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Study of genetic variability of tuber yield and storage related traits in potato (*Solanum tuberosum* L.)

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Abstract
The experiment was conducted in Randomized Block Design (RBD) with three replications at Potato Research Station, Sardarkrushinagar Dantiwada Agricultural University, Deesa during *rabi* 2017-18. The crop was harvested at 90 days after planting. The analysis of variance revealed that mean sum of squares due to genotypes were found highly significant for all the traits. This is proved that the existence of tremendous variability in the experimental material for different traits. However, from tuber yield point of view, MS/9-2196, J/7-37, K. Ganga and K. Anand were elite genotypes based on *per se* performance. The genotypes, K. Lauvkar, K. Sindhuri and DSP-7 exhibited low physiological weight loss, while genotypes, K. Surya, MS/12-655 and K. Ganga had low loss due to rottage on weight basis. Thus, these genotypes may be considered as good for storage ability at room temperature storage condition. The high heritability along with high genetic advance in plant height, leaf area, fresh weight of tops per plant, number of tuber per plant, tuber yield per plant, average tuber weight, physiological weight loss, loss due to rottage on weight basis, loss due to rottage on number basis and total weight loss, suggested that genotypic variation for the characters is probably attributed to high additive genetic effect and selection would be rewarding based on phenotypic performance.

Keywords: Tuber yield, storage life, potato genotypes, genetic variability, genetic advance and heritability

Introduction

Potato belongs to the family *Solanaceae* and genus *Solanum*, which comprises about 2000 species and the sub-section potato contains19 series and 235 species (Hawkers, 1944) [8], out of which 200 species are tuber bearing (Whitehead *et al.*, 1953) [21]. However, only two tuber bearing species *viz.*, *Solanum tuberosum* and *Solanum andigenum* have been exploited worldwide for commercial cultivation. The basic haploid and somatic chromosome number of *Solanum tuberosum* is believed to be 12 & 48 (tetraploid), respectively, which are grown throughout the world. There are about 74 per cent of tuber bearing species are diploid (2n =24) and the rest are tetraploid (2n=48), pentaploid (2n=60) and hexaploid (2n=72).

In India and particularly in Gujarat, the potato growing area is increasing at the rate of around 10 % in every year, so due to high production, the farmers facing the problem of market price of potato. Storage is necessary for considerable period of time after harvest for a regular supply of potatoes to the consumers during offseason. Improper storage conditions leads to physical and chemical quality loss in stored potatoes which affects their consumer acceptability. Physiological losses (respiration and transpiration) are generally low during dormancy period but increase rapidly as dormancy over and tubers starts sprouting and as the sprout growth progresses. Losses due to rotting or damage caused by pests, which accounts for the major wastage could occur before and after the termination of dormancy (Chourasia and Goswami, 2001) [6]. Many scientists conducted an extensive study on sprouting behavior and weight loss of potato varieties under controlled conditions, but, consolidated information on storage behavior of potato varieties under ambient conditions is lacking. Knowledge of the nature of variability and association of yield with its components is of great importance for identification of superior parents in any breeding programme. The proper evaluation and selection provides scope for identifying desirable genes for exploitation, either in itself or through hybridization.

The effectiveness of selection, in turn depends upon the genetic variability present in the population. The progress of breeding is conditioned by the magnitude, nature and interrelationship of genotypic and environmental variation in different characters. In that case, it becomes necessary to partition the observed variability into its heritable and non-heritable components with the help of suitable genetic parameters. The improvement in any crop depends upon the extent, nature and magnitude of genetic variability in the material and the extent to which it is heritable. Keeping these aspects in view, the research work was undertaken to assessed genetic variability for tuber yield, its attribute and storage related parameters in potato.

Material and Methods

The research material for present study comprises thirty-three diverse genotypes of potato collected from different eco-geographical area (Table 1). The field trial was conducted at Potato Research Station, Sardarkrushinagar Dantiwada Agricultural University, Deesa. The experiment was carried out in Randomized Block Design (RBD) with three replications during *rabi* 2017-18. Each genotype was represented by single row of 3.0 m length. The inter and intra row distances were 0.5 m and 0.2 m, respectively, which accommodated fifteen plants per plot of each genotype. All the recommended package of practices was followed for successful harvesting of the crop (Patel *et al*., 1986) [15]. The data were recorded from five randomly selected plants from each entry in each replication for nine characters viz., plant height (cm), leaf area (cm^2), number of stem per hill (No.), fresh weight of tops per plant (g), number of tuber per plant (No.), tuber yield per plant (g), average tuber weight (g), harvest index (%), tuber dry matter (%).

The storage study: At the harvest 5.0 kg potato tubers were taken from the each replications for storage study. The potato tubers were kept in sunhemp bags for 90 days at room temperature. At the beginning of the storage study, the total number of tubers (N_1) were counted. Again, five tubers were numbers 1 to 5 and initial weight of individual tuber was recorded in all the three replications. At the end of storage, total four storage study observations were recorded *viz*., physiological weight loss (%), loss due to rottage on weight basis (%), loss due to rottage on number basis (%) and total weight loss (%). The mean of the data recorded for the thirteen were used for statistical analysis. The analysis of variance was calculated with the method suggested by Panse and Sukhatme, 1985 [13]. The genotypic and phenotypic coefficients of variation (GCV and PCV) were estimated as per Burton, 1952 [4], while, classification of GCV and PCV were followed by Johnson *et al*., 1955 [9], Heritability in the broad sense and genetic advance (GA), suggested by Allard, 1960 [1]. The statistical analysis performed by Indostate software version 8.1.

Results and Discussion

The analysis of variance revealed that mean squares due to genotypes were found highly significant for all the traits. This is indicated that the existence of tremendous variability among the various traits thus, there may be a scope for improvement in these traits through selection (Table 2). The perusal of the data on mean performance (Table 3) indicating that the genotypes MS/9- 2196, J/7-37, K. Ganga and K. Anand were showed their superiority for tuber yield per plant. Potato having higher tuber dry matter is suitable for processing. The genotypes, CP-4175, MS/12-655 and Atlantic exhibited high tuber dry matter. The genotype having low physiological weight loss, weight loss due to rottage and total weight loss are the traits for suitability for the storage of potato. On the basis of the data on mean performance, genotypes K. Surya, MS/12-655, K. Ganga, K. Badshah, K.bahar and K. Sindhuri showed less weight loss under storage indicating better shelf life of these genotypes. The genotypes, K. Lauvkar, K. Sindhuri and DSP-7 exhibited low physiological weight loss, while genotypes, K. Surya, MS/12-655 and K. Ganga had low loss due to rottage on weight basis. Also same genotypes showed low loss due to rottage on number basis and total weight loss after the 90 days of storage. Thus, these genotypes may be considered as good keeper (shelf life) under room temperature storage.

The estimates of genotypic and phenotypic variances revealed that all the characters showed predominance of genotypic variance in total phenotypic variance (Table 4). So, expression of such characters showed low influence of environmental factors.

The traits fresh weight of tops per plant, number of tuber per plant, tuber yield per plant, average tuber weight, harvest index, loss due to rottage on weight and number basis and total weight loss showed high GCV and PCV values (Fig 1) suggested considerable scope for improvement of these traits by selection. High estimates of GCV and PCV in potato have been observed for tuber yield per plant and average tuber weight by Hajam *et al.* (2018) [7]; Rangare and Rangare (2013) [17] and Singh *et al.* (2015) [19] for fresh weight of tops per plant; Hajam *et al.* (2018) [7] and Pradhan *et al.* (2014) [16] for number of tuber per plant; Chandrakar (2007) [5] and Mishra *et.al* (2017) [11] for harvest index and Luthra *et al.* (2018) [10] for loss due to rottage on weight and total weight loss.

Moderate GCV and high PCV were recorded for physiological weight loss (Fig 1). Similar result was recorded by Luthra *et al.* (2018) [10]. Plant height, leaf area and number of stem per hill have moderate values of GCV and PCV. Similar results were recorded by Basavaraja *et al.* (2005) [2] and Biswas *et al.* (2005) [3] for plant height; for leaf area by Pradhan *et al.* (2014) [16]; for number of stem per hill by Hajam *et al.* (2018) [7]. Low GCV and PCV were recorded for tuber dry matter and similar result was recorded by Roy and Singh (2006) [18]. Low PCV with low GCV value in this character indicated less variability for this trait in the genotypes studied and expressed poor response to selection.

The per cent genetic advance was high (46.85 %) coupled with high heritability was also recorded for this trait (94.07 %) indicated that total weight loss is governed by additive gene action. High values of heritability in broad sense are helpful in identifying the appropriate character for selection and in enabling the breeder to select superior genotypes on the basis of phenotypic expression and its utilization in future breeding programme. High heritability was observed for traits *viz.*, plant height, leaf area, number of stem per hill, number of tuber per plant, tuber yield per plant, fresh weight of tops per plant, harvest index, average tuber weight, physiological weight loss, tuber dry matter, loss due to rottage on weight and number basis and total weight loss (Fig 2). Similar results were recorded for plant height by Tripura *et al.* (2016) [20]; Pradhan *et al.* (2014) [16] for leaf area; Patel *et al.* (2017) [14] for number of stem per hill; Singh *et al.* (2015) [19] for fresh weight of tops per plant; Tripura *et al.* (2016) [20] and Patel *et al.* (2017) [14] for number of tuber per plant; Mishra *et al.* (2017) [11] for tuber yield per plant; Panigrahi and Pradhan (2017) for harvest index; Chandrakar (2007) [5] and Tripura *et* *al.* (2016) [20] for average tuber weight; Roy and Singh (2006) [18] and Patel *et al.* (2017) [14] for tuber dry matter and for loss due to rottage on weight and basis and total weight loss by Luthra *et al.* (2018) [10].

The high heritability coupled with high genetic advance indicated that heritability in genotypes were due to additive gene effects indicating better scope for the improvement in the characters by effective selection of genotypes. The traits leaf area, fresh weight of tops per plant, number of tuber per plant, tuber yield per plant, harvest index, physiological weight loss, loss due to rottage on weight and number basis and total weight loss were exhibited high heritability with high genetic advance which could be effectively improved by selection (Fig 2). The result are close with by Ahmad *et al.* (2005), Ummyaih *et al.* (2010) and Pradhan *et al.* (2014) [16] for leaf area; Hayder *et al.* (2009) for fresh weight of tops per plant; Tripura *et al.* (2016) [20], Patel *et al.* (2017) [14] and Ummyaih *et al.* (2010) for number of tuber per plant; Sattar *et al.* (2007), Ara *et al.* (2009) and Mishra *et al.* (2017) [11] for tuber yield per plant; Panigrahi *et al.* (2017) [12] and Mishra *et al.* (2017) [11] for harvest index and Luthra *et al.* (2018) [10] for physiological weight loss, loss due to rottage on weight basis and total weight loss.

Based on over all result, it would be reasonable to suggest that a breeder engaged in the improvements of potato tuber yield per plant should place emphasis on number of stem per hill, number of tuber per plant, average tuber weight and total weight loss. Selection for these traits will therefore directly become helpful in increasing the tuber yield.

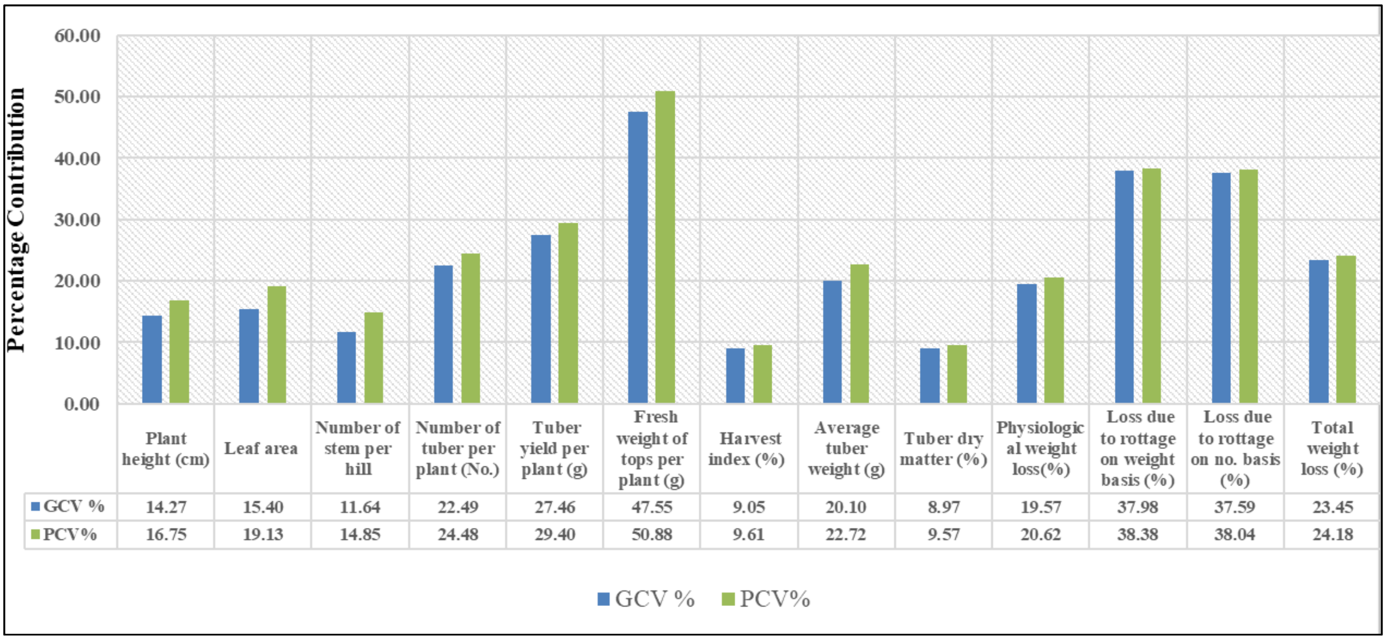

Fig 1: The estimates of genotypic and phenotypic coefficient of variation (%) for different traits in potato

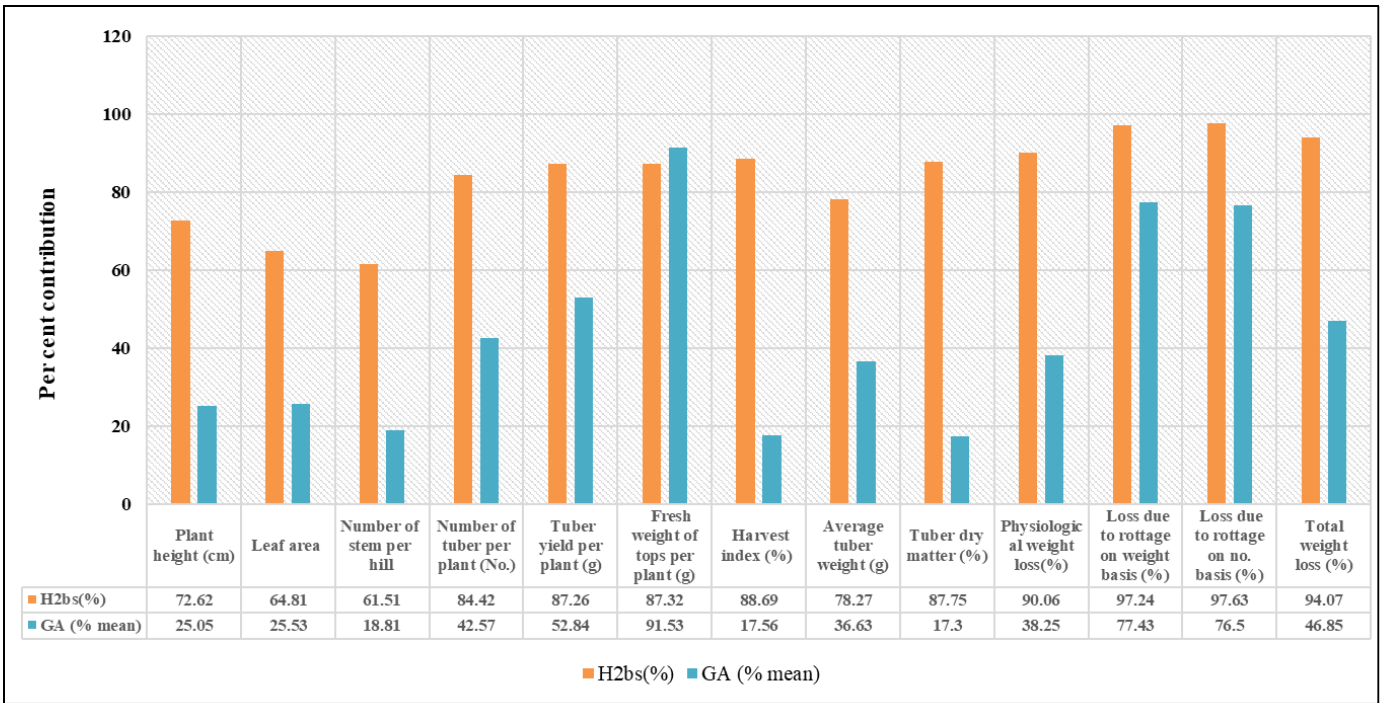

Fig 2: The estimates of Heritability (%) and Genetic advance per mean (%) for different traits in potato

Table 1: List of genotypes used in present study

S. N	Genotypes	Source	S.N	Genotypes	Source	S.N	Genotypes	Source
1	K. Badshah	CPRI, Shimla	12	K. Frysona	CPRI, Shimla	23	CP-4406	CIP, Lima
2	K. Pukhraj	CPRI, Shimla	13	K. Sinduri	CPRI, Shimla	24	MP/4-816	CPRS, Modipuram
3	K. Khyati	CPRI, Shimla	14	K. Sutlej	CPRI, Shimla	25	MCIP/11-118	CIP, Lima
4	K. Surya	CPRI, Shimla	15	K. Sadabahar	CPRI, Shimla	26	MS/12-1906	CPRS, Modipuram
5	K. Jyoti	CPRI, Shimla	16	CP 4175	CIP, Lima	27	J/7-37	CPRS, Jalandhar
6	K. Bahar	CPRI, Shimla	17	MS/12-96	CPRS , Modipuram	28	J/10-83	CPRS, Jalandhar
7	K. Anand	CPRI, Shimla	18	CP-4393	CIP, Lima	29	DSP-7	PRS, Deesa
8	K. Lauvkar	CPRI, Shimla	19	J/7-15	CPRS, Jalandhar	30	MS/12-896	CPRS, Modipuram
9	K. Garima	CPRI, Shimla	20	MS/8-1148	CPRS, Modipuram	31	J/6-182	CPRS, Jalandhar
10	K. Gaurav	CPRI, Shimla	21	MS/9-2196	CPRS, Modipuram	32	Atlantic	Exotic culture
11	K. Ganga	CPRI, Shimla	22	CP-4403	CIP, Lima	33	MS/12-655	CPRS, Modipuram
K = Kufri								

Table 2: Analysis of variance for different traits in potato

Source of variation	D.F.	Plant height (cm)	Leaf area (cm^2)	Number of stem per hill (No.)	Fresh weight of tops per plant (g)	Number of tubers per plant (No)	Tuber yield per plant (g)	Average tuber weight (g)	Harvest index (%)	Tuber dry matter (%)	Physiological weight loss (%)	Loss due to rottage on weight basis (%)	Loss due to rottage on number basis (%)	Total weight loss (%)
Replications	2	41.21	102377	0.28	344.30	0.66	4358.94	30.82	20.02	0.11	2.25	0.18	0.29	3.46
Genotypes	32	131.002**	892174**	0.72**	6678.41**	7.98**	45143.83**	501.10**	170.91**	8.92**	24.14**	152.308**	176.46**	205.76**
Error	64	14.62	136715	0.12	308.31	0.46	2095.60	42.43	6.96	0.39	0.86	1.06	1.41	4.23
S.Em.(±)		2.17	210	0.20	9.98	0.38	26.02	3.70	1.50	0.35	0.53	0.58	0.67	1.17
CD 0.05 %		5.77	558.09	0.53	26.50	1.02	69.09	9.83	3.98	0.95	1.39	1.55	1.79	3.10
*, ** Significant at 5 % and 1 % levels, respectively.														

Table 3: Mean values of genotypes for different characters in potato

S. N	Genotype	PH	LA	NSH	FWT	NTP	TY	ATW	HI	TDM	PWL	LR.Wt	LR.No	TWL
1	MS/12-655	48.46	2604.63	4.20	151.66	8.06	498.57	61.87	76.86	21.60	14.35	4.41	6.16	20.10
2	K. Ganga	48.53	2700.50	4.46	59.00	7.66	599.09	77.12	90.94	17.53	11.28	9.08	9.57	24.10
3	MS/8-1148	39.93	2915.39	3.93	69.00	10.53	508.85	49.88	88.12	17.53	16.68	15.67	16.83	35.90
4	J/7-15	40.96	2786.39	3.93	90.33	7.06	549.29	76.54	85.77	19.00	13.94	26.81	26.49	41.56
5	K. Anand	51.06	2839.44	4.33	99.33	7.46	578.93	79.79	85.40	18.73	15.63	10.63	13.55	27.50
6	K. Surya	43.33	2969.69	4.80	93.66	7.80	562.53	72.74	85.54	20.73	11.03	3.26	6.03	15.26
7	K. Khyati	40.80	3297.12	4.40	79.66	8.73	539.49	61.20	87.15	17.20	14.11	20.34	30.80	38.10
8	K. Badshah	54.06	3486.54	3.80	188.66	6.66	487.67	74.10	71.97	20.00	14.16	12.06	12.65	26.74
9	K. Pukhraj	37.53	3736.66	3.33	154.66	10.06	520.27	51.59	77.08	16.60	15.73	15.29	12.74	31.66
10	CP-4393	51.33	3068.44	4.66	40.70	9.46	571.48	60.03	93.26	19.33	15.74	19.25	19.92	34.60
11	CP-4175	57.20	3974.08	3.33	243.33	4.70	491.75	74.23	66.86	21.60	12.87	25.47	36.79	36.46
12	MP/4-816	41.20	2563.69	4.26	38.46	8.00	300.74	38.14	88.68	17.46	13.20	21.36	20.33	35.50
13	K. Bahar	40.66	2824.98	3.93	36.00	7.20	326.69	45.23	90.12	16.26	11.01	13.16	16.80	25.90
14	CP-4406	51.46	4126.02	3.06	170.66	4.66	512.68	75.04	74.90	20.13	12.22	13.12	13.74	28.16
15	K. Jyoti	40.30	4578.95	3.93	119.00	7.73	496.33	64.89	80.71	18.73	13.43	23.39	21.66	37.56
16	K. Frysona	53.33	3032.65	4.20	97.33	7.20	405.55	56.65	80.61	20.53	15.68	14.62	20.16	33.66
17	CP-4403	40.06	4073.56	3.66	103.66	5.53	277.27	50.55	72.84	20.73	15.55	20.94	21.82	36.73
18	J/6-182	38.13	3309.90	4.06	73.66	6.36	383.03	59.63	83.88	20.40	19.70	24.76	24.63	42.86
19	Atalantic	36.80	3159.92	3.33	80.00	5.03	283.92	56.81	78.01	20.86	14.75	25.16	26.41	42.20
20	K. Sindhuri	53.86	3506.59	3.93	59.33	8.33	354.55	45.52	85.57	18.46	7.65	15.36	16.86	25.30
21	MS/9-2196	45.46	3108.57	4.00	96.00	9.66	673.84	69.05	87.58	16.00	18.22	31.30	32.69	50.46
22	K. Garima	30.73	3496.20	3.93	64.33	6.33	364.49	59.42	85.18	16.46	16.59	30.68	30.92	48.56
23	MCIP/11-118	41.00	3047.12	3.86	72.96	5.73	367.24	64.28	83.34	19.66	13.06	17.54	16.82	33.76
24	MS/12-1906	44.73	3386.65	3.53	126.00	5.33	237.83	45.29	65.12	16.93	14.37	24.27	23.09	40.66
25	K. Gaurav	43.46	3224.61	2.93	73.33	8.26	499.75	61.96	87.18	20.73	15.26	22.53	26.11	41.05
26	J/7-37	36.46	3627.46	3.60	81.33	8.36	636.32	75.66	88.68	17.20	17.99	28.18	31.03	47.50
27	K. Sadabahar	39.66	2591.10	4.13	137.50	6.20	374.59	60.70	73.31	17.40	17.96	21.66	22.29	41.40
28	K. Sutlej	46.06	4222.56	3.46	150.33	5.73	294.98	52.13	66.30	17.60	15.97	15.91	16.72	34.63
29	MS/12-96	46.86	3946.45	2.73	86.33	5.43	298.62	55.55	77.66	17.86	16.48	21.69	21.96	39.63
30	K. Lauvkar	38.73	2842.91	3.13	33.00	4.53	370.49	80.36	91.81	16.86	7.27	16.41	18.89	28.41
31	DSP-7	38.86	2516.34	3.46	88.00	7.53	334.45	44.88	78.94	20.46	10.02	10.57	13.79	30.96
32	MS/12-896	48.40	2548.12	3.93	86.33	5.40	476.12	88.03	84.65	21.06	15.33	27.90	29.56	46.30
33	J/10-83	30.60	3441.84	3.60	54.40	5.53	218.22	40.62	80.05	18.93	12.43	13.99	12.70	30.03
Grand Mean		43.64	3258.95	3.81	96.90	7.04	436.23	61.51	81.54	18.80	14.23	18.69	20.32	34.94
Range		30.60-57.20	2516.34-4578.95	2.73-4.80	33.00-243.33	4.53-10.53	218.22-673.84	38.14-88.03	65.12-93.26	16.00-21.60	7.27-19.70	3.26-31.30	6.03-36.79	15.26-50.46
S.Em.(±)		2.20	213.47	0.20	10.13	0.39	26.42	3.76	1.52	0.36	0.53	0.59	0.68	1.18
CV (%)		8.76	11.34	9.21	18.11	9.66	10.49	10.59	3.23	3.34	6.50	5.50	5.85	5.88

PH= Plant height, LA= Leaf area, NSH= Number of stem per hill (No.), NTP= Number of tuber per plant (No.), TY= Tuber yield per plant (g), FWT= Fresh weight of tops per plant (g), ATW= Average tuber weight (g), TDM = Tuber dry matter (%), HI= Harvest index (%), PWL=Physiological weight loss (%), LR.Wt= Loss due to rottage on weight basis (%), LR.No. = Loss due to rottage on number basis (%), TWL= Total weight loss (%).

Table 4: The estimates of genotypic and phenotypic variances for different traits in potato

Source of variation	Plant height (cm)	Leaf area (cm²)	Number of stem per hill (No.)	Fresh weight of tops per plant (g)	Number of tubers per plant (No)	Tuber yield per plant (g)	Average tuber weight (g)	Harvest index (%)	Tuber dry matter (%)	Physiological weight loss (%)	Loss due to rottage on weight basis (%)	Loss due to rottage on number basis (%)	Total weight loss (%)
σ^2_g	38.79	251819.87	0.19	2123.37	2.50	14349.41	152.89	54.64	2.84	7.76	50.41	58.35	67.17
σ^2_p	53.42	388534.99	0.32	2431.68	2.97	16445.01	195.33	61.61	3.24	8.62	51.48	59.76	71.41

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