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Genetic Variability Among the Potato (*Solanum tuberosum* L.) Genotypes as Affected by Harvesting Period for Processing Purpose and Tuber Yield

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Abstract

The experiment was conducted in Randomized Block Design (RBD) with three replications in two sets of harvest period i.e. 90 and 105 days after planting (DAP) for tuber yield and processing traits in potato. The analysis of variance revealed that mean sum of squares due to genotypes was found highly significant for all the traits under study. The genotypes of MS/06-1947, K. Sadabahar and K. Khyati for 90 days and J/10-162, K. Sadabahar and MP/06-39 for 105 DAP were found promising for tuber yield per plant based on per se performance. The genotypes of MP/09-901, MP/04-578 and MP/04-816 exhibited high tuber dry matter, while, the genotypes, K. Himsona, K.Chipsona 1 and K.Chipsona 2 had low reducing sugar under both 90 and 105 days of harvest. The low chip colour index was exerted by genotypes of K. Chipsona 2, K. Chipsona 1, K. Chipsona 3, K. Chipsona 4 and K. Frysona under 90 days, whereas, K. Chipsona 2, Atlantic and K. Chipsona 3 under 105 days of harvest. Therefore, these genotypes suited as processing purpose. The high heritability along with high genetic advance in leaf area, number of stems per hill, number of tubers per plant, processing grade tuber yield per plant, chip colour index, reducing sugar and total soluble solids under both harvesting periods, recommended that genotypic difference for the characters ascribed to high additive genetic cause and selection would be wrathful based on phenotypic performance.

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Introduction

Potato belongs to the family *Solanaceae* and genus *Solanum*, which comprises about 2000 species and the sub-section potato contains 19 series and 235 species[1] , out of which 200 species are tuber bearing.[2] However, only two tuber bearing species *viz., Solanum tuberosum* and *Solanum andigenum* have been commercially cultivated throughout the world. The basic haploid chromosome number of *Solanum tuberosum* is believed to be 12.[3] The somatic chromosome number of cultivated potato species is 48 (Tetraploid), which is grown throughout the world. About 74 per cent of tuber bearing species are diploid (2n = 24) and the rest are polyploid viz., tetraploid (2n = 48), pentaploid (2n = 60) and hexaploid (2n = 72).

Potato is having diversified use as vegetable, processed food, livestock feed and raw material for many industrial product. It is one of the most popular vegetables, which is available throughout the year in vegetable market due to its long term storability. Now-a-day many dehydrated products like diced franules, baries, papad, biscuits, flour etc., while, fried snacks like chips, French fries etc. are prepared from the potato. Potato is widely used as raw materials in starch extraction industries. Potato tuber contains about 75 to 80 percent water, 16 to 20 percent carbohydrates, 2.5 to 3.2 percent crude protein, 1.2 to 2.2 percent true protein, 0.8 to 1.2 percent mineral, 0.1 to 0.2 percent crude fat, 0.6 per cent crude fiber and vitamins B and C.[4]

All the cultivated varieties available in the country are not suitable for processing.[5] To determine the quality of the processed potato product, dry matter and reducing sugar content of potato tuber are the two important parameters.[6] High level of reducing sugar results in dark colour of fried products. Thus, the potato required for processing need to have tuber dry matter in the range of 21 to 23 percent and reducing sugars below 150 mg per 100 g fresh weight of tubers.[7]

Information on the nature and magnitude of variability present in the population is a prerequisite for initiating any systematic breeding program. Considering the importance of yield in plant breeding program, thus it is major objective of a plant breeder but yield is the complex and polygenic character, which is highly influenced by environment. Hence, it is essential to know the relationship between various traits that have direct and indirect effects on yield. The knowledge of association between characters under study, especially yield and it's contributing traits in segregating population is useful for selection. Estimates of heritability for different characters under study provide clear picture for amount of heritable variation presence in different traits. Moreover, heritability in broad sense with higher genetic advance is a reliable measure of the amount of genetic gain through selection.[8]

Material and Methods

The research material for present study comprises 40 potato genotypes. The field trial was conducted at Potato Research Station, Sardarkrushinagar Dantiwada Agricultural University, Deesa with two harvested periods of 90 (H_1) and 105 (H_2) days after planting (DAP). The experiment was carried out in Randomized Block Design (RBD) with three replications during *rabi* 2016-17. Each genotype was represented by single row of 3.0 m length. The inter and intra row distances were 50 and 20 cm, respectively, which accommodated fifteen plants per plot of each genotype. All the recommended package of practices was followed for successful harvesting of the crop.[9] The data were recorded from five randomly selected plants from each entry in each replication for plant height (cm), leaf area (cm^2), number of stems per hill, number of tubers per plant, total tuber yield per plant (g), processing grade tuber yield per plant (g), Mean tuber weight (g), tuber dry matter (%), chip colour index (1-10), reducing sugar (%), total soluble solids (^{0}Brix). The mean of the data recorded were used for statistical analysis. The analysis of variance was calculated with the standard method.[10] The genotypic and phenotypic coefficients of variation (GCV and PCV) were estimated standard method[11], while, GCV and PCV were followed the standard classification[8], Heritability in the broad sense and genetic advance (GA) were also calculated by standard method.[12]The statistical analysis performed by Indostate software version 8.1.

Results and Discussion

The analysis of variance revealed that mean square due to genotypes was found highly significant for all the traits under study in both harvesting periods

(H_1 and H_2). 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 1).

Table 1: Analysis of variance (ANOVA) showing mean squares of different traits in potato

Source of variation	d.f.	Plant height (cm)		Leaf area (cm^2)		Number of stems per hill		Number of tubers per plant		Total tuber yield per plant(g)		Processing grade tuber yield per plant (g)	
		H_1	H_2	H_1	H_2	H_1	H_2	H_1	H_2	H_1	H_2	H_1	H_2
Replications	2	24.25	7.60	4115677.00	1795500.40	0.25	0.54	0.56	0.15	4753.13	4369.25	2572.83	953.53
Genotypes	39	158.22**	151.92**	1129960.30**	1303430.90**	2.21**	1.77**	6.48**	9.53**	19824.65**	20141-35**	19352.20**	21537.86**
Error	78	23.59	32.82	1497955.91	1702401.40	0.28	0.21	0.66	0.36	3130.82	3834.47	1351.77	1860.23
S.Em. ±		2.80	3.31	223.45	238.27	0.31	0.27	0.47	0.35	32.30	35.75	21.23	24.90
C.D. (P = 0.05)		7.90	9.31	629.14	670.70	0.86	0.75	1.32	0.98	90.95	100.66	59.76	70.11
C.V. (%)		11.92	13.48	13.97	14.58	16.51	15.63	9.35	7.79	12.92	13.69	10.21	10.89

Source of variation	d.f.	Mean tuber weight (g)		Tuber dry matter (%)		Chip colour index (1-10)		Reducing sugar (%)		Total soluble solids (^{0}Brix)	
		H_1	H_2	H_1	H_2	H_1	H_2	H_1	H_2	H_1	H_2
Replications	2	7.38	128.52	0.02	1.08	0.08	0.02	0.002	0.002	0.02	0.02
Genotypes	39	441.24**	737.80**	7.64**	5.97**	10.14**	11.41**	0.129**	0.129**	1.35**	1.37*
Error	78	93.77	140.85	0.26	0.36	0.03	0.03	0.009	0.009	0.01	0.01
S.Em.±		5.59	6.85	0.30	0.35	0.11	0.10	0.017	0.017	0.05	0.05
C.D. (P = 0.05)		15.74	19.29	0.83	0.98	0.30	0.28	0.049	0.049	0.14	0.15
C. V. (%)		17.42	17.75	2.84	3.15	4.55	4.39	7.77	9.43	2.02	2.13

*,** Significant at 5 % and 1% level, respectively

H_1 = Harvest at 90 DAP,

H_2 = Harvest at 105 DAP.

The high range of variability of mean value for tuber yield per plant was recorded in both H1 [268.00 (IPS/09-19-10) to 561.67 g (MS/06-1947)] and H2 [307.67 (IPS/09-19-10) to 631.33 g (J/10-162)] conditions with 432.96 and 465.92 g mean, respectively. The genotypes of MS/06-1947, K. Sadabahar and K. Khyati for 90 days and J/10-162, K. Sadabahar and MP/06-39 for 105 DAP were found promising for tuber yield per plant based on per se performance. The estimates of genotypic and phenotypic variances were (5564.61 and 5435.63) and (8695.43 and 9270.10) for tuber yield per plant under both harvesting periods, respectively (Table 2).

Table 2: Range, mean and components of variances of various characters in potato

Parameter	Plant height (cm)		Leaf area (cm^2)		Number of stems per hill		Number of tubers per plant		Total tuber yield per plant (g)		Processing grade tuber yield per plant (g)	
	H_1	H_2	H_1	H_2	H_1	H_2	H_1	H_2	H_1	H_2	H_1	H_2
	27.67-58.73	29.27-59.20	1738.96-4010.36	1812.21-4202.10	1.73-5.60	1.93-5.73	5.67-11.93	4.13-11.80	268 -56 1.67	307.67-631.33	187.67 -495	224 -61 1.67
Mean	40.76	42.50	2770.30	2029.83	3.20	2.94	8.67	7.72	432.96	465.92	360.12	396.14
Components $\sigma^2 g$	44.88	39.70	326721.50	377729.80	0.65	0.52	1.94	3.06	5564.61	5435.63	6000.15	6559.21
of variance $\sigma^2 p$	68.47	72.52	476517.40	547971.30	0.93	0.73	2.60	3.42	8695.43	9270.10	7351.9144	8419.

H_1 = Harvest at 90 DAP, H_2 = Harvest at 105 DAP

Parameter	Mean tuber weight (g)		Tuber dry matter (%)		Chip colour index (1-10)		Reducing sugar (%)		Total soluble solids (^{0}Brix)	
	H_1	H_2	H_1	H_2	H_1	H_2	H_1	H_2	H_1	H_2
Range	28.65-77.79	38.68 - 106.01	14.60 - 21.40	15.33 - 22.10	1.20 - 8.40	1.20 – 9.60	0.02-0.89	0.01 - 0.88	3.0 - 5.92	2.95-5.83
Mean	55.59	66.87	18.03	19.16	4.06	3.90	0.36	0.33	4.41	4.32
Components $\sigma^2 g$	115.82	198.99	2.46	1.87	3.37	3.80	0.045	0.043	0.45	0.46
of variance $\sigma^2 p$	209.60	339.84	2.72	2.24	3.40	3.83	0.045	0.043	0.46	0.47

H_1 = Harvest at 90 DAP, H_2 = Harvest at 105 DAP

Similar results were found in another study.[13] Potato having high dry matter, low reducing sugar and chip colour index suitable for processing. The genotypes of MP/09-901, MP/04-578 and MP/04-816 exhibited high tuber dry matter, while, genotypes of K. Himsona, K. Chipsona 1, K. Chipsona 2 had low reducing sugar under both 90 and 105 days of harvest. The low chip colour index was exerted by genotypes of K. Chipsona 2, K. Chipsona 1, K. Chipsona 3, K. Chipsona 4 and K. Frysona under 90 days, whereas, K. Chipsona 2, Atlantic, K. Chipsona 3 under 105 days of harvest. Thus, considering above attributes of these genotypes may be considered for processing purpose. The estimates of genotypic and phenotypic variances revealed that more contribution of genotypic variance to the total variance was observed for all the traits at both the harvesting periods.

The traits as leaf area, number of stems per hill, processing grade tuber yield per plant, chip colour index and reducing sugar exerted high genotypic and phenotypic coefficients of variation under both the harvesting periods of 90 and 105 DAP (Table 3). In another study found high values of GCV and PCV (%) for reducing sugar.[14] The high values of GCV and PCV (%) for chip colour index15 and high GCV and PCV values for leaf area16 were observed in other studies. Moderate to high genotypic and phenotypic coefficients of variation were observed for plant height and total tuber yield per plant in both 90 and 105 days of harvest, while, mean tuber weight exhibited moderate to

high GCV and PCV only under 90 days harvest. Earlier 17 reported moderate to high genotypic and phenotypic coefficients of variation for total tuber yield per plant. Number of tubers per plant depicted moderate GCV and PCV in 90 days and high in 105 days of harvest. Low to moderate GCV and PCV were exhibited by total soluble solids and tuber dry matter under both 90 and 105 days of harvesting, respectively.

Table 3: Genotypic and phenotypic coefficient of variation , heritability and genetic advance in per cent of mean for different characters in potato

Parameter	Plant height (cm)		Leaf area (cm^2)		Number of stems per hill		Number of tubers per plant		Total tuber yield per plant(g)		Processing grade tuber yield per plant (g)	
	H_1	H_2	H_1	H_2	H_1	H_2	H_1	H_2	H_1	H_2	H_1	H_2
GCV (%)	16.44	14.82	20.63	21.72	25.11	24.52	16.08	22.66	17.23	15.82	21.51	20.45
PCV (%)	20.30	20.04	24.92	26.16	30.05	29.08	18.60	23.96	21.54	20.67	23.81	23.16
H_2bs (%)	66.50	55.70	68.80	68.90	69.80	71.10	74.70	89.40	64.00	58.60	86.60	77.90
GA (% mean)	27.41	22.60	35.20	37.15	43.22	42.60	28.63	44.15	28.39	24.96	40.03	37.17

Parameter	Mean tuber weight (g)		Tuber dry matter (%)		Chip colour index (1-10)		Reducing sugar (%)		Total soluble solids (^{0}Brix)	
	H_1	H_2	H_1	H_2	H_1	H_2	H_1	H_2	H_1	H_2
GCV (%)	19.36	21.09	8.70	7.14	45.24	50.02	59.28	63.45	15.18	15.64
PCV (%)	26.05	27.57	9.15	7.80	45.46	50.21	59.79	64.15	15.31	15.78
Error	93.77	140.85	0.26	0.36	0.03	0.03	0.009	0.009	0.01	0.01
H_2bs (%)	55.30	58.60	90.40	83.70	99.00	99.20	98.30	97.80	98.30	98.20
GA (% mean)	29.65	33.25	17.04	13.45	92.72	102.65	121.08	129.29	30.99	31.92

Where:

H_2bs = Heritability (Broad sense), H_1 = Harvest at 90 DAP, H_2 = Harvest at 105 DAP

The high heritability along with high genetic advance were depicted in leaf area, number of stems per hill, number of tubers per plant, processing grade tuber yield per plant, chip colour index, reducing sugar and total soluble solid under both the harvesting periods revealed that genotypic variation for the traits was probably attributed to high additive genetic effect. Hence, selection may be possible in desired direction based on phenotypic performance. The high heritability along with high genetic advance for number of stems per hill, numbers of tubers per plant and chip colour index were also found in other study.[13] The high heritability accompanied with moderate genetic advance in tuber dry matter, whereas, high genetic advance coupled with moderate heritability was observed in mean tuber weight in both 90 and 105 days of harvest, while, plant height and total tuber yield per plant had at 105 days of harvest, suggesting the variability among genotypes was due to both additive and non-additive interaction of gene showed limited scope of improvement in this character could be possible by

direct selection. Earlier 18,19 observes high genetic advance coupled with moderate heritability for mean tuber weight and total tuber yield.

Based on over all study it can be concluded that, the genotypes MP/09-901, MP/04-578 and MP/04-816 exhibited high tuber dry matter, while, the genotypes, K. Himsona, K.Chipsona 1 and K.Chipsona 2 recorded low reducing sugar under both 90 and 105 days of harvest. In case of chip colour, low index was exerted by genotypes of K. Chipsona 2, K. Chipsona 1, K. Chipsona 3, K. Chipsona 4 and K. Frysona under 90 days, whereas, K. Chipsona 2, Atlantic and K. Chipsona 3 under 105 days of harvest.

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