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Genetic studies of variability, character association and path analysis of yield and its component traits in potato (*Solanum tuberosum* L.)

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ABSTRACT

Potato is one of fourth largest and versatile non-cereal food crop in the world. Considering the importance of potato the present investigation was taken up at the Instructional Farm BCKV, Nadia, West Bengal during 2012-2013 for 16 characters of 23 potato genotypes. Genotype G-4 was found to be tallest of growth which also shown good per-se performance with respect to leaf length, steam girth, lateral leaflet length and terminal leaflet breadth. The genotypes J-99/243, MS-1/4053, K. Khyati and K. Bahar were promising with respect to total production of tubers of which MS-1/4053, also accompanied by a number of superior yield related characters like highest plant height, steam girth and weight of tubers plant^{-1} and these line can be used in breeding program with other high yielding genotypes to increase productivity. High heritability coupled with high genetic advance was recorded in tuber breadth and tuber number. Number of tubers plot^{-1} and plant height showed positive correlations with maximum direct effect on yield and these characters can be considered for selection of high yielding genotypes on the basis of their phenotypic data because these character were least influenced by environment.

***Keywords*:** Correlation, path analysis, potato variability

Potato (*Solanum tuberosum* L.) is one of fourth largest and versatile non-cereal food crop in the world. India is now the world's second largest potato producing country and nearby one third of world's potato is being harvested from China and India (FAO, 2008). It produces more calories and protein per unit land area with minimum time and water than most of the major food crops (Upadhya, 1995). Potato cultivars are generally distinguished on the basis of morphological traits and have a wide variability of botanical characteristics. The existence of variability in a particular trait is an important prerequisite for its heritable improvement. The availability of morpho-genetic variation in agronomic characters of a crop would be of considerable importance in determining the best method to improve the yield of that crop. High yield with good quality is the most important objective in potato breeding. It was evident that yield and quality cannot be improved simultaneously rather independent selection for both may be beneficial (Datta *et al.*, 2014).Tuber yield is a complex character associated with many interrelated components. Study of correlation between different quantitative characters provides an idea of association that could be effectively utilized in selecting a better plant type in potato breeding programme. Genotypic and phenotypic correlation coefficients tell us the association between and among two or more characters. A significant association suggests that such characters could be improved simultaneously. However, such an improvement depends on phenotypic correlation, additive variance and heritability (Hayes *et al.*, 1955). It is necessary to have a good knowledge of those characters that have significant association with yield because the characters can be used to direct selection criteria or indices to enhance performances of varieties in a new plant population. Path coefficient analysis shows the extent of direct and indirect effects of the causal components on the response component (Tuncturk and ÇiftÇi, 2005). Considering the importance of potato on these aspects the present investigation was taken up to evaluate potato germplasm to identify genotypes with high yield and to study these genetic parameters which would be utilized for further improvement of potato through appropriate breeding programs.

MATERIALS AND METHODS

The field experiment was conducted at the Instractional Farm BCKV, Jaguli, Nadia, West Bengal during winter (*Rabi*) season, sown on 27th November 2012 and tubers were harvested in 27th February 2013. Twenty three potato genotypes namely Kufri. Jyoti, MS-1/4906, MS-1/1871, MS-1/3708, MS-1/4053, K. Sadabahar, K. Pukhraj, K. Anand, K. Chipsona-1, K. Chipsona-2, K. Khyati, K. Puskar, G4, K-22, K. Jawahar, K. Ashoka, K. Chandramukhi, K. Bahar, J-95/227, J-99/48, J-99/243, K. Surya, K. Sutlej were collected through Central Potato Research Institute (CPRI, Shimla). The experiment was laid following

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randomized block design with 3 replications. The unit plot size was 2 × 2 m with row to row spacing was 25 cm. The intercultural operations were done timely to raise a good crop. Observations were recorded from 10 randomly selected plants in each line for plant height (cm), branch number at 30 DAP (Days, leaves no. at 30 DAP, leaves length at 30 DAP, lateral leaflet length at 30 DAP, terminal leaflet length 30 at DAP, terminal leaflet breadth at 30 DAP, stem girth at 60 DAP, Plant height at 60 DAP, Number of tuber plant $^{-1}$, Weight of tuber plant $^{-1}$ (gm), Tuber Number, Single tuber weight (g), Tuber length (mm), Breadth of tuber (mm), Tuber yield (Kg plot^{-1}). Genotypic and phenotypic variation and coefficients of variation, broad sense heritability, genetic advance and genotypic correlation coefficients were estimated using the formula suggested by Singh and Chaudhury (1979), Johnson *et al.* (1955) and Al-Jibouri *et al.* (1958). Path coefficients analysis was done according to the method suggested by Dewey and Lu (1959). All the statistical analysis was carried out using Genres computer software.

RESULTS AND DISCUSSION

Analysis of genetic parameters for different morphological and yield characters

A wide range of variation was noticed in all the characters among the genotypes which indicated that diverse genotypes were included in the present investigation which may provide sufficient scope for further selection for improvement on these traits. This variability could be harnessed to gain improvement in yield and its attributing traits following appropriate breeding methods. Monsang *et al.* (2010) also found significant variation among potato genotypes for yield and its component traits. Genotype G-4 was found to be tallest at 30 days as well as 60 days of growth which also shown good ***per-se*** performance with respect to leaf length, steam girth, lateral leaflet length and terminal leaflet breadth. K. Surya had large number of branches and leaves (Table 1). Number of tubers plant^{-1} was highest in J-95/227, MS-1/4906 and weight of tuber plant^{-1} was found highest in J-95/227 followed by MS-1/4053. Highest tuber yield was observed in J-99/243, MS-1/4053, K. Khyati and K. Bahar. MS-1/4053 high yielding genotype was also accompanied by highest plant height, steam girth and wt. of tubers plant^{-1}, lateral leaflet length, terminal leaflet length, terminal leaflet breadth, steam girth, number of tuber per plant and number of tubers per plot.

The estimates of phenotypic and genotypic variances were found to be very high for weight of tuber plant^{-1}, tuber number, tuber breadth, and single tuber weight and comparatively high in plant height at 60 (Table 2). So, selection for improvement of potato could be done on the basis of characters showing high genetic variability. The magnitude of PCV was either substantially or marginally higher than GCV for most of the character. The characters having high GCV indicate high potential for effective selection (Burton, 1957). The difference between PCV and GCV was noted maximum for the characters terminal leaflet length, number of branches, leaf length, number of leaves, terminal leaflet breadth and these characters are suggested to be substantially influenced by the environment. Least difference between PCV and GCV were noted for weight of tuber per plant, number of tubers, single tuber weight, tuber yield, plant height, tuber dimension and these characters are least influenced by environment and on the basis of phenotypic values the selection can be reliably progressed to gain improvement on these traits. Estimates of genotypic coefficients of variation alone are not sufficient to assess the heritable variation. For more reliable conclusion, estimates of high heritability and high genetic gain should be considered together (Johnson *et al.*, 1955). The heritability estimates were high for weight of tuber plant^{-1}, tuber number, tuber breadth, plant height 60 days, tuber length and stem girth. High heritability coupled with high genetic advance was noted in weight of tuber plant^{-1}, single tuber weight and tuber breadth which indicated the influence of additive gene effect on these characters and simple breeding methods may be employed for carrying out improvement programme on these traits. Comparatively low heritability with low genetic advance was noted for terminal leaflet length, lateral leaflet length, number of tubers per plant which suggested non-additive gene action and complex breeding methods may be suggested for improvement of the traits. Genetic advance was found to be moderately high for number of branches with moderately high heritability and these characters are influenced by additive and non- additive gene action. Panse (1957) suggested that effective selection may be done for the characters having high heritability accompanied by high genetic advance which is due to the additive gene effect. He also reported that low heritability accompanied with genetic advance is due to non-additive gene effects for the particular character and would offer less scope for selection because of the influence of environment. Sattar *et al.* (2007) also reported high heritability coupled with high genetic advance as percent of mean and high genotypic coefficients were observed for number of tubers per plant, yield per plant and average weight of tuber.

Character association

Selection of a character for its improvement may simultaneously lead to selection of the associated characters. Therefore, in plant breeding it is essential to

Table 1: Mean of sixteen characters of twenty three genotypes in *S. tuberosum*

Genotypes	PH 30DS	BN 30DS	LN 30DS	LL 30DS	LLL 30DS	TLL 30DS	TLB 30DS	PH 60DS	SG 60DS	NT/P	WTT/P (gm)	TN	STW (gm)	TL (mm)	TB (mm)	T.Y (kg plot$_{-1}$)
K.Jyoti	23.80	2.40	25.40	13.93	9.60	5.00	4.53	42.23	26.32	4.40	227.93	62.66	110.65	69.95	56.02	2.98
MS-1/4906	22.96	2.23	19.43	13.73	9.80	5.33	4.73	55.76	35.49	6.26	230.66	61.46	105.37	67.12	54.41	2.91
MS-1/1871	17.73	2.90	23.56	12.30	7.20	4.56	4.10	50.76	31.66	4.76	211.05	29.66	112.82	73.22	43.90	0.87
MS-1/3708	21.03	3.10	28.90	13.70	9.16	5.36	4.13	51.40	32.85	5.06	189.73	35.17	97.14	75.55	45.54	1.55
MS-1/4053	24.40	2.90	25.86	16.73	10.56	6.66	5.60	63.33	37.72	5.73	296.05	72.19	102.28	69.40	55.39	3.54
K.Sadabahar	22.70	3.00	25.83	14.63	9.43	5.16	4.56	50.40	32.35	5.56	293.71	49.39	129.85	72.89	55.56	2.04
K.Pukhraj	23.23	2.16	22.56	14.33	8.73	5.66	4.36	40.53	27.28	5.06	182.03	53.47	98.81	73.80	55.33	2.95
K.Anand	25.86	2.10	20.50	14.60	8.66	5.23	4.00	49.73	27.68	5.56	279.92	48.93	82.49	68.67	46.55	2.00
K.Chipsona-1	16.70	2.66	20.56	10.53	7.40	4.46	3.66	51.57	33.08	5.46	247.88	56.71	116.84	64.59	60.17	1.75
K.Chipsona-2	23.36	2.43	22.73	14.60	9.86	5.63	4.20	54.70	32.44	5.20	229.75	45.10	109.90	79.82	57.86	2.83
K.Puskar	23.60	3.23	23.63	14.90	9.76	6.03	4.50	43.24	26.70	6.20	249.92	65.77	107.40	70.93	49.61	2.70
K.Khyati	24.40	3.03	26.70	14.83	9.56	5.26	4.36	55.86	35.13	5.50	230.05	88.58	104.51	73.38	103.85	3.16
G4	26.53	2.10	23.66	16.46	10.10	5.60	4.86	60.63	35.59	5.06	246.77	51.27	111.31	70.54	50.11	1.61
K22	25.26	2.50	24.63	13.76	8.66	4.96	4.06	47.80	28.19	6.03	268.49	52.56	109.74	63.60	59.46	2.10
K.Jawahar	14.16	2.16	15.50	12.03	7.33	4.76	4.43	46.59	29.55	4.63	273.91	44.10	103.92	73.61	54.63	1.75
K.Ashoka	20.26	3.50	25.70	13.06	8.50	5.90	5.03	45.37	28.52	5.73	237.06	54.50	94.69	72.55	47.64	2.68
K.Chandramukhi	24.73	3.30	26.23	16.33	8.70	5.80	3.46	42.38	26.37	6.20	233.97	67.51	103.57	68.40	51.52	2.41
K.Bahar	27.70	3.40	28.16	14.63	8.86	5.96	4.33	46.08	28.74	5.83	278.67	71.37	105.62	71.14	54.39	3.32
J-95/227	26.33	1.73	19.56	15.43	9.60	6.40	4.03	40.27	26.30	7.06	433.18	64.55	117.40	83.75	56.72	3.01
J-99/48	22.76	2.66	24.83	11.66	8.66	4.86	3.23	56.00	34.75	4.83	257.75	68.60	117.69	68.46	93.33	3.05
J-99/243	24.46	2.83	25.76	15.70	9.66	5.56	4.43	50.18	29.44	4.96	225.67	81.97	117.85	69.60	58.75	4.16
K.Surya	23.56	3.53	27.20	15.16	9.56	4.93	3.90	42.44	26.39	5.80	199.20	59.36	117.56	70.49	54.69	3.08
K.Sutlej	21.66	3.03	23.63	15.46	8.76	5.33	3.63	47.51	30.38	4.10	189.20	44.58	104.64	72.13	47.36	1.85
Grand Mean	22.92	2.73	23.93	14.28	9.05	5.41	4.27	49.34	30.56	5.43	248.37	57.80	107.91	71.46	57.08	2.53
SEm(±)	**0.723**	**0.172**	**1.057**	**0.640**	**0.408**	**0.290**	**0.168**	**0.685**	**0.585**	**0.295**	**1.034**	**0.791**	**0.930**	**0.603**	**0.670**	**0.164**
LSD (0.05)	**1.450**	**0.340**	**2.130**	**1.290**	**0.820**	**0.580**	**0.330**	**1.380**	**1.170**	**0.590**	**2.080**	**1.590**	**1.880**	**1.210**	**1.350**	**0.330**

***Note:** PH - plant height, BN - branch number, LN - leaves number, LL -leaves length, LLL - lateral leaflet , TLL- terminal leaflet length, TLB- terminal leaflet breadth, SG- tteam girth, NT/P- number of tuber plant^{-1},WT/P- weight of tuber plant^{-1}, TN- tuber number, STW- single tuber weight, TL- tuber length, TB-tuber breadth, TY-tuber yield*

Table 2: Variability and genetic parameters for different yield parameters of potato

Characters	Range	Mean	LSD	Variance			GCV	PCV	h^2	GA	GA
				GV	PV	EV					(%) of Mean
Plant ht. at 30 days	14.16 – 27.70	22.92	1.45	10.11	10.89	0.78	13.87	14.39	0.92	0.50	27.52
Plant height at 60 days	40.27 – 63.33	49.34	1.38	39.61	40.31	0.70	12.75	12.66	0.98	0.75	26.04
Branch no at 30 days	1.73 – 3.53	2.73	0.34	0.24	0.28	0.45	17.98	19.56	0.84	3.07	34.04
Leaves no at 30 days	15.50 – 28.90	23.93	2.13	9.47	11.15	1.67	12.85	13.94	0.84	0.48	24.41
Leaves length at 30 days	10.53 – 16.73	14.28	1.29	2.25	2.86	0.61	10.50	11.84	0.78	0.33	19.17
Lateral leaflet at 30 days	7.20 – 10.56	9.05	0.82	0.68	0.93	0.25	9.17	10.70	0.73	0.25	16.18
Terminal leaflet length at 30 days	4.46 – 6.66	5.41	0.58	0.27	0.39	0.12	9.59	11.61	0.68	0.21	16.31
Terminal leaflet breadth at 30 days	3.23 – 5.60	4.27	0.33	0.26	0.30	0.04	11.97	12.90	0.86	0.27	22.89
Steam girth at 60 days	26.30-37.72	30.56	1.17	12.52	13.03	0.51	11.57	11.81	0.96	0.53	23.38
No. of tuber plant^{-1}	4.10-7.06	5.43	0.59	0.42	0.55	0.13	12.03	13.74	0.76	0.27	21.69
Wt. of tuber plant^{-1} (g)	182.03-433.18	248.37	2.08	2679.72	2681.32	1.60	20.84	20.84	0.99	2.90	42.29
Tuber no.	29.66-88.58	57.80	1.59	197.88	198.82	0.93	24.33	24.39	0.99	1.07	50.01
Single tuber wt. (g)	82.49-129.85	107.91	1.88	95.44	96.75	1.30	9.05	9.11	0.98	1.26	18.52
Tuber length (mm)	63.60-83.75	71.46	1.21	19.10	19.65	0.54	6.11	6.20	0.97	0.83	12.42
Tuber breadth (mm)	43.90-103.85	57.08	1.35	194.88	195.56	0.67	24.45	24.49	0.99	1.07	50.29
Tuber yield (kg plot^{-1})	0.87-4.16	2.53	0.33	0.58	0.62	0.04	30.08	31.10	0.93	0.62	59.92

Note: *LSD = Least significant difference, GV= genotypic variance, PV= phenotypic variance, EV= environmental variance, GCV = genotypic coefficient of variation, PCV = phenotypic coefficient of variation, ECV = environmental coefficient of variation,* h^2 *= heritability (Broad sense),GA = genetic advance*

Table 3 : Genotypic and phenotypic correlation coefficient among different yield parameters of potato

Characters	G & P co-relation	BN 30DS	LN 30DS	LL 30DS	LLL 30DS	TLL 30DS	TLB 30DS	PH 60DS	SG 60DS	NTP^{-1}	WTP^{-1}	TN	STW (g)	TL (mm)	TB (mm)	TY (kg p^{-1})
PH 30DS	G	-0.03	0.43	0.76**	0.75**	0.62*	0.10	0.01	-0.12	0.45	0.27	0.50	-0.04	0.02	0.11	0.52
	P	-0.04	0.09	0.66*	0.64*	0.48	0.09	0.01	-0.12	0.38	0.26	0.48	-0.03	0.02	0.10	0.48
BN 30DS	G		0.75**	0.11	0.01	0.09	-0.01	-0.10	-0.06	0.01	-0.41	0.17	0.03	-0.19	-0.01	0.11
	P		0.68**	0.04	-0.05	0.006	-0.06	-0.10	-0.07	0.002	-0.38	0.16	0.04	-0.18	-0.01	0.10
LN 30DS	G			0.37	0.40	0.22	0.04	0.06	0.04	-0.03	-0.34	0.27	0.08	-0.10	0.13	0.27
	P			0.28	0.26	0.14	0.03	0.03	0.02	-0.02	-0.31	0.25	0.08	-0.11	0.12	0.23
LL 30DS	G				0.77**	0.73**	0.31	0.03	-0.09	0.27	0.12	0.35	-0.08	0.20	-0.17	0.40
	P				0.71**	0.65*	0.33	0.04	-0.05	0.23	0.11	0.31	-0.06	0.19	-0.15	0.34
LLL 30DS	G					0.66*	0.50	0.29	0.20	0.30	0.15	0.48	0.11	0.18	0.11	0.62*
	P					0.57*	0.42	0.27	0.21	0.26	0.12	0.41	0.08	0.16	0.08	0.53
TLL 30DS	G						0.49	-0.01	-0.05	0.58*	0.42	0.41	-0.25	0.39	-0.18	0.55*
	P						0.47	0.005	-0.03	0.37	0.35	0.34	-0.20	0.34	-0.14	0.44
TLB 30DS	G							0.33	0.30	0.11	0.11	0.13	-0.17	0.07	-0.22	0.25
	P							0.31	0.28	0.09	0.10	0.11	-0.15	0.05	-0.20	0.21
PH 60DS	G								0.94**	-0.18	-0.04	0.06	0.02	-0.20	0.30	-0.04
	P								0.93**	-0.15	-0.15	0.06	0.02	-0.19	0.29	-0.03
SG 60DS	G									-0.20	-0.07	0.04	0.11	-0.12	0.36	-0.08
	P									-0.16	-0.07	0.04	0.11	-0.11	0.35	-0.06
NT P^{-1}	G										0.62*	0.35	0.02	0.07	-0.02	0.27
	P										0.54	0.32	0.02	0.05	-0.02	0.26
WTP^{-1}(g)	G											0.22	0.21	0.31	0.06	0.15
	P											0.22	0.21	0.30	0.06	0.15
TN	G												0.14	-0.19	0.61*	0.83**
	P												0.13	-0.19	0.23	0.81**
STW(g)	G													0.04	0.23	0.10
	P													0.04	-0.05	0.09
T.L(mm)	G														-0.06	0.03
	P														-0.05	0.03
T.B(mm)	G															0.09
	P															0.38

Note: &**: at 5% & 1% level of significance, respectively*

Table 4: Path coefficient among different yield parameters of potato.

Character	PH 30DS	BN 30DS	LN 30DS	LL 30DS	LLL 30DS	T.LL 30DS	TLB 30DS	PH 60DS	SG 60DS	NT/P	WT/P	TN	STW (gm)	TL (mm)	TB (mm)	TY (kg P^{-1})
PH 30DS	**1.98**	-0.06	-0.57	-0.86	0.57	-1.13	0.007	-0.01	-0.16	-0.26	0.10	1.05	0.02	0.02	-0.18	0.52
BN 30DS	-0.07	**1.54**	-1.00	-0.12	0.008	-0.17	-0.001	0.07	-0.08	-0.01	-0.16	0.36	-0.01	-0.24	0.01	0.11
LN 30DS	0.86	1.17	**-1.32**	-0.42	0.30	-0.40	0.003	-0.04	0.05	0.02	-0.13	0.57	-0.04	-0.12	-0.21	0.27
LL 30DS	1.51	0.17	-0.49	**-1.13**	0.59	-1.32	0.02	-0.02	-0.12	-0.15	0.05	0.74	0.04	0.24	0.28	0.40
LLL 30DS	1.49	0.01	-0.53	-0.87	**0.76**	-1.19	0.03	-0.22	0.26	-0.17	0.05	1.02	-0.06	0.21	-0.18	0.62
TLL 30DS	1.24	0.14	-0.29	-0.83	0.50	**-1.80**	0.03	0.009	-0.07	-0.33	0.16	0.87	0.14	0.47	0.29	0.55
TLB 30DS	0.21	-0.02	-0.05	-0.35	0.38	-0.90	**0.06**	-0.25	0.39	-0.06	0.04	0.27	0.09	0.09	0.35	0.25
PH 60DS	0.03	-0.15	-0.08	-0.04	0.22	0.02	0.02	**-0.76**	1.21	0.10	-0.01	0.13	-0.01	-0.24	-0.48	-0.04
SG 60DS	-0.25	-0.09	-0.05	0.10	0.15	0.10	0.02	-0.72	**1.28**	0.11	-0.03	0.08	-0.06	-0.15	-0.58	-0.08
NT P^{-1}	0.89	0.02	0.05	-0.31	0.23	-1.04	0.008	0.14	-0.25	**-0.57**	0.24	0.75	-0.01	0.09	0.04	0.27
WT P^{-1}(gm)	0.54	-0.64	0.45	-0.14	0.11	-0.77	0.008	0.03	-0.10	-0.35	**0.39**	0.47	-0.11	0.37	-0.10	0.15
TN	0.99	0.26	-0.35	-0.40	0.37	-0.74	0.009	-0.05	0.05	-0.20	0.08	**2.10**	-0.07	-0.23	-0.97	0.83
STW(gm)	-0.08	0.05	-0.11	0.09	0.08	0.46	-0.01	-0.02	0.14	-0.01	0.08	0.29	**-0.55**	0.05	-0.38	0.10
TL(mm)	0.04	-0.30	0.13	-0.22	0.13	-0.71	0.005	0.15	-0.15	-0.04	0.12	-0.40	-0.02	**1.21**	0.09	0.03
TB(mm)	0.22	-0.01	-0.17	0.20	0.08	0.33	-0.01	-0.23	0.0.46	0.01	0.02	1.28	-0.13	-0.07	**-1.60**	0.39

Note: *Residual effect : 0.002 PH - plant height, BN - branch number, LN - leaves number, LL -leaves length, LLL - lateral leaflet , TLL- terminal leaflet length, TLB- terminal leaflet breadth, SG- tteam girth, NT/P- number of tuber plant^{-1},WT/P- weight of tuber plant^{-1}, TN- tuber number, STW- single tuber weight, TL- tuber length, TB-tuber breadth, TY-tuber yield* understand the inter-relationship among different characters so that improvement of the targeted character does not carry with it the non-targeted characters rather desirable characters could be simultaneously included which may lead to ultimate success on breeding programme. The correlation coefficients at genotypic level were in general higher than phenotypic correlation values. Higher genotypic correlations than phenotypic ones might be due to modifying or masking effect of environment in the expression of these characters under study as explained by Nandpuri *et al*., (1973). Johnson *et al*. (1955) also reported that higher genotypic correlation than phenotypic correlation indicated an inherent association between various characters. The tuber yield was positively and significantly correlated with lateral leaflet length at 30 days, terminal leaflet length at 30 days and tuber number plot^{-1} at genotypic as well as phenotypic levels (Table 3). Tuber number was found to have positive and significant association with tuber breadth and total tuber yield. Sattar *et al*., (2007) also reported highly significant genotypic and phenotypic correlation between number of tubers per plant and weight of tubers per plant. Plant height at 30 days was found to have positive and significant correlation with length of the leaves at 30 days, lateral leaflet length at 30 days, terminal leaflet length at 30 days both at genotypic and phenotypic levels and showed non-significant positive correlation in high magnitude both at genotypic and phenotypic levels with tuber yield per plant. Number of branches showed significant positive correlation with number of leaves both at genotypic and phenotypic levels but failed to show such relationship with total yield. Positive and significant relationship of tuber yield with tuber number, with lateral leaflet length at 30 days, terminal leaflet length at 30 days suggested that the tuber yield can be increased by simple selection of these characters.

Path coefficient analysis

While correlation values illustrate the inter-relationship between different characters, path coefficient splits the amount of inter relationship to measure contribution due to their direct and indirect effects. Therefore, in order to obtain a clear picture of the inter-relationship between different characters the direct and indirect effects of different characters on tuber yield plot^{-1} are presented in table 4. The path coefficient analysis developed by Wright (1921) provides an effective mean of untangling direct and indirect cases of relationship and permits a critical examination of the specific forces acting to produce a given correlation. Direct effects of independent characters viz. total number of tubers followed by plant height at 30 days, number of branches, stem girth, tuber length, lateral leaflet length at 30 days, terminal leaflet breadth at 30 days, weight of tuber plant^{-1} showed positive effect on yield. Number of leaves, length of the leaves, terminal leaflet length, plant height at 60 days, number of tuber plant^{-1}, single tuber weight, and tuber breadth incurred negative direct effect towards tuber yield plant^{-1}. Total tuber number imparted the maximum positive direct effect (2.10) on tuber yield plant^{-1} followed by plant height at 30 days, branch number at 30 days, stem girth at 60 days and tuber length. Roy and Singh (2006) observed plant height, no. of tubers plant^{-1} and marketable yield to exert positive direct effect on total yield. Some characters showed undesirable direct or indirect effect on total tuber yield like number of leaves, leaf length, terminal leaflet length therefore a restricted selection model may be followed to nullify the undesirable indirect or direct effects in order to make efficient use of characters with high positive direct effect and it was particularly true from plant height where number of characters have negative indirect effect along with its high direct effect on yield per plant. Yield was positively and significantly correlated with total tuber number, terminal leaflet length at 30 days with positive direct effect, therefore direct selection for these characters would be effective for yield improvement in potato.

The genotypes J-99/243, MS-1/4053, K.Khyati and K.Bahar were promising with respect to total production of tubers of which MS-1/4053, also accompanied by a number of superior yield related characters and the line can be used in breeding program with other high yielding genotypes to increase productivity. Number of tubers/plot and plant height showed positive correlations with maximum direct effect on yield and these characters can be considered for selection of high yielding genotypes on the basis of their phenotypic data because these character were least influenced by environment. As yield plot^{-1} was found to be controlled by additive gene effect so simple breeding methods may be followed to develop elite lines and for selection for such lines, the number of tubers plant^{-1} and tuber breadth may be given due consideration because these characters were also found to be pre dominantly controlled by additive genes.

REFERENCES

Al-Jibouri, H. A., Miller and Robinson, H. F. 1958. Genotypic and environmental variation and correlation in upland cotton cross of interspecies origin. *Agron, J*., **50**: 633-37.

Burton, W. G. 1957. The influence of sprout development at planting on subsequent growth and yield. The growth of potato. Proc. 10th Easter School in Agril. Sci., Univ. of Nottingham, 1963. Butter Worths, London. pp. 21-29.

CPRI 1995-96. *Annual Scientific Report*, Central Potato Research Institute, Shimla, HP, pp.31.

Datta, S. Das, R. Singh, D. Thapa, U and Mandal, A. R. 2014. Study of correlation among various characters of different potato (*Solanum tuberosum* L.) germplasm . *J. Crop Weed*, **10**:186-88.

Dewey, D. R. and K. I. Lu. 1959. A correlation and path coefficients analysis of components of crested wheat grass seed production. *Agron. J.* **1**: 515-18

FAO 2008. *International Year of the Potato* 2008. http://www.potato2008.org/

Hayes, H. K., Forrest, R. I. and Smith, D. C. 1955. *Methods of Plant Breeding Correlation and Regression in Relation to Plant Breeding*. McGrow - Hill Company Inc. 2nd Ed. pp. 439–57.

Johnson, H. W., H. F. Robinson and R. E. Comstock. 1955. Estimation of genetic and environmental variability in soybean. *Agron. J.*, **47**:314-18.

Monsang, T.L., Sarkar, K.K., Mandal, A.B. and Dewanjee, S. 2010. Genetic assessment on some important traits in potato with their correlation. *Env. Eco.*, **28**: 259-61.

Nandipuri, B. S., B. S. Singh and T. Lal. 1973. Studies on the genetic variability and correlation of some economic characters in tomato. *J. Res*., **10**: 316-21.

Panse, V. G. 1957. Genetics of quantitative characters in relation to plant breeding. *Indian J. Genet. Pl. Breed.*, **17**: 318-28.

Roy, A.K., Singh, P.K. 2006. Genetic variability, heritability and genetic advance for yield in potato (*Solanum tuberosum L.). Int. J.Pl.Sci.*, **1**:282-85.

Sattar, M.A., Sultana, N., Hossain, M.M. and Rashid. M.H. 2007. Genetic Variability, Correlation and Path Analysis in Potato (*Solanum Tuberosum* L.). *J. Pl. Breed. Genet.*, **20**: 33-38.

Singh, R. K. and Choudhary. B. D. 1979. *Biometrical Methods in Quantitative Genetic Analysis*. Revised ed. Kalyani Publishers, New Delhi. pp. 57.

Tuncturk, M. and ÇiftÇi, V. 2005. Selection criteria for potato breeding. *Asian J. Pl.Sci.*, **4**: 27-30.

Upadhya, M. D. 1995. The potential of true potato seed technology for increased potato production in Bangladesh. *Proc. Nat. Workshop on Nat. Prog. for True Potato Seed* (TPS) in Bangladesh, May 5, 1995, Bangladesh Agricultural Research Council, Dhaka.

Wright, S. 1921. Correlation and causation. *J. Agric. Res.*, **20**: 557–85.