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Genotypic Variation with Respect to Post-harvest Losses of Potato on Storage under Ambient Temperature

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ABSTRACT

The experiment was conducted at All India Coordinated Research Project on Potato, Odisha University of Agriculture and Technology, Bhubaneswar, Odisha, India during two different years (2016 and 2021) to study on the genotypic variation among 25 potato varieties with respect to post-harvest losses and storage. Approximately 5 kg potatoes of each genotype were kept inside perforated plastic containers under ambient temperature for this study. Rottage of tubers on number and weight basis were recorded at 30, 60, 75 and 90 days. Similarly sprouting of tubers in different genotypes was recorded at 75 and 90 days. It was observed that the percentage of tuber rottage on weight basis at the end of storage period (90 days) varied from 2.5% in Kufri Ashoka to 65.1% in Kufri Sinduri. There was also wide variation among different genotypes for sprouting at 75 and 90 days. Five genotypes did not sprout even at 90 days under storage at ambient temperature. Maximum storage loss of 86.9% was observed in Kufri Sinduri while minimum storage loss was recorded in Kufri Ashoka (8.5%). Highest direct effect on storage loss was exerted by percentage of rottage at 90 days. The direct effect of sprouting at 75 and 90 days on storage loss was very less clearly indicating its minor role. Weight loss of tubers of varying weights (20–40 g, 40–60 g and >60 g) in two varieties were also taken into consideration at 4, 7, 11, 18 and 26 days. The variety Kufri Pukhraj exhibited higher weight loss than Kufri Surya for all grades of tubers. The tubers weighing 20–40 g had the highest weight loss (1.22–2.81) among all the grades. However, the tubers of >60g showed the least weight loss in both the varieties.

KEYWORDS: Potato, weight loss, sprouting, rottage, ambient temperature

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1. INTRODUCTION

Variety of potato, cultural practices followed and precautions during harvesting and post-harvest operations determine the storability of potato. Weight loss during storage and changes in chemical composition adversely affect the quality of potato (Eltawil et al., 2006). Apical dominance characterized by the shoot tip's strong demand for sugars inhibits auxiliary bud outgrowth by limiting the amount of sugar translocated to those buds (Mason et al., 2014). Understanding physiological mechanisms during tuber development, storage and processing could help in improving tuber quality (Alamar et al., 2017). Slight modification in ambient ware potato stores could substantially improve the long-term storability and increase the income of potato farming households (Wauters et al., 2022).

The number of sprouts to be formed depends on the storage temperature. High storage temperature (15-20°C) promotes apical dominance and helps in decreasing the number of sprouts (Classens and Vreugdenhil, 2000). Endodormancy could be broken through exogenous ethylene application (10 $\mu l\ l^{-1}$) (Foukaraki et al., 2014), but it has also been found that ethylene inhibits sprout growth when supplied continuously either after harvest or at first indication of sprouting (Foukaraki et al., 2016a). However, investigation carried out on cv. Russet Burbank minitubers showed that ethylene was not involved in hormone-induced dormancy break (Suttle, 2009). All these findings lead to the conclusion that the impact of ethylene depends on the physiological condition of potato tubers.

The effect of ABA on sprouting of potato has been studied by several workers. A sustained synthesis and action of ABA is required for inducing dormancy (Suttle, 2004). It has been observed that although ABA levels decrease as endodormancy weakens, there is no evidence of an ABA threshold concentration for dormancy release (Biemelt *et al*., 2000, Destefano-Beltran et al., 2006, Suttle et al., 2012). The rise in ABA due to exogenous ethylene application has been postulated to delay dormancy break (Foukaraki et al., 2016b). During sprouting there is decrease in ABA with corresponding increase in sucrose contents (Viola et al., 2007, Sonnewald and Sonnewald, 2014). Auxins play their role in vascular development by favouring symplastic reconnection of the apical bud region. This reconnection is essential for sucrose to reach the meristematic apical bud. High sucrose levels also promote trehalose-6-phosphate accumulation (T6P) which helps in sprouting probably by decreasing sensitivity to ABA (Debast et al., 2011, Tsai and Gazzarrini, 2014).

The potato growers generally select varieties having low levels of natural losses and storage diseases, and a long period of dormancy (Sowa-Niedziałkowska, 2004, Gupta et al., 2015, Gupta and Luthra, 2020). The intensity of metabolic processes of each potato genotype is modulated by environmental factors which also affect their reaction to diseases (Burton et al., 1992, Perombelon, 2002). Each genotype has its intrinsic quality for long-term storage, which may be affected by the environment during growth and storage (Iritani et al., 1977, Sowa-Niedzialkowska and Zgorska, 2005). The storage traits are no less important than the agronomical traits. Loss in storage due to weight loss, sprouting and rottage is viewed as seriously as production losses in potato and it increases with the rise in temperature. Transpiration and respiration cause approximately 90% and 10% of the total weight losses, respectively while average potato losses caused by disease may range from 0.6% to 10%.

In the present investigation, the variation among potato varieties has been studied with respect to three major storage traits, viz. rottage, sprouting and weight loss under ambient temperature. In addition, gradual weight loss of different size tubers from the date of storage under room temperature has been studied in two popular varieties.

2. MATERIALS AND METHODS

2.1. Location and planting material

Both the experiments were executed in the research farm of All India Coordinated Research Project on Potato, Odisha University of Agriculture and Technology, Bhubaneswar, Odisha located at 20°15'N latitude, 85°52'E longitude and an altitude of 25.5 m above MSL. Freshly harvested seed tubers of 25 potato varieties were utilized in the first experiment during February–May, 2016; and two varieties, Kufri Surya and Kufri Pukhraj, were utilized in the second experiment conducted during March, 2021.

2.2. Weather data

Data on different weather parameters like minimum and maximum temperature, minimum and maximum relative humidity, rainfall and evaporation were recorded daily during whole storage period in 2016 (first experiment) which were later converted to weekly basis. In the second experiment, all the above data except evaporation were recorded along with bright sunshine hours and presented on weekly basis.

The daily weather data during storage period (20 February–20 May, 2016) gives good information on temperature, relative humidity and evaporation which affect shelf life of potato (Figure 1). The weekly mean minimum temperature ranged from 21.29°C during 9th SMW (26 February–4 March) to 27.29°C during 20th SMW (14–20 May). Similarly, the weekly mean maximum temperature ranged from 33.74°C during 9th SMW (26th February–4th March) to 42.91°C during 15th SMW (9–15 April). The

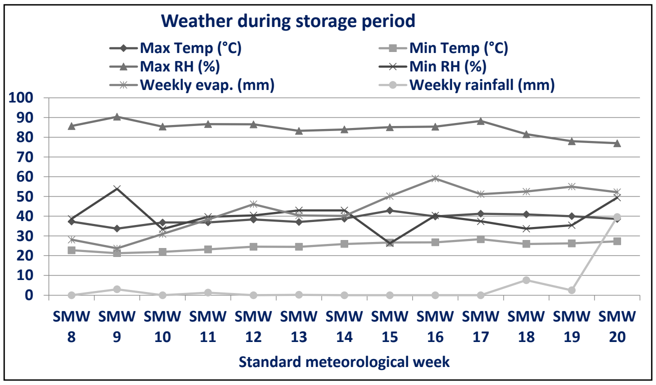

Figure 1: Daily weather data (mean temperature, relative humidity and open pan evaporation) during storage months

weekly mean temperature was the lowest (27.52°C) on 9th SMW (26th February–4th March) and the highest (34.83°C) on 17th SMW (23rd–29th April). The weekly maximum relative humidity ranged from 77% on 20th SMW (14–20 May) to 90.43% on 9th SMW (26th February–4th March), while the minimum relative humidity ranged from 26.29% on 15th SMW (9th–15th April) to 53.86% on 9th SMW (26th February–4th March). There was no high rainfall event during storage period that could have abruptly affected sprouting and rottage. The high rainfall event of 36.8 mm on the last day of observation may not be considered in this study.

During the short storage period of 26 days in 2021, the minimum temperature varied from 22.67°C to 24.63°C; maximum temperature from 36.34 to 39.73°C; minimum relative humidity varied from 29.86 to 36%; maximum relative humidity from 91.29 to 95% and bright sunshine hours from 3.93 to 7 hours in different weeks. There was no rainfall in first 3 weeks and only 7.5 mm rainfall during 4th week.

2.3. Storage study

For the first experiment, approximately 5 kg potatoes of each genotype were kept inside perforated plastic containers under ambient temperature. Rottage of tubers on number and weight basis were recorded at 30, 60, 75 and 90 days. Similarly sprouting of tubers in different genotypes was recorded at 75 and 90 days. Finally, weight of healthy tubers at the end of storage study was observed. In the second experiment, tubers of varying weights (20–40 g, 40–60 g and >60 g) in two varieties were taken and their weight loss (from initial weight after harvesting) was observed at 4, 7, 11, 18 and 26 days and the cumulative weight loss was expressed in percentage.

2.4. Data analysis

The weather data presented in graph and simple statistical analyses like mean, range, standard deviation and coefficient of variation were derived from all data utilizing Microsoft Excel. Correlation and path analyses were done following Singh and Choudhury (1977) and the dendrogram was constructed to exhibit genetic diversity following TNAUSTAT software.

3. RESULTS AND DISCUSSION

3.1. Experiment 1

After harvest, potato (*Solanum tuberosum* L.) tubers are prone to physiological losses caused by respiration and transpiration. During respiration, sugar and starches present in potato tuber are converted to carbon dioxide & water and lost to the environment. Similarly transpiration occurs from tuber surface due to the vapour pressure difference between the tubers and the surrounding air. The temperature and relative humidity of storage chamber greatly influences the shelf life of potato. In majority of the cold stores in India, temperature of 2–4°C and relative humidity of 90–95% are maintained where physiological losses are minimized but reducing sugar content rises. Somewhat higher temperature of 8–10°C is maintained in special cold stores to minimize the reducing sugar build up and keep the tubers more healthy for consumption although there is hike in respiration rate and thereby storage loss as compared to tubers stored at 2–4°C. To check sprouting of tubers at 8–10°C maintained in such special stores, CIPC treatment is given which is also a costly affair. However, many farmers still store potatoes in heaps in well ventilated rooms for short term storage for consumption or marketing within 2–3 months.

Storage of tubers at room temperature is done under complete darkness to prevent greening. The temperature, relative humidity and air circulation in the room greatly affects keeping quality of stored potatoes. Temperature below 3°C and above 15°C is not recommended for most of the varieties due to steep hike in respiration. When the temperature is below 3°C, accumulation of reducing sugar becomes so high that it affects flavor as well as boiling and baking quality.

There are several factors affecting rate of respiration and weight loss of tubers such as variety, seed tuber health and maturity level, and growth condition in the field. Several varieties of potato are available in India which differ from each other with respect to many morphological and physiological traits. Different forms of storage like low temperature storage, controlled atmosphere storage, storage in diffused sunlight, in situ storage, storage in pits and storage in bamboo baskets are followed in different parts of the world. Ezekiel et al. (2002) reported rottage in room storage and heap storage to be 4.7% and 3.8%, respectively. Cold stored potatoes have significantly higher accumulation of reducing sugar as compared to other methods of storage

(Khanal and Bhattarai, 2020).

In case of potato, tubers are stored for future consumption, processing and maintenance of seed reserves. It is always better to use fresh potatoes or tubers stored at 8–10°C for consumption and processing. Necessary care is taken to consume or process tubers before sprouting. For use as seed, tubers are stored at 2–4°C where chances of sprouting and rottage are minimum. When tubers are stored under room temperature, respiration and transpiration become high resulting more storage loss, and simultaneously increasing the rate of sprouting and rotting. Loss of moisture from tuber results in shrinkage and makes the tubers non-marketable (Singh and Kaur, 2016).

In our experiment, storage was done at relatively high temperature and relative humidity. There was no rottage in one red-skinned variety, Kufri Kanchan and five white-skinned table purpose varieties, Kufri Pushkar, Kufri Himsona, Kufri Ashoka, Kufri Laukar and Kufri Jyoti and two white-skinned processing varieties, Kufri Chipsona-3 and Atlantic within 30 days (Table 1). Highest rottage was observed in Kufri Sinduri (27.6%) on the basis of number of tubers and in Kufri Lalima (21.6%) on the basis of

Table 1: Rottage, sprouting and storage loss of potato genotypes under ambient temperature

Genotype	% Rottage (Number basis)*				% Rottage (Weight basis)*				% Sprouting of tubers		% healthy tubers at the end of storage (90 d) (Weight basis)	Storage loss (%) at 90 d
	30 d	60 d	75 d	90 d	30 d	60 d	75 d	90 d	75 d	90 d		
K. Arun	14.3	0.0	5.7	5.7	10.6	0.0	4.5	3.8	2.9	5.7	71.5	28.5
	14.3	14.3	20	25.7	10.6	10.6	15.1	18.9	2.9	5.7	71.5	28.5**
K. Sinduri	27.6	17.1	20.7	13.8	19.8	15.2	18.8	11.3	0.0	0.0	13.1	86.9
	27.6	44.7	65.4	79.2	19.8	35	53.8	65.1	0.0	0.0	13.1	86.9
K. Lalit	3.4	25.7	10.3	3.4	3.6	22.5	9.5	1.9	0.0	10.3	50.9	49.1
	3.4	29.1	39.4	42.8	3.6	26.1	35.6	37.5	0.0	10.3	50.9	49.1
K. Lalima	18.5	14.3	14.8	11.1	21.6	17.0	13.1	7.7	0.0	0.0	30.3	69.7
	18.5	32.8	47.6	58.7	21.6	38.6	51.7	59.4	0.0	0.0	30.3	69.7
K. Kanchan	0.0	0.0	0.0	12.5	0.0	0.0	0.0	10.2	0.0	12.5	80.1	19.9
	0.0	0	0	12.5	0.0	0	0	10.2	0.0	12.5	80.1	19.9
K. Pukhraj	3.7	5.7	11.1	7.4	3.3	4.8	10.4	9.6	3.7	7.4	61.5	38.5
	3.7	9.4	20.5	27.9	3.3	8.1	18.5	28.1	3.7	7.4	61.5	38.5
K. Chandramukhi	17.6	5.7	0.0	5.9	14.4	8.3	0.0	5.2	0.0	23.5	58.5	41.5
	17.6	23.3	23.3	29.2	14.4	22.7	22.7	27.9	0.0	23.5	58.5	41.5
K. Pushkar	0.0	2.9	7.1	7.1	0.0	1.9	12.9	4.0	0.0	7.1	67.8	32.2
	0.0	2.9	10	17.1	0.0	1.9	14.8	18.8	0.0	7.1	67.8	32.2
K. Himsona	0.0	2.9	0.0	3.6	0.0	2.8	0.0	3.3	10.7	100	82.5	17.5
	0.0	2.9	2.9	6.5	0.0	2.8	2.8	6.1	10.7	100	82.5	17.5
K. Ashoka	0.0	0.0	0.0	3.4	0.0	0.0	0.0	2.5	3.4	20.7	91.5	8.5
	0.0	0	0	3.4	0.0	0	0	2.5	3.4	20.7	91.5	8.5
K. Surya	3.3	2.9	0.0	0.0	1.1	3.0	0.0	0.0	6.7	13.3	88.5	11.5
	3.3	6.2	6.2	6.2	1.1	4.1	4.1	4.1	6.7	13.3	88.5	11.5
K. Anand	8.7	5.7	0.0	0.0	11.7	11.0	0.0	0.0	0.0	0.0	72.4	27.6
	8.7	14.4	14.4	14.4	11.7	22.7	22.7	22.7	0.0	0.0	72.4	27.6
K. Laukar	0.0	11.4	0.0	9.5	0.0	13.7	0.0	11.8	9.5	23.8	66.8	33.2
	0.0	11.4	11.4	20.9	0.0	13.7	13.7	25.5	9.5	23.8	66.8	33.2
K. Shailaja	10.7	5.7	3.6	7.1	7.6	6.8	2.6	7.0	0.0	17.9	65.0	35
	10.7	16.4	20	27.1	7.6	14.4	17	24	0.0	17.9	65.0	35

Figure 1: Continue...

Genotype	% Rottage (Number basis)*				% Rottage (Weight basis)*				% Sprouting of tubers		HTES	Storage loss (%) at 90 d
	30 d	60 d	75 d	90 d	30 d	60 d	75 d	90 d	75 d	90 d		
K. Garima	3.8	11.4	7.7	7.7	3.2	10.4	4.0	2.3	7.7	100	57.8	42.2
	3.8	15.2	22.9	30.6	3.2	13.6	17.6	19.9	7.7	100	57.8	42.2
K. Gaurav	12.0	11.4	8.0	12.0	8.3	13.0	9.6	8.8	20.0	100	44.4	55.6
	12.0	23.4	31.4	43.4	8.3	21.3	30.9	39.7	20.0	100	44.4	55.6
K. Himalini	4.0	8.6	4.0	0.0	2.8	11.8	3.7	0.0	16.0	100	76.1	23.9
	4.0	12.6	16.6	16.6	2.8	14.6	18.3	18.3	16.0	100	76.1	23.9
K. Jyoti	0.0	5.7	12.9	6.5	0.0	5.1	14.5	5.3	0.0	16.1	67.7	32.3
	0.0	5.7	18.6	25.1	0.0	5.1	19.6	24.9	0.0	16.1	67.7	32.3
K. Badsah	13.3	2.9	0.0	0.0	10.3	6.7	0.0	0.0	0.0	0.0	70.9	29.1
	13.3	16.2	16.2	16.2	10.3	17	17	17	0.0	0.0	70.9	29.1
K. Khyati	3.6	8.6	7.1	10.7	4.7	11.7	9.5	6.5	7.1	39.3	55.9	44.1
	3.6	12.2	19.3	30	4.7	16.4	25.9	32.4	7.1	39.3	55.9	44.1
K. Jawahar	12.5	11.4	9.4	9.4	10.9	5.8	7.8	7.7	0.0	0.0	54.4	45.6
	12.5	23.9	33.3	42.7	10.9	16.7	24.5	32.2	0.0	0.0	54.4	45.6
K. Chipsona-1	2.9	2.9	5.9	2.9	4.1	2.0	6.3	2.5	11.8	100	76.9	23.1
	2.9	5.8	11.7	14.6	4.1	6.1	12.4	14.9	11.8	100	76.9	23.1
K. Chipsona-3	0.0	0.0	0.0	7.4	0.0	0.0	0.0	5.9	3.7	7.4	71.5	28.5
	0.0	0	0	7.4	0.0	0	0	5.9	3.7	7.4	71.5	28.5
K. Frysona	3.7	2.9	0.0	0.0	4.1	3.0	0.0	0.0	0.0	22.2	90.3	9.7
	3.7	6.6	6.6	6.6	4.1	7.1	7.1	7.1	0.0	22.2	90.3	9.7
Atlantic	0.0	2.9	5.0	0.0	0.0	3.2	3.9	0.0	5.0	100	85.7	14.3
	0.0	2.9	7.9	7.9	0.0	3.2	7.1	7.1	5.0	100	85.7	14.3
Mean	6.54	6.75	5.33	5.88	5.68	7.19	5.24	4.69	4.33	33.09	66.08	33.92
	6.5	13.3	18.6	24.5	5.7	12.9	18.1	22.8	4.33	33.09	66.08	33.92
Minimum	0	0	0	0	0	0	0	0	0	0	13.1	8.5
	0	0	0	3.4	0	0	0	2.5	0	0	13.1	8.5
Maximum	27.6	25.7	20.7	13.8	21.6	22.5	18.8	11.8	20	100	91.5	86.9
	27.6	44.7	65.4	79.2	21.6	38.6	53.8	65.1	20	100	91.5	86.9
Standard deviation	7.41	6.15	5.65	4.40	6.32	6.07	5.65	3.83	5.62	39.49	18.38	18.38
C.V. (%)	113.2	91.2	106.0	74.8	111.1	84.4	107.8	81.7	129.9	119.3	27.8	54.2
Correlation with storage loss (r)	0.729**	0.743**	0.799**	0.698**	0.722**	0.707**	0.736**	0.589**	-0.103	-0.205	-	-

HTES: % healthy tubers at the end of storage (90 d) (Weight basis); *: Rotten tubers were removed after each observation at 30, 60, 75 and 90 days; **Figures in 2nd row indicates cumulative values

weight of tubers. The coefficient of variation for rottage at 30, 60, 75 and 90 days was found to be 113%, 91%, 106% and 75%, respectively on the basis of weight of tubers. The percentage of rottage on weight basis at the end of storage period (90 days) varied from 2.5% in Kufri Ashoka to 65.1% in Kufri Sinduri. There was wide variation among different genotypes for sprouting at 75 and 90 days. The genotypes exhibiting no sprouting even at 90 days after storage were

Kufri Sinduri, Kufri Lalima, Kufri Anand, Kufri Badshah and Kufri Jawahar. Although maximum sprouting of 20% was noticed in Kufri Gaurav at 75 days of storage, some genotypes like Kufri Himsona, Kufri Garima, Kufri Gaurav, Kufri Himalini, Kufri Chipsona-1 and Atlantic exhibited 100% sprouting at 90 days after storage. The average sprouting at 75 and 90 days after storage was 4.33% and 33.09%, respectively.Maximum storage loss of 86.9% was observed in Kufri Sinduri (86.9%) followed by Kufri Lalima (69.7%) and Kufri Gaurav (55.6%) while minimum storage loss was recorded in Kufri Ashoka (8.5%) and Kufri Frysona (9.7%). The average storage loss at 90 days under ambient condition was found to be 33.92%. Therefore, our experiment clearly shows the length of safe storage period of different potato varieties under ambient temperature in coastal Odisha.

Significantly high positive correlation was observed between the number of rotten tubers at 30 days and 75 days (Table 2). The number of rotten tubers at 60 days had significant positive correlation with that of 75 days. Similar association was observed between the number of rotten tubers at 75 and 90 days. Highly significant positive association was found between the weight of rotten tubers at 30 and 60 days. Sprouting at 75 days exhibited positive correlation with sprouting at 90 days. Rotting at all the dates of observation exhibited highly significant positive correlation with storage loss. However sprouting at 75 and 90 days of storage had non-significant and mostly negative correlation with rottage at different dates and storage loss.

Table 2: Correlation among storage traits

Traits	RotN30	RotN60	RotN75	RotN90	RotW30	RotW60	RotW75	RotW90	Spr75	Spr90
RotN60	0.372*									
RotN75	0.468**	0.626**								
RotN90	0.334	0.330	0.522**							
RotW30	0.955**	0.395*	0.462**	0.302						
RotW60	0.408*	0.928**	0.478**	0.248	0.466**					
RotW75	0.360*	0.538**	0.953**	0.522**	0.355*	0.410*				
RotW90	0.280	0.262	0.411*	0.913**	0.233	0.195	0.406*			
Spr75	-0.238	0.016	-0.119	-0.026	-0.290	0.088	-0.095	-0.027		
Spr90	-0.303	-0.035	-0.099	-0.186	-0.330	-0.009	-0.120	-0.264	0.802**	
St.loss	0.729**	0.743**	0.799**	0.698**	0.722**	0.707**	0.736**	0.589**	-0.103	-0.205

*,** Significant at (p=0.05) and (p=0.01), respectively

The respiration rate increases gradually as sprouting starts. Physiological changes in potato during sprouting cause an increase in reducing sugar. The enzymatic conversion of starch and sucrose leads to an increase in reducing sugar (Amjad et al., 2020). Although respiration is a catabolic process and more respiration of sprouted tubers is expected to be associated with more weight loss, the varieties exhibiting better sprouting in our study contradict the prediction. Probably, varieties showing better sprouting are metabolically more active and more resistant to rottage for which they exhibit reduced storage loss. All observations on rottage (both on number and weight basis) exhibited highly significant positive correlation with storage loss; highest direct effect on storage loss being observed for percentage of rotten tubers at 90 days followed by that at 30 days. In contrast, the direct effect of sprouting at 75 and 90 days on storage loss was found to be very less clearly indicating minor role of sprouting on the storage loss (Table 3).

Difference in the speed of sprouting of genotypes may be attributed to several factors like storage conditions (Sowa-Niedziałkowska and Zgorska, 2005), periderm thickness (Ezekiel et al., 2004), individual metabolism of particular variety (Senning et al., 2010) and environmental conditions including temperature and rainfall during crop growth (Rykaczewska, 2004, Czerko and Grudzinska, 2014).The legislation on CIPC application puts constraints on its use (Blenkinsop *et al.*, 2002) and therefore alternate technologies for extending post-harvest storage of potato must be worked out. Even the alternate sprout control chemicals like hydrogen peroxide plus (HPP) (Al-Mughrabi, 2010; Mani et al., 2014), 1, 4-dimethylnaphthalene (1, 4- DMN) (de Weerd et al., 2010), UV-C (Cools et al., 2014, Pristijono et al., 2016) etc. have their own merits and demerits. Sweetening of tubers, although governed by variety (Elmore et al., 2016) and growing location (Muttucumaru et al., 2017), is significantly induced by cold. Such tubers also become unsuitable for sugar patients and for processing due to brown coloration out of Maillard reaction on cooking at high temperatures (>120°C). Formation of carcinogenic

Table 3: Path matrix for storage traits

Traits	RotN30	RotN60	RotN75	RotN90	RotW30	RotW60	RotW75	RotW90	Spr75	Spr90	'r' with Stg. loss
RotN30	0.327	0.027	0.048	0.128	0.034	0.117	0.061	-0.012	0.003	-0.004	0.729**
RotN60	0.122	0.072	0.064	0.126	0.014	0.265	0.092	-0.011	0.000	0.000	0.743**
RotN75	0.153	0.045	0.102	0.200	0.016	0.137	0.163	-0.018	0.002	-0.001	0.799**
RotN90	0.109	0.024	0.053	0.382	0.011	0.071	0.089	-0.039	0.000	-0.002	0.698**
RotW30	0.312	0.028	0.047	0.116	0.035	0.133	0.061	-0.010	0.004	-0.004	0.722**
RotW60	0.133	0.067	0.049	0.095	0.016	0.286	0.070	-0.008	-0.001	0.000	0.707**
RotW75	0.118	0.039	0.097	0.200	0.012	0.117	0.171	-0.018	0.001	-0.001	0.736**
RotW90	0.091	0.019	0.042	0.349	0.008	0.056	0.069	-0.043	0.000	-0.003	0.589**
Spr75	-0.078	0.001	-0.012	-0.010	-0.010	0.025	-0.016	0.001	-0.013	0.009	-0.103
Spr90	-0.099	-0.003	-0.010	-0.071	-0.012	-0.003	-0.020	0.011	-0.010	0.012	-0.205

Residual = 0.03298

acrylamide as a byproduct of Maillard reaction with reducing sugar (Muttucumaru et al. (2017) is also a matter of concern. A suitable variety with long shelf life is always the best option.

Based on the difference in post harvest traits, all the 25 potato genotypes fell into three broad groups at 40% dissimilarity level (Figure 2). Group-I comprising Kufri Sinduri and Kufri Lalima exhibited maximum distance from rest of the genotypes. Group-II comprised only one variety,

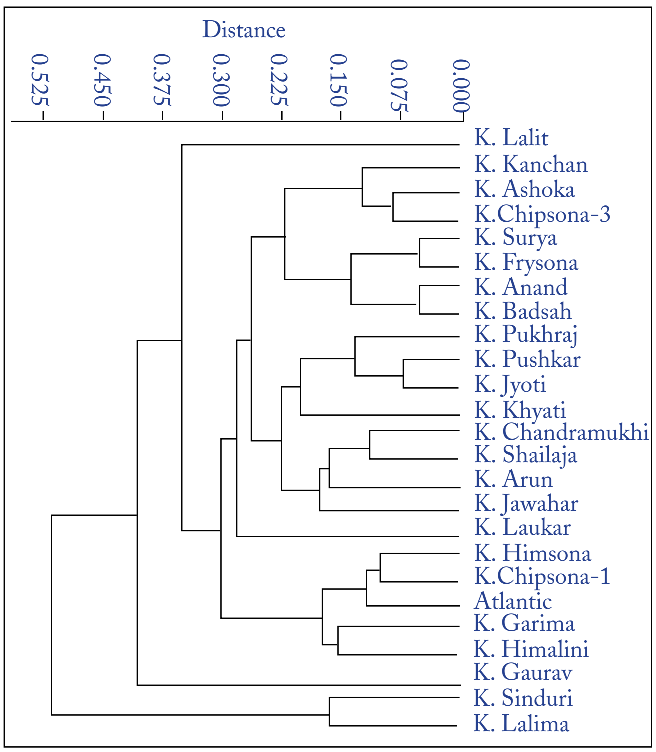

Figure 2: Diversity among potato varieties with respect to post harvest traits

Kufri Gaurav. Group –III included maximum number (22) of genotypes. At 30%, dissimilarity level, Group-III was divisible into three sub-groups: III (a) comprising Kufri Himsona, Kufri Chipsona-1, Atlantic, Kufri Garima and Kufri Himalini. However, three processing type varieties, Kufri Himsona, Kufri Chipsona-1 and Atlantic clearly separated from Kufri Garima and Kufri Himalini at 15% dissimilarity level. Sub-group III(b) comprised of 16 genotypes which in turn formed eight mini groups at 15% dissimilarity level. Two varieties, Kufri Surya and Kufri Frysona with oblong tubers and suitable for processing were found close to each other. Two other varieties, Kufri Anand and Kufri Badshah were also close to each other. Sub-group III(c) comprised of single genotype Kufri Lalit with light pink skin.

3.2. *Experiment 2*

The weight loss of all the grades of tubers was observed in both of the varieties (Kufri Pukhraj and Kufri Surya) up to 26 days of storage in 2021 (Table 4). Even this short storage period was having comparatively high temperature and relative humidity to enhance post-harvest losses.

The variety Kufri Pukhraj exhibited higher weight loss than Kufri Surya for all grades of tubers. The tubers weighing 20–40 g had highest weight loss (1.22–2.81) among all the grades. However, the tubers of >60 g showed the least weight loss in both the varieties. The speed of weight loss in Kufri Pukhraj was higher than that of Kufri Surya as evident from the weight loss data at different days of storage.

The coefficient of variation for weight loss of all the tuber grades was observed to be the highest at 4 days of storage in both the varieties. In both the varieties, the tubers of 20–40 g grade had higher weight loss as well as higher CV (%). The coefficient of variation for weight loss after 4 days of harvest ranged from 52.86 for >60 g tuber grade to 106.63

Table 4: Extent of weight loss of different size tubers after harvest in two potato varieties, Kufri Pukhraj and Kufri Surya (in 2021)

Seed grade (Weight in g)	% of weight loss (cumulative) from initial weight on different days after harvesting						
	Parameters	Initial wt (g) (5.3.21)	WL1 (9.3.21)-4 days	WL2 (12.3.21)-7 days	WL3 (16.3.21)-11 days	WL4 (23.3.21)-18 days	WL5 (31.3.21)-26 days
Kufri Pukhraj							
20-40 g	Range	27.25-38.64	0.03-0.43	0.03-0.71	0.37-1.06	0.81-1.66	1.22-2.81
	Mean*	33.35+3.47	0.10+0.11	0.27+0.17	0.57+0.19	1.13+0.26	1.81+0.46
	CV (%)	10.42	106.63	60.80	33.64	22.92	25.64
40-60 g	Range	42.3-56.96	0.02--0.1	0.13-0.35	0.3-0.71	0.67-1.42	1.09-2.21
	Mean	47.96+4.38	0.05+0.03	0.21+0.09	0.46+0.15	0.98+0.29	1.55+0.45
	CV (%)	9.13	62.27	41.28	33.37	29.50	28.83
>60 g	Range	60.26-87.03	0.05-0.18	0.18-0.43	0.4-0.75	0.87-1.51	1.37-2.14
	Mean	70.8+11.43	0.09+0.05	0.28+0.08	0.57+0.13	1.13+0.23	1.71+0.30
	CV (%)	16.14	52.86	29.85	22.60	20.26	17.47
Kufri Surya							
20-40 g	Range	22.99-39.63	0.03-0.15	0.17-0.38	0.41-0.76	0.92-1.49	1.44-2.25
	Mean	34.19+ 5.18	0.06+0.03	0.25+0.07	0.53+0.10	1.08+0.16	1.68+0.25
	CV (%)	15.15	54.70	28.83	19.83	15.25	14.59
40-60 g	Range	40.6-59.52	0-0.06	0.04-0.25	0.19-0.57	0.45-1.17	1.01-1.84
	Mean	46.08+5.72	0.04+0.02	0.19+0.05	0.44+0.10	0.95+0.18	1.50+0.23
	CV (%)	12.42	52.91	28.19	21.39	19.37	14.99
>60 g	Range	63.39-68.84	0.04-0.09	0.16-0.35	0.36-0.63	0.73-1.16	1.17-1.72
	Mean	65.66+2.59	0.06+0.02	0.23+0.08	0.47+0.11	0.95+0.18	1.50+0.27
	CV (%)	3.94	36.00	36.03	24.38	18.62	17.85

* Mean±Standard deviation

for 20–40 g tuber grade in potato cv. Kufri Pukhraj and from 36.0 for >60 g tuber grade to 54.70 for 20–40 g tuber grade in potato cv. Kufri Surya. This shows that variation among genotypes for weight loss was maximum in small tubers and minimum in large tubers. The coefficient of variation showed a decreasing trend with increase in storage period showing that weight loss gradually become uniform among genotypes when the storage period is extended. Small seed tubers (20–40 g) having more moisture percentage exhibited higher weight loss than the seed tubers of 40–60 g and >60 g grades. Samotus et al. (1973) reported that the degree of weight loss is influenced by relative humidity in the storage atmosphere and the variety.

Khanal and Bhattarai (2020) observed lowest post-harvest loss of tubers (4.38%) in cold store and highest loss (13.04%) under in-house condition. Similarly, respiration rate in cold-stored potatoes and in-basket potatoes at 60 days of storage was found to be 3.17 and 6.55 mg CO_2 kg^{-1} $hour^{-1}$, respectively. Tubers remain in dormant state with low and constant rate of respiration inside cold store. Activity of invertase rises at low temperature in cold stores (Singh and Kaur, 2009) which is about 2 to 12 folds from harvesting to after-cold storage moment (Karim et al., 2008).

4. CONCLUSION

Considering the storage loss due to rottage, shrinkage and sprouting of potato tubers after harvest, our investigation seems to help potato growers to choose appropriate variety for maximum shelf life under room temperature. There was wide variation among different genotypes for sprouting at 75 and 90 days. Highest direct effect on storage loss was exerted by percentage of rottage at 90 days. The variation among genotypes for weight loss was maximum in small tubers and minimum in large tubers.

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