DOI:10.5958/j.0976-4038.5.1.004

Evaluation of Early and Late Harvested Potatoes for Yield, Quality and Storability

Bimal Das[1*], K. K. Sarkar[1], Bhanu Priya[1], A. S. Dudhane[1], A. M. Pradhan[1] and Aparajita Das[2]

[1]Department of Plant Breeding, BCKV, Nadia, West Bengal (741 252), India
[2]Department of Genetics and Plant Breeding, UBKV, Cooch Behar, West Bengal (736 165), India

Article History

Manuscript No. cn206
Received in 22nd January, 2013
Received in revised form 28th November, 2013
Accepted in final form 5th March, 2014

Correspondence to

*E-mail: bimal.das987@gmail.com

Keywords

Potato quality, storage tuber, dry matter, starch

Abstract

Potato is an important food crop which is also valued in processing industries. Present experiment was undertaken to evaluate yield performance and storagability on 22 genotypes of potato along with quality parameters related to processing as well as cuisine purpose. The experiment was conducted in the field and laboratory of Dept. of Plant breeding, BCKV in 2011-12. In the study some of characters were measured such as dry matter, tuber shape and depth of eyes, chips color and quality, cooking type, texture firmness, flavor, starch and total sugar content. Genotypes G-4, Kufri Khyati, K. Chipsona-3 and PH-3 were found to be promising for their yield. Kufri Chipsona-3 and K-22 was found to be superior for processing purposes as these were associated with a number of desirable quality parameters like high dry matter content and starch content, low total sugar content and less blackening effect on cooked potato after cooling with persistence of good chip colour for a long period. For cuisine purposes K. Sadabahar and K. Jyoti was found to be most promising as they had tubers of good shape and shallow depth eyes, acceptable flesh colour and highly acceptable cooked potatoes. The varieties like K. Khyati, K. Pukhraj, K. Ashoka, PH-4 can be considered to increase flavor of cooked potatoes.

1. Introduction

Potato (*Solanum tuberosum* L.) a starchy, tuberous crop belongs to family Solanaceae. It is a crop that grows mainly in climate with cool temperature with bright sunlight, moderate day temperature and cool night. Traditionally, consumers select potatoes by visual characteristics such as tuber size, shape, color and skin brightness from fresh market. However, presently the consumers of both developed and developing countries are showing increasingly greater interest for nutrient-rich potato, having potential antidote against diseases due to malnutrition, cancers and cardiovascular problems (Andre et al., 2007). Variation within potato is unique with respect to tuber appearance, nutritional composition and tuber quality and it can be utilized for important of potatoes destined for direct consumption, processing and propagation. There are two important classes of tuber quality: Physical and chemical or external and after-cooking quality (Storey and Davies, 1992). Physical quality aspects are mainly determined by tuber size; shape free from wounds and defects, specific gravity and dry matter content (Hogy and Fangmeier, 2009). Proteins, mineral elements, starch, reducing carbohydrates, organic acids, amino acids, glycoalkaloids and anions etc in tuber constitute chemical quality parameters (Storey and Davies, 1992). Dry matter accounts for as much as 60 to 80% of the tuber dry weight and is the major storage component of tubers (Kolbe and Stefan-Beckmann, 1997). Present investigation is outlined for identification of high yielding genotypes with good shelf life in ambient conditions with least effect of quality in tubers which can be effectively utilized for processing or cooking purpose. Genetic influence of these characters was studied for planning appropriate breeding strategies to strength the high yielding genotypes with enhanced quality parameters and their extended shelf life in country storage.

2. Material and Methods

The experiment was conducted at the Block Seed Farm, govt of WB, Adisaptagram, Hoogly during *rabi* season of 2011 considering 22 genotypes early and late, namely K. Jyoti, MM-12, K. Pushkar, EM-1, K. Ashoka, K. Khyati, K. Pukhraj, K. Suriya, K-22, G-4, K. Sadabahar and Himalini, Sailoza, LB-3, LB-4, LB-5, PH-1, PH-2, PH-3, PH-4, Atlantic, K. Chipsona-3 were collected from AICRP as sent through Central Potato Research Institute (CPRI, Shimla). The Block Seed Farm is situated at 22.57^0 N latitude 88.20^0 E longitudes and 7.8 m altitude above mean sea level. The experiment was laid out in a Randomize Block Design (RBD) with three replications. The individual plot size for each genotype was 2.5×2.5 m^2 respectively with spacing of 60 cm from row to row and 20 cm from plant to plant. The different characters considered for the yield and attributing traits like germination percentage, plant height (at 30 and 60 DAP and observations were recorded from 5 randomly taken plants per replication), marketable and non-marketable yield and dry matter content. Determination of quality study parameter considered as type of eye and tuber shape, raw tuber flesh colour, flesh colour change after 24 hrs, cooking type, texture, chip colour (assessment were done by using various scale), starch and total sugar content. Estimation of starch and sugar was done by anthrone reagent method. For storage study 5 kg from each genotype were kept under ambient temperature during 90 days of storage and observation were recorded as single tuber weight, equatorial and polar diameter, (at the initiation of storage and 90 days of after storage), no of sprout $tuber^{-1}$, sprouting percentage and rotting percentage. The mean of these data were done by statistical analysis (Singh and Chowdhury, 1985).

3. Results and Discussion

3.1. Studies on yield and attributing traits

Wide range of variation was observed for all yields and its attributing among the genotypes which provides ample scope for yield improvement in potato. Germination percentage was found to highest in K. Pushkar and K. Chipsona-3 as observed from (Table 1 and 2) for yield and its attributing traits. Tallest plant height in early and late harvested potatoes were G-4, K-22, Atlantic and K. Chipsona-3 respectively. Among early genotypes K. Khyati was found to most promising for its maximum yield of marketable tubers and K-22 for maximum dry matter content and among late genotypes K. Chipsona-3 had highest marketable tuber and PH-2 had highest dry matter content. Kumar and Pandey (2001) also observed high dry matter content in K. Chipsona. Genotypes like G-4, K. Khyati, PH-2 and Chipsona-3 were also found to be promising for their yield.

High magnitude of genotypic variation among late and early genotypes was observed from germination percentage, followed by dry matter content (Table 3 and 4). Though ample variation for plant height at 30 and 60 days of growth was observed in early genotypes, it was very low among late genotypes. Highest difference between PCV and GCV was observed for non-marketable tuber yield in early and late harvested potato genotypes. With high magnitude of difference between PCV and GCV, which implied that environment effect predominantly acting upon the expression of phenotypic behaviour of the character and proper management in cultivation may reduce environmental factor to enhance marketable produce. High heritability was recorded in dry matter content (%) followed by germination %, plant height and total tuber yield for early harvested potato genotypes. Similarly high heritability was recorded in dry matter content (%) followed by germination percentage, total tuber yield and marketable tuber yield for late harvested genotype. High heritability was also observed for the traits irrespective of variations in genotypes and date of harvesting. Kim et al. (1993) observed more than 70% heritability for dry matter content in tuber for early and late harvested potato. Genetic advance was found to be highest in non-marketable tuber per plant followed by plant height and dry matter content in early genotypes and in non-marketable tuber yield followed dry matter content and total yield per plot

Table 1: Mean of yield and attributing traits for early genotypes harvested at 75 days after planting

Variety	Germination (%)	Plant height (30 DAP(cm)	Plant height (60 DAP) (cm)	Wt.of marketable tubers $plot^{-1}$(kg)	Wt.of non-marketable tubers $plot^{-1}$ (kg)	Dry matter content (%)	Total tuber yield (kg $plot^{-1}$)
K. Jyoti	94.46	21.80	59.20	14.91	1.71	18.72	15.88
MM 12	96.64	22.53	59.80	14.63	2.10	13.85	16.73
K. Pushkar	99.50	25.16	62.20	18.50	1.00	17.77	19.50
EM-1	95.94	24.93	56.20	18.16	1.01	21.76	19.18
K. Ashoka	97.13	23.43	60.66	19.16	1.33	18.87	19.86
K. Khyati	94.68	34.83	58.40	20.83	0.66	23.65	21.50
K. Pukhraj	97.20	27.16	53.33	13.33	2.25	19.33	15.58
K. Suriya	87.08	34.16	58.20	14.76	2.36	21.61	17.40
K-22	75.66	39.46	71.66	16.33	3.53	28.91	19.20
G-4	76.96	41.50	79.33	20.23	2.73	20.97	22.96
K. Sadabahar	88.00	32.16	61.33	18.16	1.83	19.04	20.52
Grand mean	91.20	29.74	61.84	17.18	1.86	20.40	18.94
SEd	1.066	1.385	3.406	1.127	0.523	0.158	0.903
CD (p=0.05)	2.224	2.890	7.106	2.351	1.090	0.329	1.883

of late genotypes. All these character were accompanied by high heritability and it could be suggested that the characters were governed predominantly by additive gene actions, which could provide scope to improve crops with respect to these characters through selection and selection is negative direction for non marketable tubers could be practiced the total tuber yield in both early and late genotypes could be substantially enhanced.

3.2. Character association and path coefficient analysis

Stronger positive correlations were found between tuber yield and marketable tubers, plant height and dry matter. Germination percentage showed negative effect with all the character, which was highly significant with plant height at two different growth period and marketable tubers (Table 5 and 6). Therefore through selection of genotype with high percentage of germination may substantially reduce the non-marketable yield. Plant height at 30 and 60 days showed significant positive association with dry matter content and total tuber yield both at phenotypic as well as genotypic levels though they failed to show significant positive effect with the two characters even plant height at 30 days showed non-significant negative correlation coefficient with total tuber yield. Weight of marketable tuber had showed significantly high positive correlation with total tubers yield at both phenotypic and genotypic levels in late as well as early genotype. Non-marketable tuber yield showed significant positive association with total tubers yield in late genotype, which made it difficult to improve tuber yield with substantial reduction in non-marketable tuber. The improvement programme for yield in early harvested potato genotypes escaped such problems as non-marketable tuber yield had negative not significant correlation with total tuber yield. Dry matter content positive association with total tuber yield in early genotypes. Khayatnezhad et al. (2011) also reported stronger positive and significant correlation

Table 2: Mean of yield and attributing traits for late genotypes harvested at 90 days after planting

Variety	Germination (%)	Plant height (30 DAP(cm)	Plant height (60 DAP) (cm)	Wt.of marketable tubers plot^{-1} (kg)	Wt.of non-marketable tubers plot^{-1} (kg)	Dry matter content (%)	Total tuber yield (kg plot^{-1})
Himalini	80.94	24.86	58.33	17.33	0.40	23.08	17.73
Sailoza	98.04	26.56	58.60	19.66	0.86	23.73	20.53
LB-3	89.11	25.50	57.40	17.66	0.80	18.00	18.46
LB-4	87.83	23.56	56.86	18.16	0.46	22.80	18.63
LB-5	81.85	23.16	60.00	17.50	0.46	24.50	17.96
PH-1	97.26	16.56	55.33	18.50	3.63	11.72	22.13
PH-2	75.63	22.22	57.26	13.66	2.30	25.76	15.96
PH-3	92.40	19.80	58.26	20.33	3.53	22.62	23.86
PH-4	90.26	16.72	54.40	20.16	2.43	24.34	22.60
Atlantic	97.60	19.81	64.73	17.50	5.16	23.25	22.66
Chipsona-3	99.15	22.60	63.26	23.33	4.66	22.51	28.00
Grand mean	90.00	21.94	58.58	18.53	2.24	22.03	20.77
SEd	1.604	1.689	1.754	0.630	0.630	0.490	0.937
CD (p=0.05)	3.346	3.523	3.659	2.273	1.315	1.022	1.954

Table 3: Variability and genetic parameters for different yield parameters of potato harvested after 75 days planting

Characters	Range	Mean	CD	Variance			GCV	PCV	h^2	GA	GA (%) of mean
				GV	PV	EV					
Germination (%)	75.66-99.50	91.207	2.22	68.06	69.76	1.70	9.04	9.15	0.975	6.78	18.40
Plant height (30 DAP) (cm)	21.80-41.50	29.742	2.89	48.01	50.89	2.879	23.29	23.98	0.943	13.86	46.61
Plant height (60 DAP) (cm)	53.33-79.33	61.848	7.10	48.67	66.07	17.405	11.28	13.14	0.736	12.33	19.94
Wt.of marketable tubers plot^{-1} (kg)	13.33-20.83	17.186	2.35	5.69	7.59	1.905	13.88	16.03	0.749	4.25	24.75
Wt.of non-marketable tubers plot^{-1} (kg)	0.667-3.533	1.868	1.09	0.58	0.99	0.410	40.89	53.34	0.587	1.20	64.57
Dry matter content (%)	13.85-23.65	20.409	0.32	14.44	14.47	0.037	18.61	18.64	0.997	7.81	38.30
Total tuber yield (kg plot^{-1})	15.58-22.96	18.940	1.88	5.03	6.25	1.222	11.84	13.20	0.804	4.14	21.89

CD: Critical 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 4: Variability and genetic parameters for different yield parameters of potato harvested after 90 days planting

Characters	Range	Mean	CD	Variance			GCV	PCV	h^2	GA	GA (%) of mean
				GV	PV	EV					
Germination (%)	75.63-99.15	90.00	3.34	61.22	65.08	3.86	8.69	8.96	0.94	15.63	17.36
Plant height (30 DAP) (cm)	16.56-26.56	21.94	3.52	9.81	14.09	4.27	14.27	17.10	0.69	5.38	24.54
Plant height (60 DAP) (cm)	54.40-64.73	58.58	3.65	8.06	12.68	4.61	4.84	6.07	0.63	4.66	7.96
Wt.of marketable tubers $plot^{-1}$ (kg)	13.66-23.33	18.53	2.27	5.24	7.02	1.78	12.35	14.30	0.74	4.07	21.99
Wt.of non-marketable tubers $plot^{-1}$ (kg)	0.400-5.167	2.24	1.31	2.97	3.57	0.59	76.71	84.05	0.83	3.24	144.25
Dry matter content (%)	11.72-24.50	22.03	1.02	15.32	15.68	0.36	17.76	17.97	0.98	7.97	36.18
Total tuber yield (kg $plot^{-1}$)	15.96-28.00	20.77	1.95	11.63	12.95	1.31	16.41	17.31	0.90	6.66	32.05

CD: Critical 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 5: Genotypic and phenotypic correlation coefficient among different yield parameters of potato at 75 days of harvesting

Characters	Genotypic and phenotypic correlation	Plant height (30 DAP) (cm)	Plant height (60 DAP) (cm)	Wt.. of marketable tubers $plot^{-1}$ (kg)	Wt. of non-marketable tubers $plot^{-1}$ (kg)	Dry matter content (%)	Total tuber yield (kg $plot^{-1}$)
Germination (%)	G	-0.883**	-0.863**	-0.147	-0.896**	-0.643*	-0.450
	P	-0.851**	-0.740**	-0.110	-0.649*	-0.633*	-0.380
Plant height (30 DAP) (cm)	G		0.755**	0.355	0.586	0.70*	0.626*
	P		0.587	0.333	0.492	0.685*	0.576
Plant height (60 DAP) (cm)	G			0.481	0.653*	0.373	0.713*
	P			0.321	0.461	0.318	0.494
Wt.of marketable tubers $plot^{-1}$ (kg)	G				-0.525	0.238	0.949**
	P				-0.303	0.205	0.918**
Wt.of non-marketable tubers $plot^{-1}$ (kg)	G					0.401	-0.199
	P					0.310	-0.027
Dry matter content (%)	G						0.344
	P						0.310

*significant at 5% level **significant at 1% level

Table 6: Genotypic and phenotypic correlation coefficient among different yield parametrers of potato after 90 days of planting

Characters	Genotypic and phenotypic correlation	Plant height (30 DAP) (cm)	Plant height (60 DAP) (cm)	Wt.of marketable tubers $plot^{-1}$ (kg)	Wt..of non-marketable tubers $plot^{-1}$ (kg)	Dry matter content (%)	Total tuber yield(kg $plot^{-1}$)
Germination (%)	G	-0.259	0.343	0.791**	0.605*	-0.413	0.837**
	P	-0.231	0.291	0.646*	0.543	-0.397	0.761**
Plant height (30 DAP)	G		0.329	-0.159	-0.689*	0.340	-0.455
	P		0.093	-0.113	-0.549	0.282	-0.372
Plant height (60 DAP)	G			0.293	0.533	0.318	0.466
	P			0.097	0.392	0.247	0.277
Wt.of marketable tubers $plot^{-1}$ (kg)	G				0.432	-0.117	0.890**
	P				0.235	-0.102	0.860**
Wt.of non-marketable tubers $plot^{-1}$ (kg)	G					-0.193	0.796**
	P					-0.149	0.698*
Dry matter content (%)	G						-0.176
	P						-0.153

between tuber yield and plant height. Highest direct effect on total tuber yield in early harvested genotypes was exerted by total marketable tuber yield followed by plant height (Table 7). Roy & Singh (2006) observed plant height, no. of tubers plant^{-1} and marketable yield to exert positive direct effect on total yield. The finding of direct effect by plant height on tuber yield were also reported by Khayatnezhad et al. (2011). Dry matter content showed negative direct effect on total tuber yield though it showed positive correlation with the characters which may be effected via indirect of germination percentage. Plant height at 60 days showed negative direct effect on tuber yield and mainly via indirect influence of germination percentage and marketable tubers yield, it exerted signification positive correlation with total tuber yield. Like early genotypes late harvested genotypes, showed highest direct effect on total tuber yield by total marketable tuber yield followed by non-marketable tuber yield and germination percentage did not show high negative direct effect. Kim et al. (1993) showed different pattern of direct and indirect effect on characters in early and late harvested genotype. In conclusion, correlation coefficient analysis measures the magnitude of relationship between various plant characters and determines the component character on which selection can be based for improvement in potato tuber yield. However, path coefficient analysis helps to determine the direct effect of traits and their indirect effects on yield.

3.3. Determination of quality characteristics

The quality of potato tubers after tubers after prolonged storage in country storage under ambient condition depicted as follows (Table 8) and assessment of some quality traits were done by using various scales (Table 9).

Among the early and late K. Sadabahar, K. Jyoti, PH-1 and PH-4, could be considered as promising one in processing and cooking purpose as it had oval round tubers with shallow depth eyes with comparatively high tuber yield. Genotype K. Sadabahar could be considered as promising one as it had oval round tubers with shallow depth eyes with comparatively high tuber yield for processing and cooked food and these genotypes can be favourably improved if their dry matter content can be increased following hybridization with genotypes with high dry matter content like K. Khyati and K-22 as suggested by Harris (1978) and NIVA, 2002. Harris (1978) and NIVA, (2002) reported that round oval tubers weighing 150-200g as best to determine quality potato. With respect to colour of tuber flesh the promising early and late varieties were cvs. MM-12, K. Pushkar, EM-1, K. Pukhraj, K. Suriya, K. Khyati, Himalini LB-3, LB-4, and PH-1, Atlantic. Least colour change was observed after 24 hrs of peeling in K. Khyati, K. Pukhraj, K. Pushkar, LB-3, LB-5 among early and late genotypes. Hassanpanah et al. (2011) observed lowest to medium colour change of raw tuber flesh after 24 hrs among different potato. Accepted cooked potatoes after 20 minutes of cooking were K. Jyoti, K. Pushkar, EM-1, K. Pukhraj, K. Suriya, K-22, K. Sadabahar, LB-4, LB-5, PH-3, Atlantic and K. Chipsona-3 among early and late genotypes. Cvs. K. Khyati, K. Suriya, and K-22 PH-1, PH-2, Chipsona-3 were rather strong texture of cooked potatoes. Very soft-to-soft cooked potatoes may be used for salad purpose, rather soft structure suitable for meshing and mealy structure for french fries. Blackening of cooked potato after cooling was found to the almost negligible in K. Pushkar, EM-1, K. Khyati, K-22, Sailoza, LB-3, LB-4, PH-1 and PH-4. Good flavor of cooked potato among early genotypes were

Table 7: Path analysis among different yield parameters in early (A) and late (B) harvested potatoes

Character		Germination (%)	Plant height (30 DAP) (cm)	Plant height (60 DAP) (cm)	Wt.of marketable tubers plot^{-1} (kg)	Wt.of non-marketable tubers plot^{-1} (kg)	Dry matter content (%)	Total tuber yield (kg plot^{-1})
Germination (%)	A	-0.92624	-0.09382	0.40833	-0.15294	0.08180	0.23286	-0.450
	B	0.00006	0.00003	0.00002	0.53068	0.30599	-0.0000	0.837**
Plant height (30 DAP) (cm)	A	0.81777	0.10626	-0.35719	0.36952	-0.05351	-0.25663	0.626*
	B	-0.00001	-0.00012	0.00002	-0.10706	-0.34811	0.0000	-0.455
Plant height (60 DAP) (cm)	A	0.79964	0.08025	-0.47298	0.50059	-0.05957	-0.13493	0.713*
	B	0.00002	-0.00004	0.00006	0.19658	0.26963	0.0000	0.466
Wt.of marketable tubers plot^{-1} (kg)	A	0.13603	0.03771	-0.22737	1.04133	0.04794	-0.08614	0.949**
	B	0.00004	0.00002	0.00002	0.67129	0.21862	-0.0000	0.890**
Wt.of non-marketable tubers plot^{-1} (kg)	A	0.83013	0.06231	-0.30869	-0.54693	-0.09127	-0.14502	-0.199
	B	0.00003	0.00008	0.00003	0.29028	0.50557	-0.0000	0.796**
Dry matter content (%)	A	0.59600	0.07536	-0.17635	0.24786	-0.03657	-0.36189	0.344
	B	-0.00002	-0.00004	0.00002	-0.07874	-0.09768	0.00001	-0.176

*significant at 5% level; **significant at 1% level; residual effect (A): 0.1685; residual effect (B): 0.0020

Table 8: Quality parameters assessment in different genotypes of potato

Early variety	Type of eye	Shape	RTC	FCC	CT	TF	ACB	F	CC	SC	TSC
K. Jyoti	Shallow	Moderately round	White	6	2	3	4	5	7	67.5^{e}	3.080^{b}
MM 12	Medium	Moderately oval	Yellow	3	1	4	7	6	5	62.25^{h}	4.391^{a}
K. Pushkar	Shallow	Moderately oval	Yellow	4	2	3	9	5	7	73^{c}	1.938^{e}
EM-1	Medium	Moderately round	Yellow	4	2	3	8	6	3	67.4^{e}	1.670^{fg}
Ashoka	Medium	Long oval	White	3	3	3	4	7	6	70^{d}	3.295^{b}
Khyati	Medium	Moderately oblong	Yellow	2	3	2	8	7	5	52.5^{j}	1.761^{f}
Pukhraj	deep	Moderately oblong	Yellow	2	2	3	4	7	1	64.75^{g}	1.581^{g}
K. Suriya	Shallow	Moderately oblong	Yellow	4	2	2	7	6	3	66.75^{f}	2.496^{d}
K-22	Shallow	Long oval	White	6	2	2	8	6	5	77.5^{a}	1.062^{h}
G-4	Shallow	Long oval	Yellow	5	1	4	7	6	1	75.75^{b}	1.581^{g}
K. Sadabahar	Shallow	Oval round	White	4	2	2	6	4	5	61.625^{i}	2.789^{c}
Late Variety											
Himalini	Medium	Moderately round	Yellow	6	3	3	6	4	3	70^{g}	2.673^{a}
Sailoza	Deep	Round oval	White	5	1	4	9	4	6	63.25^{k}	1.876^{bc}
LB-3	Shallow	Long oval	Yellow	5	1	4	8	5	7	66.75^{j}	1.839^{bc}
LB-4	Shallow	Long oval	White	5	2	4	8	5	3	68.5^{h}	1.977^{b}
LB-5	Shallow	Long oval	White	5	2	3	6	2	1	67.7^{i}	1.083^{f}
PH-1	Shallow	Oval round	Yellow	5	4	2	8	5	8	75.25^{b}	1.858^{cd}
PH-2	Very deep	Round oval	White	6	3	2	4	4	8	72.5^{d}	1.690^{d}
PH-3	Medium	Moderately round	White	5	2	3	7	5	7	71.4^{e}	1.086^{f}
PH-4	Shallow	Moderately round	White	5	1	4	9	7	7	73.25^{c}	1.522^{e}
Atlantic	Medium	Moderately oval	Yellow	7	2	3	4	6	8	70^{f}	1.981^{cd}
K. Chipsona-3	Shallow	Moderately oval	White	6	2	2	7	6	8	78.5^{a}	0.453^{g}

RC: Raw tuber flesh colour; FCC: Flesh colour change (24 hrs); CT: Cooking type; TF:Tex-ture firm-ness; ACB: After cooking blackening; F: Flavor; CC: Chip colour; SC: Starch content (%); TSC: Total sugar content (mg g^{-1})

Table 9: Using different scale for quality assessment

Scale	Colour change of raw tuber after 24 hrs	Cooking time 20 min	Texture firmness	After cooking blackening	Flavour	Chip colour
1	Very low	Very soft	Strong	Severe	Very poor	Very dark brown
2	Very low to low	Soft	Rather strong	Some to severe	Very poor to poor	
3	Low	Rather soft	Rather mealy	Some	Poor	Dark brown
4	Low to medium	Mealy	Mealy	Little to some	Poor to moderate	
5	Medium to high	Very mealy		Some	Moderate	Brown
6	Medium			Trace to little	Moderate to good	Pale yellow
7	High			Trace	Good	Very pale yellow
8	Very high to high			None to trace	Good to very good	Cream
9	Very high			None	Very good	Pale cream to till white

present in K. Khyati, K. Pukhraj, MM-12, EM-1, K. Suriya, K-22, G-4, PH-3, Atlantic and K. Chipsona-3. Accepted chip colour and consistency were recorded in K. Chipsona-3, PH-1, PH-2, PH-3, PH-4 Atlantic and LB-3. Hassanpanah et al. (2011) observed significant variation from these quality characters potato genotypes. Increased dry matter production, increased the potato chips production efficiency and produced good chips with less fat, better taste than potatoes with less dry matter (Talburt, 1987). Highest starch content in early and late genotypes during storage period was found in K-22 and Chipsona-3 and low sugar content in storage in Chipsona-3 and K-22. Varieties with lower magnitude of reducing sugar content are desirable in processing industries, as it is one of the determining for production of acceptable chips or fries as being observed by Hendrickx and Vleeschonwer, (2006).

3.4. Studies on storage behaviour of different potato genotypes

Among the early and late genotypes low dessication loss was found in K-22, G-4, LB-4 and Chpsona-3 (Table 10 and Table 11). Minimum storage effect in both polar and equatorial diameter was found in K. Khyati, K. Pushkar, K. Sadabahar, K. Himalini and PH-1. K. Pushkar and PH-3 could be utilized to maximize shelf-life in storage to check loss due physiological factor. Percentage of rotting tuber during storage lowest was observed in K. Suriya and K. Himalini. Among early maturing potato genotypes K. Sadabahar had highest percentage of total loss due to various factor followed by K. Khyati, K-22, EM-1, MM-12 and K. Pukhraj and lowest in G4, K. Jyoti K. Suriya, K. Pushkar and K. Ashoka. In late potato genotypes PH-3 followed by PH-2 and LB-5 showed maximum total loss while and K. Sioloza, LB-4, K. Himalini, LB-5, Atlantic LB-3, PH-1 and K. Chipsona-3 showed minimum total loss during storage.

Wide range of difference among genotypes for the characters considered in storage experiments were revealed for early as well as late harvested potatoes (Table 12 and Table 13).

Table10: Mean value of storage parameters for early genotypes

Variety	Single tuber weight (g)(A)	Single tuber weight (g)(B)	Equatorial diameter (mm) (A)	Equatorial diameter (mm) (B)	Polar diameter (mm) (A)	Polar diameter (mm) (B)	No. of sprout tuber^{-1}	% of tuber sprouts at 90 days	% of rotting tuber at 90 days	Total loss (%)
K. Jyoti	67.23	53.40	51.35	49.31	62.243	54.42	5.00	8.04	21.90	29.95
MM- 12	98.58	67.28	48.54	40.38	65.103	60.25	3.00	31.84	15.85	47.70
K. Pushkar	93.52	82.47	53.41	51.27	72.490	67.42	3.00	15.06	17.15	32.22
EM-1	81.36	64.21	52.97	51.23	72.573	59.26	4.00	15.11	41.98	57.10
K. Ashoka	78.30	57.52	47.26	46.44	66.650	56.34	4.66	10.21	23.40	33.61
K. Khyati	88.36	64.13	52.56	51.40	70.307	65.64	4.00	8.64	54.23	62.87
K. Pukhraj	112.44	49.23	52.42	48.32	73.237	63.44	6.00	10.90	37.89	48.79
K. Suriya	121.29	95.30	51.60	47.55	78.367	77.35	5.00	26.87	0.00	26.87
K-22	71.98	66.40	49.22	45.45	69.273	64.51	5.33	24.31	35.72	60.04
G-4	70.41	63.41	47.27	42.39	63.313	62.39	5.00	13.81	3.33	17.14
K. Sadabahar	98.41	72.49	52.31	50.49	67.440	62.31	4.00	24.49	60.09	84.58
Grand mean	89.26	66.89	50.81	47.66	69.182	63.03	4.45	17.2	28.32	45.53
CD (p=0.05)	1.648	1.101	0.776	0.400	0.314	0.459	0.938	0.326	1.312	1.356

A: At the initiation of storage, B: After 90 days of storage

Table 11: Mean value of storage parameters for late genotypes

Variety	Single tuber weight (g)(A)	Single tuber weight (g)(B)	Equatorial diameter (mm) (A)	Equatorial diameter (mm) (B)	Polar diameter (mm) (A)	Polar diameter (mm) (B)	No. of sprout tuber^{-1}	% of tuber sprouts at 90 days	% of rotting tuber at 90 days	Total loss (%)
Himalini	135.25	94.50	55.18	52.51	67.16	65.29	4.00	27.43	21.62	49.06
Sailoza	95.52	61.44	51.44	46.37	54.45	50.53	4.00	16.84	24.32	41.17
LB-3	102.95	87.83	49.43	46.54	80.43	67.21	5.00	31.11	24.49	55.60
LB-4	94.38	93.47	51.59	45.63	87.53	72.03	4.00	13.13	34.84	47.98
LB-5	139.57	93.47	56.29	49.45	82.46	70.51	3.66	28.31	33.92	62.23
PH-1	77.61	65.79	56.19	55.45	65.51	61.30	2.00	21.15	34.54	55.69
PH-2	98.53	79.45	58.33	48.44	63.40	55.55	2.33	22.04	58.08	80.13
PH-3	79.32	67.48	51.16	40.28	62.63	55.32	2.00	16.06	69.06	85.12
PH-4	94.59	66.31	50.45	47.45	64.18	60.36	3.00	23.01	33.71	56.73
Atlantic	113.62	64.62	47.53	39.24	62.45	52.10	3.00	16.14	36.57	52.72
Chipsona-3	89.44	78.56	47.50	40.12	65.33	57.38	3.00	13.43	43.75	57.19
Grand mean	101.89	77.54	52.284	46.50	68.68	60.69	3.27	20.79	37.72	58.51
CD (p=0.05)	1.761	1.538	0.407	0.457	1.020	0.979	0.99	0.173	1.142	1.233

A: At the initiation of storage, B: After 90 days of storage

Table 12: Variability and genetic parameters for different storage characters of early harvested genotypes

Characters	Range	Mean	CD	Variance			GCV	PCV	h^2	GA	GA (%) of mean
				GV	PV	EV					
Single tuber weight (g)(A)	67.23-121.29	89.26	1.64	307.15	308.08	0.936	19.63	19.66	0.997	36.04	40.38
Single tuber weight (g)(B)	49.23-95.30	66.89	1.10	168.90	169.31	0.418	19.42	19.45	0.997	26.73	39.97
Equatorial diameter (mm) (A)	47.26-53.41	50.81	0.77	5.24	5.44	0.207	4.50	4.59	0.961	4.62	9.10
Equatorial diameter (mm) (B)	40.38-51.40	47.66	0.40	13.80	13.85	0.055	7.79	7.81	0.996	7.63	16.02
Polar diameter (mm) (A)	62.24-78.36	69.18	0.31	23.30	23.34	0.034	6.97	6.98	0.998	9.93	14.36
Polar diameter (mm) (B)	54.42-77.35	63.03	0.45	37.50	37.57	0.073	9.71	9.72	0.998	12.60	19.99
No. of sprout $tuber^{-1}$	3.00-6.00	4.45	0.93	0.79	1.09	0.303	20.00	23.51	0.723	1.56	35.05
% of tuber sprouts at 90 days	8.04-31.84	17.21	0.32	67.75	67.79	0.037	47.82	47.83	0.999	16.95	98.49
% of rotting tuber at 90 days	0.00-60.09	28.32	1.31	378.42	379.02	0.593	68.67	68.73	0.998	40.04	141.36
Total loss (%)	17.14-84.58	45.53	1.35	389.94	390.57	0.634	43.36	43.40	0.998	40.64	89.26

A: At the initiation of storage, B: After 90 days of storage

Table 13: Variability and genetic parameters for different storage characters of late harvested genotypes

Characters	Range	Mean	CD	Variance			GCV	PCV	h^2	GA	GA (%) of mean
				GV	PV	EV					
Single tuber weight (g)(A)	79.32-139.57	101.89	1.76	408.38	409.44	1.069	19.83	19.85	0.997	41.57	40.80
Single tuber weight (g)(B)	61.44-94.50	77.54	1.53	169.44	170.25	0.815	16.78	16.82	0.995	26.75	34.49
Equatorial diameter (mm) (A)	47.50-58.33	52.28	0.40	13.55	13.61	0.057	7.04	7.05	0.995	7.56	14.47
Equatorial diameter (mm) (B)	39.24-55.45	46.50	0.45	26.22	26.30	0.072	11.01	11.02	0.997	10.53	22.65
Polar diameter (mm) (A)	54.45-87.53	68.68	1.02	103.15	103.51	0.359	14.78	14.81	0.996	20.88	30.40
Polar diameter (mm) (B)	50.53-72.03	60.69	0.97	53.11	53.44	0.331	12.00	12.04	0.993	14.96	24.66
No. of sprout $tuber^{-1}$	2.00-5.00	3.27	0.99	0.79	1.13	0.339	27.22	32.52	0.700	1.53	46.94
% of tuber sprouts at 90 days	13.43-31.11	20.79	0.17	38.60	38.61	0.010	29.88	29.88	0.999	12.79	61.55
% of rotting tuber at 90 days	21.62-69.06	37.72	1.14	209.56	210.01	0.450	38.37	38.41	0.997	29.78	78.96
Total loss (%)	41.17-85.12	58.51	1.23	174.33	174.86	0.524	22.56	22.59	0.997	27.15	46.41

A: At the initiation of storage, B: After 90 days of storage

Genotypic variations for equatorial diameter, rotting loss, and total loss among the genotypes was found to be substantially high in magnitude which could provide opportunity for selection of genotypes with minimum storage loss and also could be harnessed to improve other high yielding varieties with good quality parameters. Moreover, all storage characters were found to be least influenced by environment. High heritability coupled with high genetic advance was observed on loss due to sprouting and rotting. So breeding improvement through selection towards negative direction against such detrimental components could favourably developed lines with tubers sustainable for long storage at ambient conditions.

4. Conclusion

Genotypes like G-4, Kufri Khyati, PH-2 and K.Chipsona-3 were found to be promising for their high yield. High heritability was recorded in dry matter content (%) followed by germination percentage. Chipsona-3 and K-22 was found to be most promise for processing purposes as these were associated with a number of desirable quality parameters like high dry matter content and low sugar content. For cuisine purposes K. Sadabahar and K. Jyoti was found to be most promising as they had tubers good shape and shallow depth eyes, acceptable flesh and highly acceptable cooked potatoes. The varieties like K. Khyati, K. Pukhraj, MM-12, EM-1 can considered to increase flavour of cooked potatoes. To reduce storage loss in these favourable genotypes combination breeding with K.Suriya, K.Pushkar K.Himalini, and PH-3 may be done as these varieties were least affected due to rotting or sprouting during storage.

5. References

Andre, C.M., Ghislain, M., Bertin P., Qufir, M., Herrera, MDR., Hoffman, L., Hausman, JFO., Larondelle, Y., Evers, D., 2007. Andean potato cultivars (*Solanum tuberosum* L.) as a source of antioxidant and mineral micronutrients. Journal of Agricultural Food Chemistry 55, 366-378.

Harris, P.M., 1978. The Potato Crop. Chapman and Hall Ltd., London, 81-82.

Hassanpanah, D., Hassanabadi, H., Chakherchaman, S.H.A., 2011. Evaluation of cooking quality characteristics of advanced clones and potato cultivars. American Journal of Food Technology 6(1), 72-79.

Hendrickx, E., Vleeschouwer, K., 2005. Quantify the formation of carcinogens during food processing acrylamide. Trends Food Science Technology 16, 181-193.

Khayatnezhad., Shahariari, M.R., Gholamin, R., Jamaati-e-Somarin, S., Zabihi-e-Mahmoodabad, R., 2011. Correlation and path analysis between yield and yield components in potato. (*Solanum tuberosum*.L.). Middle-East Journal of Scientific Research **7**(1),17-21.

Kim, J.K., Cho, H.M., Kim, S.Y., Cho, C.H., 1993. Early and late varietal differences on growth, development, dry matter accumulation patterns and genetic characters of potatoes (*Solanum tuberosum* L.) in alpine areas. 3. Heritability and changes of genetic characters affected by different varieties. RDA-Journal-of-Agricultural-Science,-Horticulture 35(2), 442-451.

Kolbe, H., Stefen-Beckmann, S., 1997. Development, growth and chemical composition of the potato crop (*Solanum tuberosum* L.).II. Tuber and whole plant. Potato Research 40, 135-153.

Kumar, D., Pandey, S.K., 200l. Potato processing quality of indigenous and exotic potato varieties for processing in late planted crop in NW plains. Journal of Indian Potato Association 28, 167-168.

NIVA., 2002. On the road to potato processing. The Natherlands.http://www.potato.nl/uk/about/_potatoes/agronomy/on_the_road_to_potato_processing.

Roy, A.K., Singh, P.K., 2006. Genetic variability, heritability and genetic advance for yield in potato (*Solanum tuberosum L.).* International-Journal-of-Plant-Sciences-Muzaffarnagar 1(2), 282-285.

Singh, R.K., Chowdhury, B.D., 1985. Biometrical methods in quantitative genetics analysis. Kalyani Publishers., NEW Delhi, India.

Talburt, W.F., 1987. Potato Processing. AVI Publisher Co., USA, 19-37.