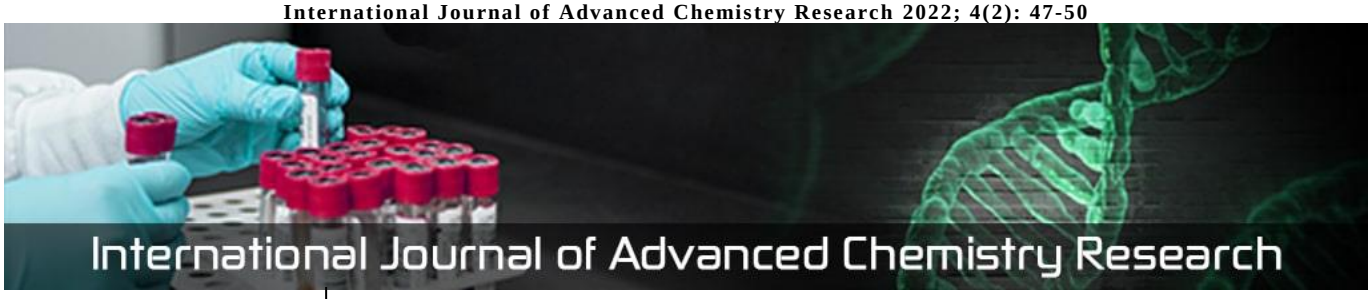

ISSN Print: 2664-6781
ISSN Online: 2664-679X
Impact Factor: RJIF 5.32
IJACR 2022; 4(2): 47-50
www.chemistryjournals.net
Received: 19-07-2022
Accepted: 21-08-2022

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Association analysis for yield and yield contributing traits of potato (*Solanum tuberosum* L.)

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DOI: https://doi.org/10.33545/26646781.2022.v4.i2a.76

Abstract
To understand interrelationships among different yield and yield attributing traits in potato (*Solanum tuberosum* L.) an experiment was conducted using twenty potato genotypes including 2 checks namely Khufri Pukhraj and Kufri Chipsona 1. The observations were recorded on eighteen traits. Correlation coefficient analysis revealed that total tuber yield plot^{-1} was showed highly and significantly positive correlated with specific gravity, number of shoots plant^{-1}, dry matter content of shoots, unmarketable tuber weight plant^{-1} and starch content at genotypic level. However, it had exhibited highly significant positive association with number of branches plant^{-1} at genotypic and phenotypic level respectively. Thus direct selection for above traits will be effective and helpful in improving total tuber yield. Path coefficient analysis unveil that total tuber yield plot^{-1} was found high positive and direct effect for the traits plant emergence %, number of branches plant^{-1}, number of shoots plant^{-1}, dry matter content of shoots, tuber weight plant^{-1}, marketable tuber weight plant^{-1}, unmarketable tuber weight plant^{-1}, harvest index and specific gravity. So these traits would be most suitable for direct selection and improvement of potato genotypes for tuber yield.

Keywords: Potato, correlation and path coefficient analysis

Introduction
Potato is an excellent low fat source of carbohydrates with one of fourth largest and versatile non-cereal food crops in the world. India is now the world's second largest potato producing country and nearby one third of world's potato being harvested from china and India. Its provides more calories and protein per unit area with maximum time and water than most of the major food crops. Potato of an average size with skin provides about 10 percent of the recommended daily intake of fibre. However breeders should take the challenge to provide food materials at cheaper rate to the millions of hungry people in developing countries by also increasing the production of potato per unit area and per unit time. Correlation coefficient estimates the degree of association of different component characters of yield among them and with the yield. The correlation studies between various yields attribute with tuber yield provides a basis for further breeding programmes. Genotypic and phenotypic correlation was worked out according to Miller *et al.* (1958) [13]. Path coefficient analysis provides more effective means of separating direct and indirect factors, permitting a critical examination of the specific forces acting to produce a given correlation and measuring the relative importance of the causal factors as per Dewey and Lu (1959. The path coefficient analysis under such situations helps to determine the direct contribution of these characters and their indirect contributions *via* other characters.

Material and Methods
A field experiment with twenty potato genotypes (eighteen genotypes/test entries with two check variety namely-K. Pukhraj and K. Chipsona-1) was conducted at research cum instructional farm, Department of Genetics and Plant Breeding, College of Agriculture/Research Station, Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.), during *Rabi* season 2019-20 at Chhattisgarh Plain (Raipur), Bastar Plateau (Jagdalpur) and Northern hills (Main pat Ambikapur). The experiment was grown in Randomized Complete Block Design with three replication. The data observations were recorded on five randomly selected plants in each genotype for each replication and mean data was calculated. Correlation analysis was help to determine the yield and its related traits with the estimation

of association between two variables. In present study correlation coefficient were also calculated at phenotypic and genotypic levels in all possible combination according to Miller *et al.* (1958) [13]. The path coefficient analysis under such situations helps to determine the direct contribution of these characters and their indirect contributions *via* other characters according to Dewey and Lu (1959) [2].

Results and discussion

Correlation between total tuber yields with yield attributing traits.

Total tuber yield plot^{-1} was high positively and significantly correlation with specific gravity (0.490), number of shoots plant^{-1} (0.555), dry matter content of shoots (0.376), unmarketable tuber weight plant^{-1} (0.368) and starch content (0.265) at genotypic level. However, it had exhibited positively and significantly correlation with number of branches plant^{-1} (0.476, 0.277) at genotypic and phenotypic level respectively. The higher value of genotypic correlation as compare to phenotypic correlation indicates an inherent association between various traits reported by Johnson *et al.* (1955). This indicates that traits are heritable with governing of additive gene action for effective selection criteria.

This trait was significantly and positively associated with tuber weight plant^{-1} (0.369), marketable tuber weigh plant^{-1} (0.397), number of eyes tuber -1 (0.379), harvest index (0.305) and starch content (0.376) at genotypic level respectively. The positive with significant association on total tuber yield plot^{-1} similar results to the finding by Supritiana *et al.* (2019) [11] for dry matter content of shoots, Mishra *et al.* (2018) [5] for tuber weight plant^{-1} marketable tuber weight plant^{-1}, unmarketable tuber weight plant^{-1}, finding by Pandey *et al.* (2005) [6], Panigrahi *et al.,* (2014) [7], Workayehu *et al.,* (2021) [12], Sahu *et al.* (2017) [9] for harvest index and specific gravity, Lavanya *et al.* (2019) [4] for marketable tuber weight plant-1 and dry matter contents of shoots. Thus, these characters deserve greater weightage during selection for yield performance attribute.

Path coefficient analysis

Path coefficient analysis estimates direct and indirect effects of various independent traits toward dependent traits. It shows whether the association of these independent traits with tuber yield plot^{-1} were due to their direct effect on yield or consequence of their indirect effect through other component traits. The estimates of genotypic path coefficient are furnished in table 2a and 2b.

Path coefficient analysis was also showed highly positive direct effect on total tuber yield plot^{-1} for number of branches plant^{-1} (0.47), number of shoots plant^{-1}(0.55), dry matter content of shoots (0.37), unmarketable tuber weight plant^{-1} (0.36), starch content (0.26) and specific gravity (0.49). Similar finding reported by Rangare and Rangare, (2017) [8] and Das *et al.* (2015) [1] for marketable tuber weight plant^{-1} and plant height at maturity (cm). Similarly, like direct effect, the indirect effects will also find its contribution via different traits towards tuber yield plot$^{-1.}$ Majority of indirect effects of various independent traits via other traits were extremely low of either sign. The residual effects (0.22) in the analysis were found less which indicates that in present investigation most of the important characters were included in the expression of total tuber yield. Similar results were reported by Subha and Singh (2018) [5].

Conclusion

It had been seen in the study that among eighteen yield attributing traits only tuber weight plant^{-1} and marketable tuber weight plant^{-1} had showed positive and significant association as well as direct effect on total tuber yield. Thus we can conclude that to obtain higher total tuber yield we have to focus for selection of those genotypes which have high tuber weight plant^{-1} with high marketable tuber weight plant^{-1}.

Table 1a: Genotypic and phenotypic correlation coefficient of eighteen yield and yield attributing traits of potato genotypes in 2019-20

Ch.		PE	PH	NLPP	NBPP	NSPP	DMCS	NTPP	TWPP	MTWPP	UTWPP	NEPT	TE	HI	DMCT	SC	RS	SG	TTYPP
PE	P	1.000	0.1110	0.1836	0.1057	0.0221	0.1606	0.0918	0.0068	0.0033	0.0270	0.1282	0.1162	0.0896	0.0022	0.1202	0.0270	0.1515	0.0763
	G	1.000	0.387	0.546	0.255	0.2190	0.389	0.0987	0.0799	-0.0819	0.1718	0.1693	0.2258	0.1900	0.1035	0.266	0.322	0.551	0.1106
PH	P		1.000	0.1010	0.0356	0.0805	0.0271	0.1476	0.0612	0.0198	0.1240	0.0611	0.1633	0.0390	0.2101	0.0447	0.1011	0.0555	0.1008
	G		1.000	0.1195	0.0796	0.411	0.0433	0.1980	0.1795	0.1153	0.387	0.297	0.2249	0.1061	0.334	0.1082	0.0904	0.411	0.1909
NLPP	P			1.000	0.351	0.0978	0.0789	0.1096	0.0745	0.0579	0.1113	0.1088	0.0144	0.0272	0.0292	0.0717	0.0995	0.0797	0.1546
	G			1.000	0.720	0.325	0.1422	0.0095	0.1886	0.1447	0.546	0.367	0.0023	0.0417	0.0324	0.1766	0.1984	0.469	0.2205
NBPP	P				1.000	0.406	0.1415	0.0338	0.263	0.312	0.0861	0.1091	0.1154	0.0979	0.0359	0.0079	0.1296	0.0699	0.277
	G				1.000	0.733	0.2121	0.0181	0.469	0.473	0.255	0.531	0.1834	0.255	0.0904	0.0156	0.267	0.644	0.476
NSPP	P					1.000	0.0831	0.1856	0.318	0.333	0.0690	0.0238	0.0894	0.0458	0.0321	0.0474	0.0460	0.0407	0.2434
	G					1.000	0.1714	0.605	0.790	0.746	0.2190	0.304	0.1711	0.358	0.1915	0.1735	0.269	0.875	0.555
DMCS	P						1.000	0.0269	0.0069	0.0331	0.1577	0.1438	0.421	0.306	0.327	0.0061	0.0473	0.0169	0.2445
	G						1.000	0.0165	0.0471	0.0838	0.389	0.370	0.560	0.490	0.445	0.0534	0.0413	0.0325	0.376
NTPP	P							1.000	0.1634	0.1737	0.0887	0.0382	0.0491	0.1988	0.0037	0.1820	0.0796	0.0384	0.1651
	G							1.000	0.396	0.397	0.0987	0.379	0.1634	0.305	0.0048	0.376	0.2029	0.1437	0.2278
TWPP	P								1.000	0.801	0.1545	0.1870	0.520	0.417	0.2113	0.0251	0.1234	0.0167	0.0723
	G								1.000	0.997	0.0799	0.283	0.538	0.594	0.297	0.0296	0.437	0.0057	0.1119
MTWPP	P									1.000	0.0767	0.1637	0.486	0.376	0.1347	0.0585	0.1430	0.0291	0.1106
	G									1.000	0.0819	0.416	0.514	0.529	0.295	0.1000	0.355	0.1255	0.1430

*, ** and *** significant at 5%, 1% and 0.1% level respectively.

PE = Plant emergence	NSPP = Number of shoots plant^{-1}	MTWPP = Marketable tuber weight plant^{-1}	HI = Harvest index %	SG = Specific gravity.
PH = Plant height at maturity (cm)	DMCS = Dry matter content of shoots	UMTWPP = Unmarketable tuber weight plant^{-1}	DMCT= Dry matter contents of tuber	
NLPP = Number of leaves plant^{-1}	NTPP = Number of tubers plant^{-1}	NEPT = Number of eyes tuber^{-1}	SC = Starch content %,	
NBPP = Number of branches plant^{-1}	TWPP = Tuber weight plant^{-1}	TE = Tuberization efficiency (tuber:haulm ratio),	RS = Reducing sugar,	

Table 1b: Genotypic and phenotypic correlation coefficient of eighteen yield and yield attributing traits of potato genotypes in 2019-20

Ch.		PE	PH	NLPP	NBPP	NSPP	DMCS	NTPP	TWPP	MTWPP	UTWPP	NEPT	TE	HI	DMCT	SC	RS	SG	TTYPP
UTWPP	P										1.000	0.1060	0.0437	0.0288	0.0385	0.0042	0.0693	0.0482	0.2295
	G										1.000	0.933	0.480	0.354	0.0744	0.1526	0.428	0.422	0.368
NEPT	P											1.000	0.0407	0.0803	0.0431	0.0626	0.0886	0.0792	0.0073
	G											1.000	0.1433	0.1103	0.0077	0.0176	0.462	0.0469	0.0832
TE	P												1.000	0.631	0.0524	0.1289	0.0539	0.0333	-0.0772
	G												1.000	0.907	0.0390	0.1053	0.1677	0.0381	-0.1216
HI	P													1.000	0.1226	0.1357	0.0521	0.0210	0.0234
	G													1.000	0.1774	0.312	0.0655	0.1914	0.0672
DMCT	P														1.000	0.1464	0.1556	0.0375	0.0307
	G														1.000	0.290	0.478	0.0014	0.0136
SC	P															1.000	0.1318	0.1416	0.1555
	G															1.000	0.404	0.351	0.266
RS	P																1.000	0.0298	-0.0101
	G																1.000	0.0767	-0.2279
SG	P																	1.000	0.0668
	G																	1.000	0.490
TTYPP	P																		1.000
	G																		1.000

*, ** and *** significant at 5%, 1% and 0.1% level respectively

PE = Plant emergence	NSPP = Number of shoots plant^{-1}	MTWPP = Marketable tuber weight plant^{-1}	HI = Harvest index %	SG = Specific gravity
PH = Plant height at maturity (cm)	DMCS = Dry matter content of shoots	UMTWPP = Unmarketable tuber weight plant^{-1}	DMCT= Dry matter contents of tuber	
NLPP = Number of leaves plant^{-1}	NTPP = Number of tubers plant^{-1}	NEPT = Number of eyes tuber^{-1}	SC = Starch content %	
NBPP = Number of branches plant^{-1}	TWPP = Tuber weight plant^{-1}	TE = Tuberization efficiency (tuber: Haulm ratio)	RS = Reducing sugar	

Table 2a: genotypic path analysis for eighteen yield and yield attributing traits of potato genotypes in 2019-20

S.N.	Characters	PE	PH	NLPP	NBPP	NSPP	DMCS	NTPP	TWPP	MTWPP	UTWPP
1	PE	0.1881	0.0728	0.1027	0.0479	0.0412	-0.0731	0.0186	-0.015	-0.0154	0.0323
2	PH	-0.0872	-0.2253	-0.0269	-0.0179	-0.0926	-0.0098	-0.0446	-0.0404	-0.026	-0.0782
3	NLPP	-0.0761	-0.0167	-0.1394	-0.1004	-0.0453	-0.0198	-0.0013	-0.0263	-0.0202	-0.0922
4	NBPP	0.062	0.0194	0.1752	0.2433	0.1782	0.0516	0.0044	0.1141	0.115	0.1866
5	NSPP	0.0789	0.1482	0.117	0.264	0.3605	0.0618	0.218	0.2846	0.2688	0.2314
6	DMCS	-0.3669	0.0409	0.1342	0.2002	0.1618	0.9437	-0.0156	0.0444	0.0791	0.5248
7	NTPP	0.0153	0.0307	0.0015	0.0028	0.0938	-0.0026	0.1551	0.0615	0.0616	0.0132
8	TWPP	0.0287	-0.0646	-0.0679	-0.1687	-0.2841	-0.0169	-0.1426	-0.3598	-0.3586	-0.1289
9	MTWPP	-0.032	0.0451	0.0566	0.1848	0.2917	0.0328	0.1553	0.3898	0.3912	0.1555
10	UTWPP	0.0035	0.0071	0.0134	0.0156	0.013	0.0113	0.0017	0.0073	0.0081	**0.0203**
11	NEPT	-0.04	-0.0701	-0.0866	-0.1254	-0.0719	-0.0873	-0.0894	-0.0669	-0.0983	-0.2203
12	TE	-0.0651	0.0648	0.0007	-0.0529	-0.0493	0.1613	-0.0471	-0.1552	-0.1481	0.1384
13	HI	0.1169	-0.0653	0.0256	0.1568	0.2202	-0.3015	0.1874	0.3655	0.3254	-0.2178
14	DMCT	0.0785	-0.2532	0.0246	-0.0686	-0.1453	-0.3378	0.0037	-0.2255	-0.2239	0.0565
15	SC	-0.0441	-0.018	-0.0293	0.0026	-0.0288	-0.0089	-0.0624	0.0049	0.0166	-0.0253
16	RS	0.2004	0.0562	-0.1234	-0.1663	-0.1673	-0.0257	-0.1262	-0.2715	-0.2209	-0.266
17	SG	0.0498	0.0371	0.0423	0.0582	0.079	-0.0029	0.013	0.0005	-0.0113	0.0381

Residual effect (0.22) on total tuber yield plot^{-1}, *, ** and *** Significant at 5%, 1% and 0.1% level respectively.

PE = Plant emergence	NSPP = Number of shoots plant^{-1}	MTWPP = Marketable tuber weight plant^{-1}	HI = Harvest index %	SG = Specific gravity.
PH = Plant height at maturity (cm)	DMCS = Dry matter content of shoots	UMTWPP = Unmarketable tuber weight plant^{-1}	DMCT= Dry matter contents of tuber	TTYPP = Total tuber yield plot^{-1}
NLPP = Number of leaves plant^{-1}	NTPP = Number of tubers plant^{-1}	NEPT = Number of eyes tuber^{-1}	SC = Starch content %,	
NBPP = Number of branches plant^{-1}	TWPP = Tuber weight plant^{-1}	TE = Tuberization efficiency (tuber: haulm ratio),	RS = Reducing sugar,	

Table 2b: Path analysis for eighteen yield and yield attributing traits of potato genotypes in 2019-20

S.N.	Characters	NEPT	TE	HI	DMCT	SC	RS	SG	TTYPP
1	PE	0.0318	0.0425	0.0357	-0.0195	0.05	-0.0606	0.1037	0.1106
2	PH	-0.0669	0.0507	0.0239	-0.0752	-0.0244	0.0204	-0.0926	-0.1909
3	NLPP	-0.0511	0.0003	-0.0058	0.0045	-0.0246	-0.0277	-0.0654	0.2205
4	NBPP	0.1292	0.0446	0.062	0.022	-0.0038	0.0651	0.1567	0.476
5	NSPP	0.1097	0.0617	0.129	0.069	0.0625	0.0969	0.3153	0.555
6	DMCS	0.3488	-0.5281	-0.4623	0.4201	0.0504	0.039	-0.0307	0.376
7	NTPP	0.0587	0.0253	0.0472	-0.0008	0.0582	0.0315	0.0223	0.2278
8	TWPP	-0.1019	-0.1937	-0.2137	-0.1069	0.0107	-0.1571	-0.002	0.1119
9	MTWPP	0.1629	0.2009	0.2068	0.1154	-0.0391	0.139	-0.0491	0.1430
10	UTWPP	0.019	-0.0098	-0.0072	-0.0015	0.0031	0.0087	0.0086	0.368
11	NEPT	-0.2362	0.0338	0.0261	-0.0018	0.0042	-0.1091	0.0111	0.0832
12	TE	0.0413	-0.2883	-0.2616	-0.0112	0.0304	-0.0483	0.011	-0.1216
13	HI	-0.0679	0.5583	0.6154	0.1092	0.1921	-0.0403	0.1178	0.0672
14	DMCT	-0.0059	-0.0296	-0.1346	-0.7589	-0.2201	0.3626	-0.0011	0.0136
15	SC	0.0029	0.0175	-0.0518	-0.0482	-0.1661	0.067	-0.0583	0.266
16	RS	-0.2872	-0.1043	0.0408	0.2972	0.251	-0.6219	-0.0477	-0.2279
17	SG	-0.0042	-0.0034	0.0173	0.0001	0.0317	0.0069	0.0903	0.490

Residual effect (0.22) on total tuber yield plot^{-1}, *,** and *** Significant at 5%, 1% and 0.1% level respectively

PE = Plant emergence	NSPP = Number of shoots plant^{-1}	MTWPP = Marketable tuber weight plant^{-1}	HI = Harvest index %	SG = Specific gravity.
PH = Plant height at maturity (cm)	DMCS = Dry matter content of shoots	UMTWPP = Unmarketable tuber weight plant^{-1}	DMCT= Dry matter contents of tuber	TTYPP = Total tuber yield plot^{-1}
NLPP = Number of leaves plant^{-1}	NTPP = Number of tubers plant^{-1}	NEPT = Number of eyes tuber^{-1}	SC = Starch content %,	
NBPP = Number of branches plant^{-1}	TWPP = Tuber weight plant^{-1}	TE = Tuberization efficiency (tuber: haulm ratio),	RS = Reducing sugar,	

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