	0.001	0.243	-0.111	-0.605	**0.063**	-0.019	0.170	-0.043	0.340	0.170
		F_1C_2	-0.551	-0.094	0.160	-0.032	-0.168	**0.114**	0.161	0.283	0.450	-0.006	0.317**
7.	Number of tubers plant^{-1} (X_7)	bulks	-0.152	-0.004	-0.204	0.187	0.158	-0.178	**1.398**	-1.660	-0.013	0.496	0.928**
		F_1C_1	0.106	0.001	0.143	-0.041	-0.025	0.009	**-0.128**	0.566	-0.101	0.106	0.635**
		F_1C_2	-0.334	-0.313	0.387	-0.125	-0.115	0.031	**0.593**	0.385	-0.213	-0.012	0.283**
8.	Tuber weight plant^{-1} (kg) (X_8)	bulks	-0.124	0.117	-0.217	0.160	0.238	-0.186	0.837	**-1.711**	-0.011	0.593	0.996**
		F_1C_1	0.084	0.002	0.168	-0.083	-0.146	0.011	-0.076	**0.959**	-0.053	0.137	0.992**
		F_1C_2	-0.330	-0.251	0.332	-0.035	-0.083	0.026	0.183	**1.247**	-0.099	-0.033	0.957**
9.	Unmarketable yield plant^{-1} (kg) (X_9)	bulks	-0.323	-0.282	0.096	-0.054	-0.239	0.437	-0.997	0.547	**0.026**	-0.152	-0.545*
		F_1C_1	-0.221	-0.001	-0.041	0.004	-0.120	-0.015	0.069	-0.273	**0.188**	-0.060	-0.469**
		F_1C_2	0.213	-0.090	0.168	0.012	0.026	-0.060	0.147	0.144	**-0.859**	0.105	0.192
10.	Number of eyes tuber^{-1} (X_{10})	bulks	-0.120	0.097	-0.241	0.155	0.565	-0.635	0.974	-0.996	-0.004	**0.882**	0.676**
		F_1C_1	0.068	0.001	0.086	0.019	-0.263	0.133	-0.084	0.821	-0.071	**0.160**	0.872**
		F_1C_2	-0.242	-0.104	-0.051	0.081	-0.034	0.004	0.037	0.200	0.438	**-0.207**	0.121

Residual effect: 0.1733; 0.0154 and 0.1474 of bulks, F_1C_1 and F_1C_2, respectively. Diagonal bold values indicate direct effects

Table 4: Estimation of Path Coefficient in Bulk Population, F_1C_2 and F_1C_3 Clones of Potato of Experiment-II based on Genotypic Correlation Coefficients (2008-09)

S. No.	Character	Clones	(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})	Correlation (r) with Marketable Yield
1.	Plant emergence (%) (X_1)	bulks	**0.010**	0.001	-0.003	0.002	0.001	0.010	0.001	0.001	-0.025	0.021	0.001	0.008	0.001	-0.003	-0.002	0.018
		F_1C_2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
		F_1C_3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2.	Plant height (cm) (X_2)	bulks	0.001	**0.019**	-0.006	-0.002	0.001	-0.004	0.001	0.001	0.238	0.035	0.001	0.003	-0.002	-0.002	0.001	0.282
		F_1C_2	0.000	**0.666**	-0.054	0.073	-0.203	0.094	0.003	0.019	0.179	0.000	-0.150	0.138	-0.234	0.014	0.008	0.554**
		F_1C_3	0.000	**0.037**	-0.133	0.053	-0.035	0.039	-0.007	0.000	0.219	-0.019	0.008	0.013	-0.013	0.056	-0.022	0.198
3.	Number of leaves plant $^{-1}$ (X_3)	bulks	0.002	0.009	**-0.013**	0.001	0.000	0.003	0.001	0.001	0.222	-0.008	-0.001	0.001	0.001	-0.002	-0.001	0.217
		F_1C_2	0.000	0.425	**-0.084**	0.490	-0.491	0.074	0.006	0.114	0.194	0.000	-0.083	0.130	-0.226	-0.055	-0.013	0.480**
		F_1C_3	0.000	0.015	**-0.321**	0.262	-0.082	0.119	-0.006	0.004	0.522	0.043	-0.030	0.001	0.009	0.044	-0.029	0.552**
4.	Number of branches plant $^{-1}$ (X_4)	bulks	-0.007	0.016	0.001	**-0.003**	0.001	-0.011	0.002	-0.002	-0.208	0.027	0.001	0.002	0.004	-0.008	0.005	-0.182
		F_1C_2	0.000	0.063	-0.054	**0.764**	-0.453	0.001	0.014	-0.009	0.263	0.000	-0.124	0.048	-0.158	-0.070	-0.035	0.351*
		F_1C_3	0.000	0.005	-0.204	**0.413**	-0.098	0.075	-0.004	0.004	0.422	-0.042	-0.025	0.004	-0.027	0.033	-0.011	0.545**
5.	Number of shoots plant $^{-1}$ (X_5)	bulks	-0.002	-0.002	0.002	-0.001	**-0.001**	-0.014	0.001	0.001	-0.117	0.006	0.000	0.006	0.001	-0.003	0.004	-0.121
		F_1C_2	0.000	0.224	-0.069	0.575	**-0.601**	0.044	0.027	0.064	0.149	0.000	-0.202	0.267	-0.376	0.192	-0.092	0.017
		F_1C_3	0.000	0.007	-0.152	0.234	**-0.173**	0.043	-0.007	0.003	0.414	-0.064	0.003	0.014	0.070	0.067	-0.022	0.438**
6.	Dry matter content of shoots (%) (X_6)	bulks	-0.006	0.005	0.002	-0.002	-0.001	**-0.016**	0.002	0.001	-0.062	0.019	0.001	0.006	0.001	-0.002	0.004	-0.050
		F_1C_2	0.000	0.200	-0.020	0.003	-0.084	**0.313**	-0.001	0.029	0.016	0.000	-0.056	0.035	0.050	-0.199	0.013	0.300
		F_1C_3	0.000	0.007	-0.195	0.158	-0.038	**0.196**	-0.001	0.004	0.333	0.040	-0.032	0.012	-0.027	-0.064	0.008	0.399**
7.	Dry matter content of tubers (%) (X_7)	bulks	0.010	0.009	-0.006	0.002	0.001	0.005	**0.001**	0.004	0.348	0.006	-0.006	0.022	-0.048	0.040	-0.029	0.356
		F_1C_2	0.000	0.054	-0.015	0.332	-0.506	-0.010	**0.032**	0.042	0.022	0.000	0.130	0.091	-0.501	0.420	-0.087	0.003
		F_1C_3	0.000	0.011	-0.074	0.067	-0.049	0.011	**-0.024**	0.001	0.144	-0.058	-0.207	-0.006	0.105	0.174	-0.073	0.022
8.	Number of tubers plant $^{-1}$ (X_8)	bulks	0.001	0.004	-0.003	0.001	0.001	-0.003	0.001	**0.007**	0.888	0.014	-0.001	-0.004	-0.004	0.006	-0.005	0.900**
		F_1C_2	0.000	0.039	-0.030	-0.022	-0.119	0.028	0.004	**0.322**	0.216	0.000	0.002	0.054	-0.155	0.219	-0.060	0.499**
		F_1C_3	0.000	0.001	-0.118	0.145	-0.048	0.064	-0.003	**0.011**	0.581	-0.119	-0.045	0.012	0.086	0.097	-0.063	0.602**
9.	Tuber weight plant $^{-1}$ (kg) (X_9)	bulks	0.001	0.005	-0.003	0.001	0.001	0.001	0.001	0.006	**0.993**	0.010	-0.001	-0.011	-0.001	0.005	-0.005	0.999**
		F_1C_2	0.000	0.260	-0.036	0.436	-0.194	0.011	0.002	0.151	**0.460**	0.000	-0.118	-0.003	0.101	-0.074	-0.018	0.977**
		F_1C_3	0.000	0.009	-0.182	0.189	-0.078	0.071	-0.004	0.007	**0.921**	0.003	-0.048	0.011	0.050	0.056	-0.035	0.970**
10.	Unmarketable yield plant $^{-1}$ (kg) (X_{10})	bulks	-0.008	-0.026	-0.004	0.003	0.001	0.011	0.001	-0.004	-0.375	**-0.026**	-0.001	-0.016	0.002	0.008	0.004	-0.432
		F_1C_2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
		F_1C_3	0.000	0.002	0.049	0.061	-0.039	-0.028	-0.005	0.005	-0.010	**-0.281**	-0.035	-0.003	0.104	0.124	-0.084	0.140
11.	Number of eyes tuber $^{-1}$ (X_{11})	bulks	0.001	0.001	0.003	-0.001	0.002	-0.001	0.002	-0.002	-0.344	0.009	**0.003**	-0.006	0.017	-0.013	0.011	-0.321
		F_1C_2	0.000	0.329	-0.023	0.314	-0.402	0.058	-0.014	-0.002	0.180	0.000	**-0.302**	-0.002	0.194	-0.232	0.073	0.171
		F_1C_3	0.000	0.001	0.041	-0.044	-0.002	-0.027	0.021	-0.002	-0.190	0.042	**0.234**	0.003	-0.179	-0.157	0.081	-0.177
12.	Starch content (%) (X_{12})	bulks	0.004	0.003	-0.001	0.001	0.000	-0.004	0.001	-0.001	-0.544	0.020	-0.001	**0.021**	-0.009	0.001	-0.001	-0.514*
		F_1C_2	0.000	0.276	-0.033	0.111	-0.482	0.033	0.009	0.052	-0.005	0.000	0.001	**0.334**	-0.453	0.238	-0.015	0.066
		F_1C_3	0.000	0.006	-0.005	0.021	-0.032	0.031	0.002	0.002	0.129	0.012	0.008	**0.076**	0.018	0.033	-0.018	0.285**
13.	Reducing sugar mg /100 g (FW) (X_{13})	bulks	0.001	-0.002	0.002	-0.001	0.002	-0.001	0.001	-0.001	-0.050	-0.002	0.002	-0.020	**0.020**	-0.014	0.009	-0.050
		F_1C_2	0.000	-0.160	0.020	-0.123	0.232	0.016	-0.017	-0.051	0.048	0.000	-0.060	-0.155	**0.277**	-0.785	0.065	0.006
		F_1C_3	0.000	0.002	0.010	0.040	0.044	0.019	0.009	-0.004	-0.167	0.106	0.151	-0.005	**-0.278**	-0.193	0.099	-0.167
14.	Chip colour (X_{14})	bulks	0.002	0.002	-0.002	-0.001	0.001	-0.002	0.001	-0.002	-0.284	0.012	0.002	0.001	0.017	**-0.016**	0.011	-0.262
		F_1C_2	0.000	-0.010	-0.005	0.056	0.121	0.065	-0.014	-0.074	0.036	0.000	-0.073	-0.083	0.801	**-0.257**	0.103	-0.034
		F_1C_3	0.000	-0.007	0.047	-0.046	0.038	0.042	0.014	-0.004	-0.171	0.116	0.122	-0.008	-0.178	**-0.301**	0.138	-0.198
15.	Specific gravity (X_{15})	bulks	0.001	-0.001	-0.001	0.001	0.001	0.006	0.002	0.003	0.417	0.010	-0.003	0.002	-0.016	0.016	**-0.011**	0.424
		F_1C_2	0.000	-0.031	-0.006	0.154	-0.325	-0.025	0.017	0.112	0.049	0.000	0.128	0.030	-0.371	0.577	**-0.171**	0.139
		F_1C_3	0.000	0.004	-0.051	0.026	-0.020	-0.008	-0.010	0.004	0.174	-0.129	-0.104	0.007	0.150	0.226	**-0.184**	0.086

Residual effect: 0.0001; 0.0883 and 0.0670 of bulks, F_1C_2 and F_1C_3, respectively. Diagonal bold values indicate direct effects

In F_1C_1 clonal progenies of Experiment-I (table 3),, tuber weight plant $^{-1}$ recorded the highest positive direct effect on marketable tuber yield plant $^{-1}$ followed by number of leaves plant $^{-1}$, plant emergence per cent, unmarketable tuber yield plant $^{-1}$, number of eyes tuber $^{-1}$, plant height and dry matter content of shoots, while, number of shoots plant $^{-1}$ had negative direct effect followed by number of tubers plant^{-1} and number of branches plant^{-1}.

In F_1C_2 progenies of Experiment-I (table 3),, tuber weight plant^{-1} had positive direct effect on marketable tuber yield plant^{-1} followed by plant emergence per cent, number of leaves plant^{-1}, number of tubers plant^{-1} and dry matter content of shoots.

On the other hand, unmarketable tuber yield plant^{-1} followed by plant height, number of branches plant^{-1}, number of shoots plant^{-1} and number of eyes tuber had negative direct effect on marketable tuber yield plant^{-1}. Tuber weight plant^{-1}, plant emergence per cent, number of leaves plant^{-1}, number of tubers plant^{-1} and dry matter content of shoots had positive direct effect and significant positive correlation indicating true relationship.

In bulks of Experiment-II (table 4), tuber weight plant^{-1} had positive direct effect on marketable tuber yield plant^{-1} followed by starch content, reducing sugar, plant height, plant emergence per cent, number of tubers plant^{-1} and number of eyes tuber^{-1}. On the other hand, negative direct effect on marketable tuber yield plant^{-1} was influenced by unmarketable tuber yield plant^{-1}; dry matter content of shoots, chips color, and number of leaves plant^{-1}, specific gravity, number of branches plant^{-1} and number of shoots plant^{-1}. Tuber weight plant^{-1} and number of tubers plant^{-1} had positive direct effect and significant correlation indicating that effect is true and is not affected by other component traits.

In F_1C_2 progenies of Experiment-II (table 4),, number of branches plant^{-1} recorded the highest positive direct effect on marketable tuber yield plant^{-1} followed by plant height, tuber weight plant^{-1}, starch content, number of tubers plant^{-1}, dry matter content of shoots, reducing sugar and dry matter content of tubers, while, number of shoots plant^{-1}, number of eyes tuber^{-1}, chip color, specific gravity and number of leaves plant^{-1} negatively influenced marketable yield plant^{-1}. Number of branches plant^{-1}, plant height, tuber weight plant^{-1} and number of tubers plant^{-1} exhibited high positive direct effect and significant positive correlation with marketable tuber yield plant^{-1}, suggesting true relationship among traits.

In F_1C_3 clonal progenies of Experiment-II (table 4),, tuber weight plant^{-1} had positive direct effect on marketable tuber yield plant^{-1} followed by number of branches plant^{-1}, number of eyes tuber^{-1}, dry matter content of shoots, starch content, plant height and number of tubers plant^{-1} whereas, number of leaves plant^{-1} had negative direct effect followed by chip color, unmarketable tuber yield plant^{-1}, reducing sugar, specific gravity, number of shoots plant^{-1} and dry matter content of tubers. Tuber weight plant^{-1}, number of branches plant^{-1}, dry matter content of shoots plant^{-1}, starch content and number of tubers plant^{-1} had positive direct effect and significant correlation, showing true relationship among these traits. Therefore, selection based on these traits would be rewarding for bringing change in tuber yield of F_1C_3 progenies of potato and will be helpful is isolation of better clones in potato hybrids. Positive direct effect of various characters on marketable tuber yield plant^{-1} observed in the present study are also in accordance to the findings of Roy and Singh (2006); Patel *et al*. (2003); Garg and Bhutani (1991).

Correlation coefficients between tuber yield and its components revealed that plant types with more number of tubers, higher tuber weight, more leaves and branches plant^{-1} can help in identifying high yielding genotypes. Path studies for all the traits under study revealed that number of tubers plant^{-1}, tuber weight plant^{-1} and number of leaves plant^{-1} were found to be primary key traits contributing towards tuber yield. Due importance should be given to these components while selecting high yielding clones in advance generations in potato.

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