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Studies on genetic variability, heritability and genetic advances of potato (*Solanum tuberosum* L.) genotypes for yield and yield attributing traits

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Abstract
An experiment was conducted to access the amount of genetic diversity, heritability and genetic advance present in twenty potato genotypes. The analysis of variance revealed that there were high significant differences present among the genotypes for all the traits, indicates presence of sufficient amount of variability. Phenotypic coefficient of variation (PCV) were higher than genotypic coefficient of variation (GCV) for all the characters, whereas moderate PCV and GCV were found for tuber weight plant^{-1} (g), marketable tuber weight plant^{-1} (g), number of tubers plant^{-1} and number of leaves plant^{-1}, indicating the influence of environment on expression of these traits. The high heritability accompanied with high genetic advance is reported for dry matter content of shoots and tuberization efficiency (Tuber: haulm ratio), so it shows that heritability is due to additive gene effects and suggested selection will be effective for these traits for yield improvement.

Keywords: Genetic variability, PCV, GCV, heritability and genetic advance

Introduction
Potato (*Solanum tuberosum* L.) belongs to family Solanaceae with chromosome number 2n =2x = 48. Potato is one of the most important staple food crop among the vegetables; which is utilized throughout the year in India. Due to its great utility potato occupies a pre-eminent place amongst the crops and acknowledges as the "King of Vegetables". Major potato producing States are Uttar Pradesh, West Bengal, Bihar, Gujrat, Madhya Pradesh, Punjab, Haryana and Assam.

Potato plants grow small green fruits similar to green cherry tomatoes after flowering, each containing about 300 seeds. For other parts of the plant apart from the tubers, the fruit contains the toxic alkaloid solanine and thus, unfit for use. After, blooming, fruiting, and tuber formation the leaves die off. Potato is a nutritious food containing carbohydrates, proteins, nutrients, vitamin C, vitamin B, dietary fibers of high quality and phenolic compounds (Woolfe, 1987) [16]. Potato contains 17%, carbohydrates (88%starch), 2% protein, and insignificant fat in raw potato with 79% of water. It provides 322 kilojoules (77) (kilocalories) of energy in 100 grams of raw potato. It is a rich source of vitamin B_6 (23%) and vitamin C (24%) with no substantial quantities of other vitamins or minerals. Potato is rarely eaten uncooked, since human digestion of raw potato starch is low. When a potato is cooked, the content of vitamin B_6 and vitamin C degrade predominantly, while the amount of other nutrients there is no noticeable change. Potato contain significant amounts of fiber. Fiber cuts down the aggregate sum of cholesterol in the blood, so decreases the risk of coronary disease. Potatoes are an extraordinary wellspring of nutrient B_6. This assumes an indispensable job in processing, by separating starches and proteins into glucose and amino acids.

Materials and Methods
A field experiment of 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 (Mainpat Ambikapur). The experiment was grown in Randomized Complete Block Design with three replication. The data observation were recorded on five randomly selected plants in each genotypes in each replication with mean data were calculated. The data were

subjected to genetic analysis as per (Panse and Sukhatme, 1968). The GCV and PCV parameters estimated by (Burton, 1952), heritability suggested by (Johnson *et al.*, 1955) [6] and genetic advance as percentage of mean calculated by (Johnson *et al.*, 1955) [6].

Results and Discussion

Estimates of Variability Components

Analysis of variance

The analysis of variance presented in Table 1. Analysis of variance revealed high significant differences for all the traits, indicating the presence of notable genetic variability among them. This will provide a good opportunity for the breeder to select genotypes for tuber yield performance and traits related to processing aspects. These findings are similar with earlier reports of Misgana *et al*. (2015) [7], Mohanty *et al*. (2016) [8] Getachew *et al*. (2016) [4], Habtamu *et al.* (2016) [5], Wassu (2016) [14], Wassu (2017) [15] and Zeleke *et al.* (2021) [17]. The mean performance of eighteen yield and yield attributing traits is given in table 2.

Phenotypic and Genotypic Variation

The phenotypic coefficient of variation (PCV) was higher than genotypic coefficient of variation (GCV) for all traits indicated a low environmental influence on expression of these traits (presented in Table 3). Sivasubramaniah and Menon (1973) categorized PCV and GCV coefficient of variation values low (<10%), moderate (10-20%) and high (> 20%). The phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV) ranged from 1.75 to 22.17% and 0.90 to 19.09%, respectively. The potato genotypes showed moderate PCV (Phenotypic coefficient of variation) and GCV (Genotypic coefficient of variation) for tuber weight plant^{-1} (g), marketable tuber weight plant^{-1} (g), number of tubers plant^{-1} and number of leaves plant^{-}1 similar finding were reported by similar results were reported by Rangare and Rangare (2017) [12] and Narsimhamurthy *et al.*, (2018) [9].

Estimate of Heritability and Genetic Advance

Estimates of heritability in the broad sense (h^2) and genetic advance as percent of the mean (GA) for 20 traits of potato genotypes are presented in Table 3. Heritability estimates along with genetic advance is more useful than heritability alone in predicting the effectiveness of selection Johnson *et al.*, (1955) [6]. The associated values for heritability in the broad sense and genetic advance as percent of mean ranged from 24 to 83% and 0.95 to 35.85%, respectively.

The highest genetic advance as percentage of mean was observed for dry matter content of shoots (35.85) and tuberization efficiency (28.95) while, moderate for tuber weight plant^{-1}(g) (19.84) and plant height at maturity (18.22) with rest of the other traits showed low genetic advance same results were obtained by Badu *et al.* (2017) [1] for trait dry matter content of shoots as highest genetic advance. The high heritability accompanied with high genetic advance is reported for the traits dry matter content of shoots (83%, 35.85%) and tuberization efficiency (tuber: haulm ratio) (63%, 28.95%) it indicates that heritability is due to additive gene effects and selection will be effective in this traits for yield improvement, similar finding were reported by Biswas *et al.* (2005) [2] and Pradhan *et al.* (2014) [14].

Table 1: Analysis of variance (ANOVA) for eighteen yield and yield attributing traits of potato genotypes

S.N.	Source	Replication	Treatment	Error
	Degree of Freedom	**2**	**19**	**38**
1	Plant emergence (%)	1.288	73.458**	12.88
2	Plant height at maturity (cm)	8.422	188.474**	8.643
3	Number of leaves plant^{-1}	571.109	9364.687**	935.325
4	Number of branches plant^{-1}	1.16	12.66**	1.542
5	Number of shoots plant^{-1}	0.245	1.821**	0.467
6	Dry matter content of shoots (%)	2.681	160.436**	3.534
7	Number of tubers plant^{-1}	0.383	9.693**	1.12
8	Tuber weight plant^{-1} (g)	1947.62	15286.831**	1482.5
9	Marketable tuber weight plant^{-1}(g)	1011.95	8896.283**	1213.84
10	Unmarketable tuber weight plant^{-1}(g)	8.28	267.833**	60.26
11	Number of eyes tuber^{-1}	0.39	1.836**	0.421
12	Tuberization efficiency (tuber: haulm ratio)	0.02	1.594**	0.096
13	Total tuber yield per plot^{-1} (kg)	0.846	13.022**	1.411
14	Harvest index (%)	122.228	199.65**	41.695
15	Dry matter content of tubers (%)	6.049*	21.142**	1.804
16	Starch content (%)	1.953	11.026**	0.85
17	Reducing sugar (mg/100gFW)	1230.555**	851.382**	218.161
18	Specific gravity	0	0.001**	0

Where * shows significant at 5% and ** shows significant at 1% level.

Table 2: Mean performance of eighteen yield and yield attributing traits of potato genotypes

S.N.	Genotype Character	PE	PH	NLPP	NBPP	NSPP	DMCS	DMCS	TWPP	MTWPP	UTWPP	NEPT	TE	HI	DMCT	SC	RS	SG	TTYPP
1	K. GANGA	91.56	44.79	222.18	8.81	5.89	17.60	7.30	266.489	224.985	42.44	6.16	2.48	71.26	20.91	12.07	245.00	1.04	11.265
2	WS/05-146	89.12	38.13	223.46	8.48	5.86	14.80	8.57	262.650	227.702	40.93	6.18	2.78	73.36	21.51	12.62	247.11	1.04	10.857
3	MS/8-1148	86.64	35.48	210.11	8.51	5.72	26.72	7.16	295.910	243.211	47.07	6.64	2.01	66.51	24.53	13.78	255.33	1.04	10.794
4	HT/7-1105	88.36	40.47	209.40	8.84	5.50	21.98	7.74	289.901	237.691	48.91	7.07	2.38	69.93	22.32	12.36	263.00	1.04	10.419
5	MS/9-2196	95.99	41.81	227.86	8.93	5.03	16.83	7.74	200.486	168.381	50.94	7.30	1.99	65.33	20.90	12.10	240.89	1.04	10.418
6	K. THAR-2	94.02	45.11	284.69	9.32	5.80	29.48	7.94	226.265	190.500	47.85	7.40	1.42	57.29	22.83	12.61	258.33	1.04	10.954
7	PS/7-7	92.75	51.26	275.73	9.93	5.62	18.82	6.73	331.432	268.346	61.15	7.27	2.10	67.43	21.99	12.42	258.22	1.04	9.566

8	K. THAR-3	91.02	35.43	227.35	9.98	5.61	25.32	6.85	271.607	226.053	55.33	7.22	2.00	65.46	20.54	12.64	247.00	1.05	13.925
9	P-MS/10-1529	95.81	41.04	291.64	10.50	5.92	17.46	8.18	313.211	250.761	55.90	7.40	2.93	73.62	21.90	14.14	264.00	1.05	10.810
10	MS/11-664	93.60	37.71	258.25	9.52	6.30	24.46	7.53	280.271	235.354	51.43	7.41	2.73	72.76	22.32	12.32	257.56	1.04	11.528
11	K. GARIMA	94.09	36.90	348.11	12.52	5.93	21.53	7.42	300.002	254.152	49.81	7.13	2.51	71.52	21.84	12.48	254.11	1.05	12.738
12	K. KHYATI	96.26	45.05	242.65	10.87	6.20	19.64	8.31	354.064	288.654	49.03	6.60	3.24	76.25	25.07	12.29	241.00	1.06	12.353
13	K. SINDURI	88.68	45.80	248.62	11.94	6.28	28.70	7.67	306.983	253.259	56.94	7.36	1.98	66.35	24.73	12.07	258.56	1.06	12.688
14	K. JYOTI	94.80	45.79	265.15	12.12	6.51	18.12	7.60	256.238	209.548	52.76	6.68	2.43	70.18	21.42	12.29	258.11	1.06	11.439
15	K. SURYA	94.64	38.92	239.90	9.84	6.42	17.56	7.30	262.529	212.913	52.01	6.70	2.38	69.42	20.01	13.59	257.78	1.06	12.781
16	K. MOHAN	93.31	41.35	268.14	9.60	5.88	24.80	7.53	264.712	205.984	59.79	6.37	1.87	63.81	21.03	12.93	258.78	1.07	12.595
17	K. ARUN	94.90	49.07	250.35	10.39	6.78	20.56	9.38	344.355	262.465	53.84	6.91	2.22	68.36	22.63	12.70	254.44	1.07	12.713
18	K. Neelkanth	94.55	41.19	255.18	10.87	6.83	24.28	10.35	354.612	296.344	60.69	7.79	2.52	71.46	21.81	13.05	257.11	1.06	13.560
19	K. Pukhraj (Check)	89.78	40.62	248.66	10.89	6.30	23.33	9.27	334.499	262.189	54.90	7.21	2.35	69.92	20.11	12.31	278.89	1.05	11.587
20	K.Chipsona-1 (Check)	94.56	48.83	264.17	10.63	6.43	25.57	10.28	283.892	232.067	54.03	6.69	1.94	78.56	24.62	16.90	235.33	1.07	13.393
	Mean	92.72	42.24	253.08	10.13	6.04	21.88	8.04	290.01	237.53	52.29	6.97	2.31	69.44	22.15	12.88	254.53	1.05	11.819
	C.V.	3.87	6.96	12.08	12.26	11.31	8.59	13.16	13.28	14.67	14.85	9.30	13.41	9.30	6.06	7.16	5.80	1.50	10.049
	C.D. 5%	3.34	2.74	28.48	1.16	0.64	1.75	0.99	35.86	32.45	7.23	0.60	0.29	6.01	1.25	0.86	13.76	0.01	1.106
	Range lowest	86.64	35.43	209.40	8.48	5.03	14.80	6.73	200.49	168.38	40.93	6.16	1.42	57.29	20.01	12.07	235.33	1.04	9.566
	Range highest	96.26	51.26	348.11	12.52	6.83	29.48	10.35	354.61	296.34	61.15	7.79	3.24	78.56	25.07	16.90	278.89	1.07	13.925

Where,

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 3: Genetic variability parameters for eighteen yield and yield attributing traits of potato genotypes

S.N.	Parameters/Characters	Range		GCV	PCV	h^2 (Broad Sense)	Genetic Advances as% of Mean	General Mean
		Min.	Max.					
1	Plant emergence (%)	86.63	96.25	2.80	4.78	34.00	3.38	92.72
2	Plant height at maturity (cm)	35.42	51.26	10.58	12.67	70.00	18.22	42.24
3	Number of leaves plant^{-1}	209.40	348.11	12.09	17.10	50.00	17.62	253.08
4	Number of branches plant^{-1}	8.47	12.52	10.98	16.46	45.05	15.08	10.13
5	Number of shoots plant-1	5.02	6.82	6.42	13.01	24.00	6.53	6.04
6	Dry matter content of shoots (%)	14.80	29.47	19.09	20.93	83.00	35.85	21.88
7	Number. of tubers plant^{-1}	6.73	10.35	12.14	17.90	46.00	16.95	8.04
8	Tuber weight plant^{-1}(g)	200.48	354.61	13.51	18.94	51.00	19.84	290.01
9	Marketable tuber weight plant^{-1}(g)	168.38	296.34	12.30	19.14	41.00	16.28	237.53
10	Unmarketable tuber weight plant^{-1}	40.92	61.14	9.19	17.46	28.00	9.95	52.29
11	Number of eyes tuber^{-1}	6.15	7.78	5.69	10.91	27.00	6.11	6.97
12	Tuberization efficiency (tuber:haulm ratio)	1.41	3.24	17.65	22.17	63.00	28.95	2.31
13	Harvest index (%)	57.28	78.56	6.03	11.09	30.00	6.76	69.44
14	Dry matter contents tuber (%)	20.00	25.06	6.62	8.98	54.00	10.05	22.15
15	Starch content (%)	12.07	16.90	8.25	10.92	57.00	12.85	12.88
16	Reducing sugar (mg/ 100gFW)	235.33	278.88	3.30	6.67	24.00	3.35	254.53
17	Specific gravity	1.03	1.07	0.90	1.75	26.00	0.95	1.05
18	Total tuber yield plot^{-1} (kg)	9.56	13.92	9.61	13.91	48.00	13.68	11.82

Conclusion

The difference between the values of PCV and GCV was low (<5%) for the majority of the traits. This suggested that most of the traits were less influenced by environmental factors and selection based on phenotype expression of the genotypes could be applied as breeding methods to improve the traits. The use of heritability and genetic advance is used to determining the degree of genetic gain from the selection of a trait. The selection efficiency for yield and processing quality can be obtained by identifying traits that exhibit high GA and heritability. The variation within the traits means that there is a possibility of maximizing gains during crop improvement. Dry matter content of shoots and tuberization efficiency are major traits used during selection for yield and processing quality.

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