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Effect of Lifting Time and Tuber Size on Ambient Storage Performance of Potato Derived from True Potato Seed

J.S. Nipa, T.S. Roy, A.K.M.R. Amin and M. Hasanuzzaman

Department of Agronomy, Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka-1207

Abstract: Potato tuber derived from true potato seed was evaluated under the natural storage condition affected by five lifting period after haulm killing *viz*., L_0 (0 days after haulm killing), L_1 (3 days after haulm killing), L_2 (6 days after haulm killing), L_3 (9 days after haulm killing) and L_4 (12 days after haulm killing) and 3 tuber size *viz*., small, medium and large by using completely randomized design (CRD) with 3 replications at Sher-e-Bangla Agricultural University, Dhaka, Bangladesh, during 2011. The natural storage performance of tubers was influenced by lifting period and /or tuber size. Most of the post harvest parameters of tuber *viz*., dry matter content, weight loss, rotten tuber, total soluble solid content, days to sprout initiation, days to shriveling and apical sprout length showed better performance with increasing lifting period. Among the tuber sizes, small sized tubers showed better post harvest performance compared to those of large and medium. Among the lifting periods and tuber sizes, L_3 (9 days after haulm killing) and small sized tuber showed better natural storage performance.

Key words: Potato tuber · True potato seed · Tuber size · Storage condition

INTRODUCTION

Potato is the fourth biggest crop of the world after wheat, rice and maize [1-3]. Now a days potato is the third staple food/vegetable crop could contribute in poverty alleviation and food security of Bangladesh. It is estimated that local varieties were cultivated in about 184000 acres of land, producing 806000 m tons tubers and HYV varieties were cultivated in about 890000 acres of land, producing 7124000 m tons of tubers during 2009-2010 [4]. Storage problem is a serious problem in Bangladesh. In tropical and subtropical areas like Bangladesh, it is difficult to produce seed tubers of potato due to lack of appropriate storage facilities and transport, as well as the presence of viral diseases [5]. Due to its perishable nature farmers cannot store potato at home in large quantities for long period. Farmers in most places are under compulsion to sell out the major part of their product immediately after harvests with low price. The destruction of potato haulm is necessary to reduce the late blight and virus spread, to reduce interference at harvest, to improve skin-set, to control tuber size and to improve storage quality. Early and thorough haulm destruction is an essential part of good seed production. The use of True Potato Seed (TPS) for potato production has increased recently in Europe, North America and Asia, especially in the developing countries like Bangladesh [6-8]. However, knowledge on TPS progenies and appropriate lifting period for keeping quality under natural storage condition is not sufficient in our country. But the information of the storage and its mechanism is of great importance for the selection of TPS progenies having good keeping quality and better lifting period. In Bangladesh, potato is generally stored in three ways, namely, (i) in cold stores under controlled environment and (ii) in the houses under controlled environment and (ii) in the houses under ordinary room conditions. In Bangladesh, the present cold storage capacity is only about 25% of the total potato production [4]. An important characteristic of potato varieties is that, they can be stored under ordinary room conditions for a relatively longer period. Naturally the potato varieties are more convenient for those growers who wish to store their own produce for consumption and sale over a long period under ordinary room conditions and for use as seed tubers. Knowledge of proper storage environment obviously helps to maintain the quality, extend the storage period and increase the value of stored potato.

Corresponding Author: M. Hasanuzzaman, Department of Agronomy, Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka-1207.

The present study was undertaken to find out the effect of lifting period and size of potato under natural storage condition for longer dormancy.

MATERIALS AND METHODS

The experiment was conducted at the Laboratory of the Department of Agronomy, Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka-1207 during the period from March to August, 2011 to study the natural storage performance of potato as affected by lifting period after haulm killing. Any visible defects, disease symptoms and insect infestations free tubers were used for the experiment derived from BARI TPS-1. The experiment consisted of two factors, one was five harvesting periods of 3 days interval such as L_0= 0 day after haulm killing, L_1= 3 days after haulm killing, L_2=6 days after haulm killing, L_3= 9 days after haulm killing, L_4=12 days after haulm killing and another factor was three tuber sizes of BARI TPS-1 such as L=Large (>45 mm), M=Medium (28-45 mm), S=Small (<28 mm). The experiment was laid out in a Completely Randomized Design (CRD) with 3 replications. Data was recorded on different parameters. The collected data on various parameters were statistically analyzed using MSTAT statistical package. Duncan's Multiple Range Test (DMRT) at the 5% level was used to compare the significance among the treatments.

RESULTS AND DISCUSSION

Dry Matter (%) of Peel of Potato: A significant variation was found due to the effect of lifting period, different tuber size and treatment combination on dry matter percentage of peel at different days after storage (Table 1). Dry matter percentage of peel of potato increased with the increasing lifting period. The highest dry matter percentages of peel of potato (21.44, 21.72, 25.95, 27.96 and 22.90 %) were taken from the harvested potato of 12 days after haulm killing (L_4) whereas the lowest dry matter weight percentages of peel of potato (14.51, 14.18, 17.84 and 19.93%) were obtained from the harvested potato of 0 days after haulm killing (L_0) at 0, 30, 60, 90 and 120 days after storage, respectively.

Table 1: Effect of lifting period, tuber size and the treatment combination on dry matter (%) of peel of potato at different days after storage

	Dry matter (%) of peel of potato at different DAS				
Lifting period	0	30	60	90	120
L_0	14.51 d	14.18 e	17.84 e	19.93 d	21.90 b
L_1	16.27 c	16.60 d	19.41 d	22.27 c	17.79 d
L_2	17.87 b	18.14 c	22.44 c	24.48 b	19.09 c
L_3	20.78 a	20.96 b	24.93 b	27.25 a	21.79 bc
L_4	21.44 a	21.72 a	25.95 a	27.96 a	22.90 a
CV (%)	4.11	3.74	3.27	3.66	5.09
Small	14.0 b	16.51 c	16.64 c	20.20 c	22.70 c
Medium	13.43 c	17.83 b	17.95 b	22.10 b	23.95 b
Large	15.11 a	20.18 a	20.36 a	24.04 a	26.53 a
CV (%)	4.11	3.74	3.27	3.66	5.09
L_0 S	12.90 g	12.15 g	14.47 d	15.71 h	18.00 g
L_0 M	14.61 f	14.11 f	18.21 bc	17.27 g	19.62 f
L_0 L	16.02 e	16.27 e	33.02 a	20.55 ef	22.17 de
L_1 S	14.05 fg	14.65 f	18.92 b	16.82 gh	19.97 f
L_1 M	16.21 e	16.62 e	17.19 c	20.00 f	21.66 e
L_1 L	18.56 d	18.53 d	17.26 c	21.40 e	25.18 c
L_2 S	16.04 e	16.33 e	17.74 bc	20.66 ef	23.51 d
L_2 M	17.12 e	17.44 de	14.94 d	21.81 de	22.33 de
L_2 L	20.43 bc	20.64 bc	7.79 gh	24.85 c	27.61 ab
L_3 S	19.54 cd	19.86 c	10.96 e	22.86 d	25.53 c
L_3 M	20.02 bc	20.10 c	9.49 f	25.63 bc	27.73 ab
L_3 L	22.78 a	22.92 a	8.94 fg	26.29 ab	28.47 a
L_4 S	20.03 bc	20.22 c	7.88 gh	24.94 c	26.28 bc
L_4 M	21.20 b	21.493 b	7.30 h	25.80 bc	28.39 a
L_4 L	23.10 a	23.43 a	8.53 fgh	27.11 a	29.20 a
CV (%)	4.11	3.74	3.27	3.66	5.09

Table 2: Effect of lifting period, size of potato and the treatment combination on dry matter (%) of flesh of potato at different days after storage

	Dry matter (%) of flesh of potato at different DAS				
Lifting period	0	30	60	90	120
L_0	12.85 e	13.52 e	15.52 e	16.55 e	18.81 e
L_1	15.02 d	15.46 d	17.56 d	18.35 d	20.75 d
L_2	16.31 c	16.89 c	19.43 c	21.31 c	23.62 c
L_3	19.39 b	19.93 b	21.59 b	23.71 b	26.11 b
L_4	20.55 a	21.28 a	22.31 a	24.60 a	27.32 a
CV (%)	4.26	4.14	3.58	3.41	3.05
Small	15.33 c	15.89 c	17.24 c	18.59 c	21.35 c
Medium	16.62 b	17.21 b	18.87 b	20.95 b	23.02 b
Large	18.52 a	19.15 a	21.74 a	23.18 a	25.60 a
CV (%)	4.26	4.14	3.58	3.41	3.05
L_0 S	11.18 j	11.98 i	13.24 i	14.47 i	16.29 h
L_0 M	12.92 i	13.53 h	15.68 h	16.21 i	18.41 g
L_0 L	14.40 h	15.04 g	17.63 g	18.98 gh	21.73 ef
L_1 S	13.03 i	13.53 h	15.63 h	15.25 ij	17.55 g
L_1M	15.09 gh	15.79 fg	17.31 g	18.38 h	20.55 f
L_1 L	16.95 ef	17.05 f	19.74 f	21.41 de	24.15 d
L_2 S	15.08 gh	15.48 g	17.28 g	19.73 fg	22.90 e
L_2 M	15.78 fg	16.28 fg	18.16 g	20.63 ef	21.70 ef
L_2 L	18.08 de	18.91 de	22.86 bc	23.58 c	26.25 bc
L_3 S	18.04 de	18.54 e	19.85 f	21.39 de	24.22 d
L_3 M	19.06 cd	19.46 de	21.16 de	24.71 bc	26.96 bc
L_3 L	21.08 ab	21.78 ab	23.76 ab	25.04 b	27.14 b
L_4 S	19.33 cd	19.93 cd	20.21 ef	22.08 d	25.76 c
L_4 M	20.26 bc	20.96 bc	22.02 cd	24.82 bc	27.48 b
L_4 L	22.05 a	22.94 a	24.70 a	26.89 a	28.73 a
CV (%)	4.26	4.14	3.58	3.41	3.05

Table 3: Effect of lifting period, size of potato and their combination on weight loss of tuber (%) at different days after storage

	Weight loss of tuber (%)			
Lifting period	30	60	90	120
L_0	6.87 a	9.33 a	11.87 a	18.07 a
L_1	6.41 ab	8.11 b	9.64 b	16.94 b
L_2	5.83 bc	7.80 bc	8.53 c	15.67 c
L_3	5.53 c	7.17 c	8.03 d	15.27 c
L_4	5.93 bc	7.93 b	8.54 c	17.40 ab
CV (%)	11.45	8.72	7.57	4.22
Small	5.48 b	7.24 c	8.50 c	15.70 c
Medium	5.94 b	8.08 b	9.46 b	16.64 b
Large	6.92 a	8.88 a	10.01 a	17.66 a
CV (%)	11.45	8.72	7.57	4.22
L_0 S	6.80 a-c	8.90 a-d	10.11 bc	17.80 bc
L_0 M	6.70 a-c	9.40 ab	12.50 a	18.00 bc
L_0 L	7.10 ab	9.70 a	13.01 a	18.40 ab
L_1 S	6.00 b-d	7.70 d-f	8.90 c-g	16.90 c
L_1 M	6.30 a-d	8.10 b-f	9.70 b-d	16.80 c
L_1 L	6.91 a-c	8.51 a-e	10.31 b	17.11 bc
L_2 S	4.90 e	6.90 fg	7.80 fg	14.90 d
L_2 M	5.80 b-e	7.80 c-f	8.60 d-g	15.40 d
L_2 L	6.80 a-c	8.70 a-d	9.20 b-e	16.70 c
L_3 S	4.90 e	5.90 g	7.70 g	13.70 e
L_3 M	5.30 de	7.20 ef	8.00 e-g	15.40 d
L_3 L	6.40 a-d	8.40 a-e	8.40 d-g	16.70 c
L_4 S	4.80 e	6.80 fg	8.00 e-g	15.20 d
L_4 M	5.60 c-e	7.90 c-f	8.51 d-g	17.60 bc
L_4 L	7.40 a	9.10 a-c	9.10 b-f	19.40 a
CV (%)	4.06	8.72	7.57	4.22

Large sizes tuber produced the maximum dry matter weight percentage of peel (15.11, 20.18, 20.36, 24.04 and 26.53%) at 0, 30, 60, 90 and 120 days after storage, respectively whereas small sizes tuber showed the minimum result (16.51, 16.64, 20.20 and 22.70%) at all other DAS, respectively except 0 day after storage. The highest dry matter weight percentage of peel of potato (23.10, 23.43, 27.11 and 29.20%) was obtained from the combination of 12 days after haulm killing lifting period (L_4) with large sizes tuber at 0, 30, 90 and 120 DAS, respectively which was statistically at par with the combination of 9 days after haulm killing lifting period (L_3) with large sizes tuber. On the other hand, the lowest dry matter weight percentage of peel of potato (12.90, 12.15, 15.71 and 18.00%) was obtained from the combination of 0 days after haulm killing lifting period with small sizes tuber at 0, 30, 90 and 120 DAS, respectively. At 60 DAS, the highest dry matter weight percentage of peel of potato (33.02%) was found in the combination of large size tuber with 0 days after haulm killing potato whereas the lowest dry matter weight percentage (7.30%) from the combination of medium sizes tuber with the lifting period of 9 days after haulm killing.

Dry Matter Percentage of Flesh of Potato: A significant variation was found due to the effect of lifting period, different tuber size and treatment combination on dry matter percentage of flesh of potato at different days after storage (Table 2). Dry matter percentage of flesh of potato increased with the increasing lifting period and tuber size in respect of increasing the storage period. Among the lifting period, 12 days after haulm killing gave the highest dry matter weight percentage of flesh of potato (20.55, 21.28, 22.31, 24.60 and 27.32%) whereas 0 day after haulm killing produced the lowest dry matter content percentage of flesh (12.85, 13.52, 15.52, 16.55 and 18.81%) at 0, 30, 60, 90 and 120 days after storage, respectively. The highest dry matter (%) of flesh of potato (18.52, 19.15, 21.74, 23.18 and 25.60%) was observed in respect of large sizes tuber where small sizes tuber produced the lowest (15.33, 15.89, 17.24, 18.59 and 21.35%) at 0, 30, 60, 90 and 120 DAS, respectively. Dry matter (%) of flesh of potato was the maximum (22.05, 22.94, 24.70, 26.89 and 28.73%) in the combination of 12 days after haulm killing with large tuber whereas the lowest dry weight of flesh (11.18, 11.98, 13.24, 14.47 and 16.29%) was recorded from the combination of 0 days after haulm killing with small size of potato.

Weight Loss Percentage of Tubers: Weight loss of tubers was significantly influenced due to the effect of lifting period, size of potato and their combination at different days after storage (Table 3). Among the lifting period, 9 days after haulm killing (L_3) showed the minimum weight loss (5.53, 7.17, 8.03 and 15.27%) which was statistically similar with the lifting period of 6 and 12 days after haulm killing whereas the maximum weight loss (6.87, 9.33, 11.87 and 18.07%) was found from the lifting period of 0 days after haulm killing at 30, 60, 90 and 120 days after storage, respectively. Weight loss is the most important parameter of the storage period in that case minimum weight loss increase the storage period. Beside, lifting period closely correlated to weight loss because of mature potato gave the high dormancy of storage. 6, 9 and 12 days after haulm killing potato was mature and show high dormancy during storage whereas 0 days after haulm killing potato showed maximum weight loss due to immaturity of potato. The small tuber showed the long storage period than larger as well as medium tuber. Weight loss of potato also increases with the increasing storage period. Among the tuber sizes, small tubers produced the minimum weight loss (5.48, 7.24, 8.50 and 158.70%) and larger tubers showed the maximum weight loss (6.92, 8.88, 10.01 and 17.66%) at 30, 60, 90 and 120DAS, respectively. From the table 3, it was also clear that the small tuber perform the best on weight loss with the combination of all lifting periods than medium and larger tuber. Beside, lifting period of 9 days after haulm killing also showed the higher performance to compare the other lifting periods at the whole storage period. Minimum weight loss of tuber produced the long dormancy of storage in that case small tuber with 9 days after haulm killing gave the long dormancy of storage potato in this study.

Length of Sprout (cm): Length of sprout varied significantly ($P<0.01$) due to the effect of different lifting period, size of potato and their combination (Fig. 1 and Table 4). The longest sprout (1.77 cm) was found from the lifting period of 0 days after haulm killing (L_0) which was followed by the second highest (1.60 cm) with the lifting period of 3 days after haulm killing (L_1) and the shortest sprout (1.28 cm) was recorded from the lifting period of 12 days after haulm killing (L_4) storage potato. The sprout length range was 1.42 to 1.60 cm on sizes of tubers where the longest (1.60 cm) was found from large size tubers and the shortest (1.42 cm) was taken from small size tuber at 120 DAS. Similar trend of result were also reported by Roy *et al*. [9]. The longest sprout (1.96 cm) was found from the combination of the lifting period of 0 days after haulm killing (L_0) with larger sized tuber and the shortest sprout (1.20 cm) produced from the combination of 12 days after haulm killing with small sized tuber.

Table 4: Combined effect of different lifting period and sizes of potato on length of sprout and rotten tuber (%) at different days after storage

		Rotten tuber (%) at different days after storage (DAS)		
Treatments	Length of sprout (cm)	60	90	120
L_0 S	1.62 b-d	2.40 de	2.90 cd	3.07 fg
L_0 M	1.72 b	2.80 bc	3.50 ab	4.80 b
L_0 L	1.96 a	3.20 a	4.10 a	5.70 a
L_1 S	1.54 b-e	1.99 g	2.71 c-e	3.0 f-h
L_1 M	1.60 b-d	2.70 c	3.10 bc	3.70 de
L_1 L	1.67 bc	2.91 b	3.91 a	4.31 c
L_2 S	1.48 c-f	2.00 g	2.30 d-f	2.80 gh
L_2 M	1.52 c-f	2.30 ef	2.70 c-e	3.0 f-h
L_2 L	1.56 b-d	2.50 d	2.80 cd	3.40 ef
L_3 S	1.24 h	1.60 i	1.90 f	2.20 i
L_3 M	1.35 f-h	1.77 h	2.10 ef	2.50 hi
L_3 L	1.46 d-g	2.00 g	2.40 d-f	3.90 cd
L_4 S	1.20 h	2.20 f	1.90 f	2.10 i
L_4 M	1.28 gh	2.00 g	2.40 d-f	2.80 gh
L_4 L	1.36 e-h	2.40 de	2.50 c-f	3.10 fg
CV (%)	6.60	3.19	12.44	8.15

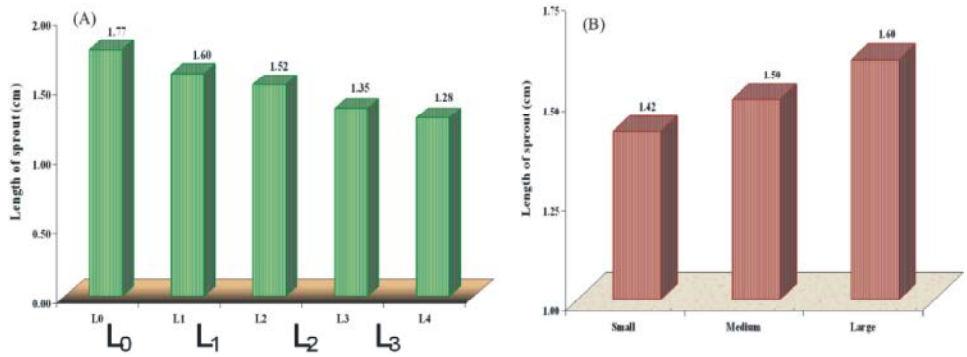

Fig. 1: Effect of length of sprout (cm) at different lifting period (A) and size (B) of potato

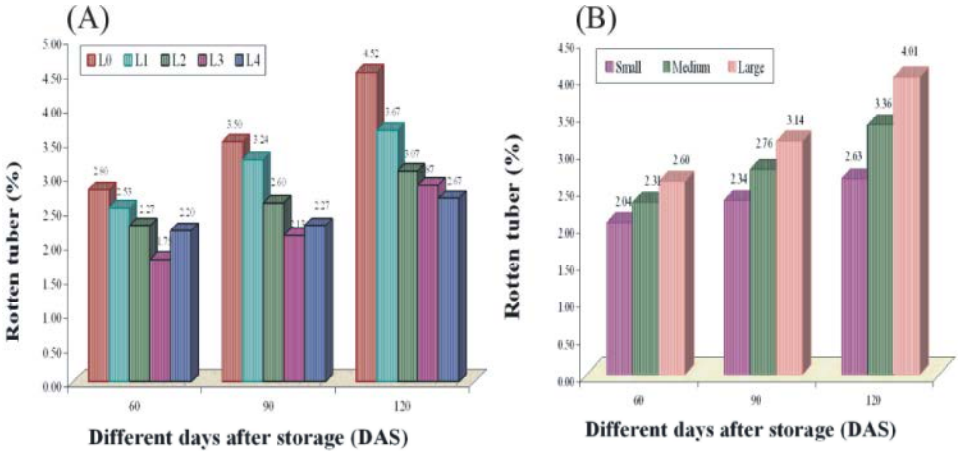

Fig. 2: Effect of lifting period (A) and size of potato (B) on rotten tuber (%) at different days after storage

Rotten Tuber (%): Rotten tubers data showed significant differences due to the lifting period, size of potato and their combination at different days after storage (Fig. 2 and Table 4). Among the storage period, maximum rotten tuber was recorded at final stage of data recording (120 DAS) because of increasing storage period increase the rotten tuber (Fig. 3). At 60 and 90 DAS the minimum number of tuber rotten (1.79 and 2.13%) was

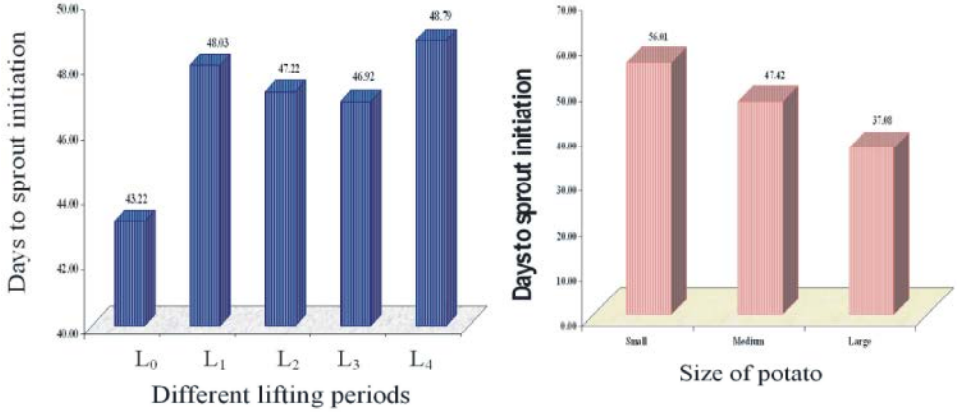

Fig. 3: Effect of lifting period and size of potato on days to sprout initiation of tubers at different days after storage

taken from the lifting period of 9 days after haulm killing where the maximum number of rotten tuber (2.80 and 3.50%) was found at 0 days after haulm killing, respectively. However, at 120 DAS the minimum number of rotten tuber (2.20) was found at 12 days after haulm killing which was statistically similar to 9 days after haulm killing whereas the maximum number of rotten tubers (4.52) was found from the lifting period of 0 days after haulm killing. The maximum number of rotten tuber was found from larger sized tuber and minimum from small sized potato tuber whereas medium sizes tuber produced the average results on rotten tuber at 60, 90 and 120 DAS, respectively. The present findings are in agreement with the reports of Small and Pahl [10]. From table 4, it was revealed that the combination of the lifting period of 0 days after haulm killing with large sized tuber produced the maximum number of rotten tubers (3.20, 4.10 and 5.70) at 60, 90 and 120 days after storage, respectively whereas the minimum number of rotten tuber (1.60) was found in the combination of 9 days after haulm killing with small size tuber of potato at 30 DAS. But at 90 and 120 DAS, the minimum number of tubers rotten (1.90 and 2.10) was observed in small tuber of 12 days after haulm killing. 0 days after haulm killing storage potato showed the maximum number of tuber rotten due to its immaturity and small tuber showed better than larger tuber due to the presence of small amount of moisture compare to large tuber.

Total Soluble Solid (%): The differences among the lifting period, size of potato and their combination in respect of total soluble solid at 60, 90 and 120 DAS showed significant at 1% level of probability (Table 5). The highest TSS (5.99, 6.74 and 8.09%) was observed from the lifting period of 9 days after haulm killing at 60, 90 and 120 DAS. However, lifting period of 0 days after haulm killing showed the minimum TSS (4.93, 5.57 and 6.57%) at 60, 90 and 120 DAS. At 60 and 90 days after storage, the highest TSS (5.37 and 6.02 %) was found from the small sizes whereas the lowest TSS (5.14 and 5.87%) was

Table 5: Effect of lifting period, size of potato and their combination on total soluble solid (%) at different days after storage

	TSS (%)		
Lifting period	60	90	120
L_0	4.93 c	5.57 c	6.57 c
L_1	5.03 bc	5.63 bc	7.03 bc
L_2	5.09 bc	5.86 b	7.66 ab
L_3	5.99 a	6.74 a	8.09 a
L_4	5.22 b	5.87 b	6.47 c
CV (%)	4.75	4.23	9.57
Small	5.37 a	6.02 a	7.23 a
Medium	5.14 b	5.87 b	7.15 ab
Large	5.25 ab	5.92 ab	7.11 b
CV (%)	3.19	12.44	8.15
L_0 S	5.40 b-d	5.93 de	6.63 cd
L_0 M	4.67 g	5.30 g	6.01 d
L_0 L	4.73 fg	5.47e-g	7.06 b-d
L_1 S	4.90 e-g	5.43 fg	6.97 b-d
L_1 M	5.17 d-f	5.73 d-g	7.17 b-d
L_1 L	5.01 d-g	5.74 d-g	6.94 b-d
L_2 S	5.00 d-g	5.84 d-f	7.33 b-d
L_2 M	5.03 d-g	5.90 d-f	8.13 ab
L_2 L	5.23 c-e	5.83 d-f	7.53 a-c
L_3 S	6.47 a	7.23 a	8.73 a
L_3 M	5.67 bc	6.57 b	8.13 ab
L_3 L	5.83 b	6.43 bc	7.40 bc
L_4 S	5.07 d-g	5.67 d-g	6.50 cd
L_4 M	5.13 d-g	5.83 d-f	6.30 cd
L_4 L	5.47 b-d	6.10 cd	6.60 cd
CV (%)	4.75	4.23	9.57

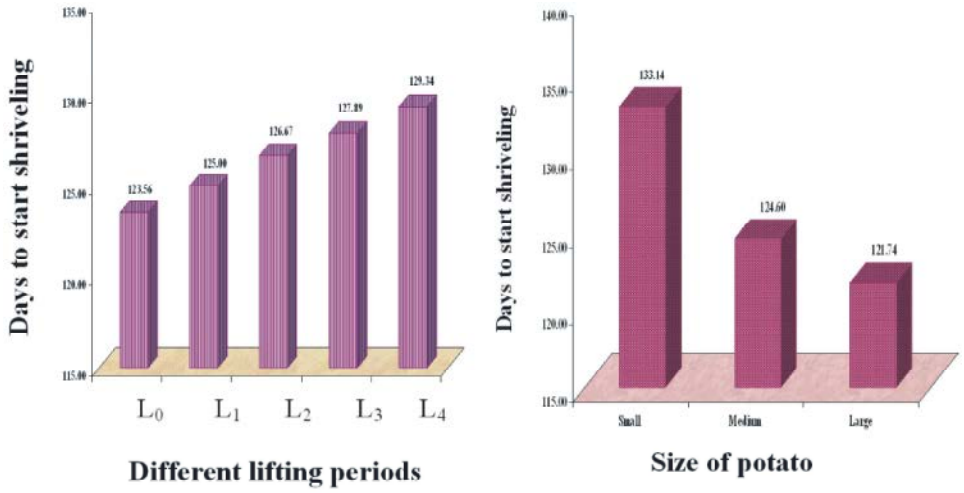

Fig. 4: Effect of lifting period and size of potato on days to start shriveling at different days after storage

produced from the medium sizes TPS. At 120 DAS, the highest (7.23%) was observed from the small sizes TPS whereas the lowest TSS (7.11%) was recorded from larger tubers. Almost similar result was obtained by Molgard and Niekoal [11]. Small sized tuber with the lifting period of 9 days after haulm killing showed the highest TSS (6.47, 7.23 and 8.73%) at 60, 90 and 120 DAS, respectively and it was closely followed by large sized tuber (5.83%) and medium sized tubers (6.57 and 8.13%) at 60, 90 and 120 DAS, respectively. In contrast, medium sized tubers with lifting period of 0 day after haulm killing storage potato showed the lowest TSS (4.67, 5.30 and 6.01%) at 60, 90 and 120 DAS, respectively.

Days to Sprout Initiation: Days to sprout initiation were significantly affected by the effect of different lifting period, size of potato and their combination (Fig. 3 and Table 7). Significant differences data in case of lifting period was presented in Fig. 3. From this figure, the longer days (48.78 days) to sprouting was observed from the lifting period of 12 days after haulm killing and the minimum days to sprout initiation (43.22 days) were recorded from the lifting period of 0 days after haulm killing. The longer days (56.01 days) to sprouting took by small sized tuber and the shorter days (37.08 days) to sprouting were found by larger TPS. Small sized tuber took longer days to sprouting which might be due to immaturity of tuber. The result is in agreement with the findings of Hossain and Rashid [12]. The maximum days (58.01 days) to sprouting was found from the combination of the lifting period of 9 days after haulm killing with small sized potato (L_3 S) and it was statistically similar to the combination of 3, 6 and 12 days after haulm killing (56.33, 55.67 and 57.01 days, respectively) with small sized potato. Among the three sizes tuber, larger size tuber took minimum number of days (33.04 days) to sprouting with 9 days after haulm killing which was statistically similar (33.33) to control lifting period with larger tuber.

Days to Start Shriveling: The size of potato was significantly influenced due to days to start shriveling of tubers but lifting period and their combination had no significant effect on this parameter (Fig. 4). Numerically maximum number of days (129.33 days) to start shriveling was observed from the lifting period of 12 days after haulm killing and the minimum of days to start shriveling (123.56 days) was noticed at the lifting period of 0 days after haulm killing. The maximum days to start shriveling (133.14 days) were obtained in small size tubers whereas the minimum days were required (121.74 days) for large. Similar trend was obtained by Roy *et al*. [13]. The combination of 12 days after haulm killing with small sized potato required maximum number of days (136.00 days) to start shriveling whereas the lowest days (119.33 days) to start shriveling for the combination of the lifting period of days after haulm killing with large sized potato.

Days to 100% Shriveling: The lifting period of potato was not significantly influenced due to days to 100% shriveling of tubers but tuber size and their combination had significant effect on this parameter (Table 6). Numerically maximum days to 100% shriveling (161.67 days) were exhibited by the lifting period of 12 days after haulm killing (L_2). However, lifting period of 0 days after haulm killing required the minimum number of days (154.47 days) to 100% shriveling. The maximum days were

Table 6: Effect of lifting period and tuber size on days to 100% shriving and apical sprout length

Lifting period	Days to 100% shriveling	Apical sprout length (cm) at 120 DAS
L_0	154.47 b	1.79 a
L_1	156.14 ab	1.60 b
L_2	158.23 ab	1.52 c
L_3	159.73 ab	1.35 d
L_4	161.67 a	1.27 e
CV (%)	4.11	4.16
Small	166.36 a	1.42 c
Medium	155.62 b	1.51 b
Large	152.16 b	1.60 a
CV (%)	4.11	4.16

Table 7: Combined effect of different lifting period and sizes on tubers at different days after storage

Sizes	Date of Sprout initiation	Days to 100% shriveling	Apical sprout length (cm) at 120DAS
L_0 S	53.01 b	162.10 a-d	1.62 cd
L_0 M	43.33 d	152.10 def	1.78 b
L_0 L	33.33 f	149.20 f	1.96 a
L_1 S	56.33 a	164.60 a-d	1.54 d-f
L_1 M	48.07 c	153.40 d-f	1.60 c-e
L_1 L	39.70 e	150.41 ef	1.67 c
L_2 S	55.67 a	166.70 a-c	1.48 ef
L_2M	47.33 c	155.90 c-f	1.52 d-f
L_2 L	38.67 e	152.10 d-f	1.56 c-f
L_3 S	58.01 a	168.40 ab	1.24 gh
L_3 M	49.71 c	157.50 b-f	1.35 g
L_3 L	33.04 f	153.30 d-f	1.46 f
L_4 S	57.01 a	170.00 a	1.20 h
L_4 M	48.67 c	159.20 a-f	1.28 gh
L_4 L	40.67 e	155.80 c-f	1.33 g
CV (%)	3.34	4.11	4.16

required to 100% shriveling (166.36 days) by small size of tubers. The earlier 100% shriveling (152.16 days) was done by larger tuber than small and medium size tubers. Early shriveling did not longer storage period and this result was agreed with Hossain *et al*. [14] In case of lifting period and tuber sizes combination, the maximum days to 100% shriveling (170.00 days) was required for small tuber size with the lifting period was 12 days after haulm killing which was statistically similar (168.4 days) in the combination of small tuber with 9 days after haulm killing. On the other hand, the minimum numbers of days were required (149.20 days) for 100% shriveling at 0 days after haulm killing storage potato with larger tuber. More or less similar trend of shriveling behavior has been documented by Singh [15].

Apical Sprout Length (cm): Apical sprout length data was recorded at 120 days after storage, where the size of potato was significantly influenced due to apical sprout length of tubers but lifting period and their combination had no significant effect on this parameter (Table 6 and 7). Numerically the longest apical sprout (1.79 cm) was recorded from the lifting period of 0 day after haulm killing (L_0). On the other hand, the shortest apical sprout (1.27 cm) was obtained from the lifting period of 12 days after haulm killing (L_4) at 120 days after storage. The longest apical sprout (1.60 cm) was in larger tuber where small tuber showed the shortest apical sprout (1.42 cm). The longest apical sprout (1.96 cm) was found from the combination of the lifting period of 0 day after haulm killing with large sized tuber. Whereas small tuber size also produced the shortest apical sprout (1.20 cm) when the lifting period was 12 days after haulm killing (Table 7).

From the study, it was found that the lifting period of 9 days after haulm killing (L_3) and small tubers (S) showed the superior results on the maximum postharvest characteristics of the study individually and combinedly. Significant extension of storage period was also recorded from the lifting period of 9 days after haulm killing in small tubers in case of minimum rotten tubers and weight loss percentage were recorded from these treatment combinations. On the other hand, lifting period of 9 and 12 days after haulm killing with small tubers took statistically maximum days to sprout initiation and 100% shriveling which will ensure the longer dormancy. So, storage period extension was occurred due to the treatment combination of L_3 and small tubers.

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