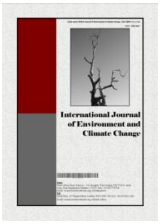

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Evaluation of Three-Way Cross Hybrids and Their Parents for Storage Losses in Onion (*Allium cepa* L.)

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Authors' contributions

This work was carried out in collaboration among all authors. Author AKP managed the work, wrote the complete draft of the manuscript, designed the study and performed the statistical analysis. Author RVG supervised the whole work of author AKP to prepare this manuscript. Author BV guided to designed the study. Authors KP and MVD helped during the experiment. All authors read and approved the final manuscript.

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ABSTRACT

The aim of present investigation was the assessment of the several new onion hybrids develop through three- way cross along with their parents for having less problem of weight losses due to sprouting and rotting, and long storage quality at normal room temperature and relative humidity. The design of experimental plot was complete randomized block design (CRBD) with three replications. This study was carried out in the year of 2018-2019 at Division of Vegetable Crops, ICAR-Indian Institute of Horticultural Research, Hessaraghatta, Bengaluru, India. Thirty hybrids developed by three- way cross, thirteen parental lines and one check have been included for the experiment. Three F_1 hybrids used as female lines and ten commercial varieties used as male testers, were taken to develop the hybrids through line x tester design. The bulbs of all these genotypes were kept for four months in normal storage chamber at 25-30°C room temperature with

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65-70% relative humidity. The overall losses of per cent bulb weigh was recorded and conclude that the three-way hybrids TWCHO-15 (26.91) were recorded for smallest amount of loss followed by TWCHO-5 (27.02), TWCHO-14 (28.83) and TWCHO-4 (29.98). These hybrids can be suggested for more profit to onion grower by keeping for long shelf-life.

Keywords: Three-way cross; storage losses; onion; sprouted; rotten; bulbs.

1. INTRODUCTION

Onion is a long duration crop and it has a huge gap between one season and next season harvest of bulbs, which causes either insufficiency or overabundance of bulbs in the market for the consumers. In case of superfluity of the bulbs, storage became severe problem in the country [1]. This creates vast fluctuation of the price for onion growers as well as buyers. Sometimes, it extremely effects to whole sequence of the onions supply chain from farm produce to consumers [2].

The production of onion (*Allium cepa* L.) was about 22.4 million tones, which is obtained from 13.05 lakh hectares area in the year of 2017 [3]. From this produce, 65-70% is usually used for local consumption, 4-6% export market, 2-4% processing industries and very less about 0.5-1.5% for bulbs to seed production. There were pragmatic of 20-25 per cent of storage loss of bulbs. These losses of onions were mainly observed in rabi harvested crops because the kharif and late kharif crops has very less storage potentiality [4]. There were huge losses of onion bulbs due to sprouting and rotting during storage.

It may be because of high or low temperature, fluctuation in relative humidity, which also favors storage disease of the bulbs. At some extent, loss of bulbs was also reported [5] due to delay harvesting, which leads to increasing of respiration rate and weight loss of the bulbs [6].

The three-way cross hybrids and their parents have its own genetical potential to protect itself from diseases, temperature and moisture variations during storage. Although inability of this feature, the keeping conditions and periods impact more on losses of onion bulbs. Because of these factors, the metabolic activity of the bulbs fluctuated heavily and it also reduced the potentiality of genotypes, which protects from storage diseases.

Study of sprouting and rotting due to these factors during storage of bulbs is an important to minimize this problem. It will be helpful for selecting good hybrids or varieties for onion growers to have good keeping storability and profitability. However, the quality of bulbs is directly affected by the environmental factors, harvesting stage of bulb development, place of storage, keeping and packing conditions [7,8]. Therefore, the present investigation was undertaken to assess the several new onion hybrids develop through three- way cross along with their parents for having less problem of weight losses due to sprouting and rotting, and long storage quality at normal room temperature and relative humidity.

2. MATERIALS AND METHODS

2.1 Planting Materials

The hybrids were grown at the experimental plot of the Division of Vegetable Crops, Indian Institute of Horticultural Research, Hessaraghatta, Bengaluru, India. For this investigation, forty-four genotypes including check were used to grow sufficient bulbs. The details of the parents, three- way cross hybrids and commercial check were given in Table 1.

2.2 Agronomic Details and Design of the Field Experiment

This experiment was conducted during the year 2018-2019 from seeds sowing to harvesting of bulbs. The design of the experiment was complete randomized block design (CRBD) with three replications. The high-quality seeds of all the genotypes were used for developing sufficient quantity of the bulbs. The seeds of three- way cross hybrids were collected from previous year (2017) crossed flowers and harvested freshly. The experimental plot was having red sandy loam soil and medium availability of major nutrients (NPK).

The basic fertilizer was applied to make available the nutrients to the crops for its maximum vegetative growth and bulb development. The quantity of these fertilizer was used about 100-120, 80-100 and 50-70kg/ha of N (Ammonium

sulphate), P (Super phosphate) and K (Potash), respectively. The nitrogen fertilizer was used in two splits (50% applied as basal dose and 50% top dressed). Thirty- five to forty tons per hectare farm yard manure was also used to make the soil more fertile. The weeding and other inter-cultural operations were carried out at regular interval. Plant protection measures (fungicides and pesticides) were adopted to regulate the major insect-pests and diseases of onion.

2.3 Storage Conditions

The harvested bulbs of all the forty-four entries were properly cured, dried and sorted; It was kept in storage room for four months in plastic crates. The storage room temperature ranged from 25°C to 30°C and relative humidity varied from 65% to 70%. The sample size was 9kg for the individual genotypes, which had different number of bulbs. The bulbs were properly dried at field also, which considers a key factor for its keeping quality and also protect from storage ailments. According to [9], the respiration rate of bulbs has directly associated with its perishability so the less moisture availability in storage favours higher keeping quality of the bulbs. Therefore, it was required to dry the bulbs before harvesting from fields, which removes additional moisture.

2.4 Observations in Storage

The observations were taken by accounting the number of bulbs and its weight, which spoiled due to sprouting and rotting after first, second, third and fourth month. The sprouted and rotted bulbs due to slight temperature variations, fluctuated humidity, storage disease or natural losses were calculated and averaged out after four months.

2.4.1 Sprouted bulbs

The initial weight of the bulbs for individual genotypes were taken same about 9kg and total number of bulbs also taken. After first, second, third and fourth month, the sprouted bulbs were removed separately and weighed it by using electronic weighing balance. The per cent of sprouted bulbs was calculated by using the following formula:

$$\text{Sprouting percentage} = \frac{\text{Weight of the sprouted bulbs}}{\text{Initial weight of bulbs}} \text{x } 100$$

2.4.2 Rotten bulbs (%)

The primary bulbs weight of the for all the genotypes were taken same about 9kg with accounting the total number of bulbs. The number of rotten bulbs were taken out from the individual lot and weighed it. The per cent of rotten bulbs was calculated after one, two, three and four months by using the following formula:

$$\text{Rotting percentage} = \frac{\text{Weight of the rotten bulbs}}{\text{Initial weight of bulbs}} \text{x } 100$$

2.5 Statistical Analysis

All the data were recorded and tabulated for statistical analysis. It was analysed through OPSTAT software, which is an available online agriculture data analysis tool created by O.P. Sheoran, Assoc. Professor, computer programmer at CCS HAU, Hisar, India.

3. RESULTS AND DISCUSSION

In the current research entitled “Evaluation of three- way cross hybrids and their parents for storage losses in onion (*Allium cepa* L.)” the data were estimated and depicted in the Table 2 and 3. Till date, no study has been found on storage of three-way cross hybrids of onion (*Allium cepa* L.). Therefore, the findings were compared with the results of straight hybrids and varieties. The results were elaborated with following sub-headings:

3.1 Per Cent Loss of Bulbs after One Month of Storage

The results presented in the Table 2 revealed that there were no losses of bulbs due to sprouting because all the genotypes showed good potentiality to keep store for one month. However, the total per cent loss of bulbs was calculated and expressed that the genotype TWCHO-13 (6.12) has highest per cent loss followed by TWCHO-23 (6.03). The lowest per cent loss of bulbs was observed in the hybrid TWCHO-15 (2.22) followed by TWCHO-14 (2.61). The maximum number of rotten bulbs were found in genotype OMP-1 (14.76), whereas minimum in TWCHO-15 (1.37). Our findings on per cent loss of storage bulbs was confirmed with the study of [10], where they got numerous outcomes for storage losses among hybrids and parents.

3.2 Per Cent Loss of Bulbs after Two Months of Storage

The bulbs were observed after keeping for two months that maximum (16.51) per cent weight loss found in the three-way cross hybrid

Table 1. Name of the parental lines and three- way cross hybrids used in present experiment

Sl. No.	Genotype names	Denoted names	Sl. No.	Genotype names	Denoted names
1	Arka Kirthiman (F_1)	OFP-1	23	Arka Kirthiman x N–2–4–1	TWCHO-10
2	Arka Lalima (F_1)	OFP-2	24	Arka Lalima x Arka Bindu	TWCHO-11
3	Super Flare (F_1)	OFP-3	25	Arka Lalima x Arka Pitambar	TWCHO-12
4	Arka Bindu	OMP-1	26	Arka Lalima x Arka Pragathi	TWCHO-13
5	Arka Pitambar	OMP-2	27	Arka Lalima x Arka Niketan	TWCHO-14
6	Arka Pragathi	OMP-3	28	Arka Lalima x Arka Kalyan	TWCHO-15
7	Arka Niketan	OMP-4	29	Arka Lalima x P–178	TWCHO-16
8	Arka Kalyan	OMP-5	30	Arka Lalima x Bhima Red	TWCHO-17
9	P–178	OMP-6	31	Arka Lalima x Bhima Raj	TWCHO-18
10	Bhima Red	OMP-7	32	Arka Lalima x Bhima Super	TWCHO-19
11	Bhima Raj	OMP-8	33	Arka Lalima x N–2–4–1	TWCHO-20
12	Bhima Super	OMP-9	34	Super Flare x Arka Bindu	TWCHO-21
13	N–2–4–1	OMP-10	35	Super Flare x Arka Pitambar	TWCHO-22
14	Arka Kirthiman x Arka Bindu	TWCHO-1	36	Super Flare x Arka Pragathi	TWCHO-23
15	Arka Kirthiman x Arka Pitambar	TWCHO-2	37	Super Flare x Arka Niketan	TWCHO-24
16	Arka Kirthiman x Arka Pragathi	TWCHO-3	38	Super Flare x Arka Kalyan	TWCHO-25
17	Arka Kirthiman x Arka Niketan	TWCHO-4	39	Super Flare x P–178	TWCHO-26
18	Arka Kirthiman x Arka Kalyan	TWCHO-5	40	Super Flare x Bhima Red	TWCHO-27
19	Arka Kirthiman x P–178	TWCHO-6	41	Super Flare x Bhima Raj	TWCHO-28
20	Arka Kirthiman x Bhima Red	TWCHO-7	42	Super Flare x Bhima Super	TWCHO-29
21	Arka Kirthiman x Bhima Raj	TWCHO-8	43	Super Flare x N–2–4–1	TWCHO-30
22	Arka Kirthiman x Bhima Super	TWCHO-9	44	Satara Garva	Check

Note: OFP- Onion female parent, OMP- Onion male parent, TWCHO- Three-way cross hybrid onion

Table 2. Evaluation of three- way cross hybrids and their parents for storage losses after first and second month

Sl. No.	Genotypes	Initial weight of bulbs (kg)	Initial bulbs (No.)	Storage loss after one month			Storage loss after two months		
				Total weight loss (%)	Sprouted bulbs (No.)	Rotten bulbs (No.)	Total weight loss (%)	Sprouted bulbs (No.)	Rotten bulbs (No.)
1	OFP-1	9.00	69.45	3.23	0.00	2.09	7.07	2.17	2.41
2	OFP-2	9.00	67.89	3.27	0.00	2.13	8.25	2.26	3.12
3	OFP-3	9.00	73.64	5.96	0.00	4.26	15.04	4.62	6.12
4	OMP-1	9.00	286.65	5.25	0.00	14.76	11.78	15.89	17.24
5	OMP-2	9.00	146.37	4.89	0.00	6.98	11.70	7.61	9.11
6	OMP-3	9.00	149.35	4.98	0.00	6.89	12.31	7.92	9.12
7	OMP-4	9.00	76.98	2.93	0.00	2.11	7.76	2.38	3.21
8	OMP-5	9.00	74.77	3.02	0.00	2.12	8.86	2.45	3.78
9	OMP-6	9.00	132.45	5.67	0.00	6.99	13.51	7.98	8.68
10	OMP-7	9.00	109.61	4.65	0.00	4.87	11.69	5.45	6.79
11	OMP-8	9.00	122.67	5.10	0.00	5.89	12.80	6.66	8.11
12	OMP-9	9.00	99.66	3.05	0.00	2.89	8.33	3.21	4.68
13	OMP-10	9.00	136.97	5.84	0.00	7.84	13.65	8.45	9.89
14	TWCHO-1	9.00	144.74	4.97	0.00	6.88	11.31	7.45	8.21
15	TWCHO-2	9.00	98.63	5.31	0.00	4.98	13.49	5.98	6.67
16	TWCHO-3	9.00	98.75	5.16	0.00	4.89	13.22	5.91	6.61
17	TWCHO-4	9.00	65.21	2.98	0.00	1.89	6.85	2.13	2.21
18	TWCHO-5	9.00	64.75	4.11	0.00	2.57	5.92	1.56	2.14
19	TWCHO-6	9.00	98.95	5.07	0.00	4.85	12.14	5.24	6.38
20	TWCHO-7	9.00	74.57	3.39	0.00	2.42	9.45	2.97	3.78
21	TWCHO-8	9.00	97.53	5.16	0.00	4.74	13.67	5.67	6.88
22	TWCHO-9	9.00	71.45	3.38	0.00	2.36	7.94	2.40	3.14
23	TWCHO-10	9.00	104.36	5.43	0.00	5.49	13.57	6.37	7.35
24	TWCHO-11	9.00	136.89	3.94	0.00	5.22	9.61	5.78	6.94
25	TWCHO-12	9.00	92.54	5.28	0.00	4.85	13.32	5.45	6.78
26	TWCHO-13	9.00	96.22	6.12	0.00	5.68	14.68	6.38	7.24
27	TWCHO-14	9.00	66.12	2.61	0.00	1.63	7.04	1.86	2.54
28	TWCHO-15	9.00	63.96	2.22	0.00	1.37	6.47	1.65	2.34
29	TWCHO-16	9.00	95.44	4.43	0.00	4.11	11.56	4.78	5.94
30	TWCHO-17	9.00	71.36	4.04	0.00	2.84	9.21	2.12	4.36

Sl. No.	Genotypes	Initial weight of bulbs (kg)	Initial bulbs (No.)	Storage loss after one month			Storage loss after two months		
				Total weight loss (%)	Sprouted bulbs (No.)	Rotten bulbs (No.)	Total weight loss (%)	Sprouted bulbs (No.)	Rotten bulbs (No.)
31	TWCHO-18	9.00	94.71	5.53	0.00	4.93	13.02	5.12	6.48
32	TWCHO-19	9.00	69.45	3.28	0.00	2.24	6.83	2.34	2.32
33	TWCHO-20	9.00	101.45	5.86	0.00	5.67	12.24	5.47	6.38
34	TWCHO-21	9.00	148.94	5.22	0.00	7.45	13.19	8.97	9.88
35	TWCHO-22	9.00	102.45	4.45	0.00	4.36	12.89	5.69	6.92
36	TWCHO-23	9.00	103.65	6.03	0.00	5.96	13.41	6.48	6.78
37	TWCHO-24	9.00	71.85	4.11	0.00	2.89	12.54	3.94	4.88
38	TWCHO-25	9.00	72.45	5.34	0.00	3.67	16.51	4.58	6.76
39	TWCHO-26	9.00	107.49	5.82	0.00	5.89	13.40	6.31	7.24
40	TWCHO-27	9.00	81.22	5.20	0.00	3.97	12.59	4.12	5.48
41	TWCHO-28	9.00	97.65	4.79	0.00	4.49	12.21	5.34	6.11
42	TWCHO-29	9.00	78.61	2.74	0.00	2.11	7.39	2.46	3.22
43	TWCHO-30	9.00	105.56	5.52	0.00	5.78	12.95	6.33	7.22
44	Satara Garva	9.00	94.89	4.20	0.00	3.98	10.97	4.52	5.87
Mean		9.00	100.42	4.54	0.00	4.54	11.19	5.05	6.08
C.D. at 5%				0.20	0.00	0.25	0.48	0.24	0.37
SE(m)				0.07	0.00	0.09	0.17	0.09	0.10
SE(d)				0.10	0.00	0.12	0.24	0.12	0.13
C.V.				2.68	0.00	3.34	2.65	2.95	3.12

Table 3. Evaluation of three- way cross hybrids and their parents for storage losses after third and fourth month

Sl. No.	Genotypes	Initial weight of bulbs (kg)	Initial Bulbs (No.)	Storage loss after three months			Storage loss after four months			Overall loss of bulbs weight (%)
				Total weight loss (%)	Sprouted Bulbs (No.)	Rotten bulbs (No.)	Total weight loss(%)	Sprouted bulbs (No.)	Rotten bulbs (No.)	
1	OFP-1	9.00	69.45	9.99	2.36	4.11	15.23	4.67	5.19	35.52
2	OFP-2	9.00	67.89	9.35	2.89	3.21	12.86	3.65	4.74	33.74
3	OFP-3	9.00	73.64	17.14	5.68	6.56	30.46	9.30	12.46	68.60
4	OMP-1	9.00	286.65	15.77	16.67	27.68	26.94	34.64	41.12	59.73
5	OMP-2	9.00	146.37	14.46	8.76	11.89	19.36	12.43	15.22	50.40
6	OMP-3	9.00	149.35	13.98	8.67	10.68	31.58	18.21	25.51	62.83
7	OMP-4	9.00	76.98	9.42	2.89	3.89	13.22	4.33	5.19	33.33
8	OMP-5	9.00	74.77	8.97	3.21	3.10	11.86	3.54	4.80	32.72
9	OMP-6	9.00	132.45	22.55	8.12	19.68	41.00	24.70	25.85	82.74
10	OMP-7	9.00	109.61	12.97	6.12	7.45	24.19	10.83	14.49	53.51
11	OMP-8	9.00	122.67	14.46	7.24	9.45	27.43	13.70	17.95	59.80
12	OMP-9	9.00	99.66	10.74	4.33	5.84	13.78	6.06	6.99	35.89
13	OMP-10	9.00	136.97	18.90	9.41	15.98	39.03	23.74	28.69	77.42
14	TWCHO-1	9.00	144.74	14.93	7.99	12.68	30.90	18.96	23.83	62.11
15	TWCHO-2	9.00	98.63	15.80	6.12	8.69	31.53	12.70	16.86	66.13
16	TWCHO-3	9.00	98.75	17.49	6.22	10.35	26.41	11.47	13.55	62.28
17	TWCHO-4	9.00	65.21	9.51	2.89	3.14	10.63	2.58	4.16	29.98
18	TWCHO-5	9.00	64.75	7.73	2.15	2.67	9.26	2.98	2.81	27.02
19	TWCHO-6	9.00	98.95	13.68	5.88	7.22	24.47	10.08	13.35	55.36
20	TWCHO-7	9.00	74.57	10.25	3.11	4.21	17.51	5.52	6.99	40.61
21	TWCHO-8	9.00	97.53	15.22	6.44	7.54	26.93	10.29	14.44	60.98
22	TWCHO-9	9.00	71.45	9.70	2.90	3.87	13.37	4.30	5.03	34.40
23	TWCHO-10	9.00	104.36	15.02	6.88	8.31	27.29	11.55	16.05	61.31
24	TWCHO-11	9.00	136.89	10.43	6.33	7.48	19.08	10.69	14.56	43.07
25	TWCHO-12	9.00	92.54	15.05	6.14	7.68	27.33	10.81	14.29	60.98
26	TWCHO-13	9.00	96.22	15.93	6.97	7.81	27.94	10.65	15.27	64.67
27	TWCHO-14	9.00	66.12	7.68	2.12	2.68	11.50	3.24	3.95	28.83
28	TWCHO-15	9.00	63.96	8.58	2.36	2.93	9.64	2.98	2.96	26.91
29	TWCHO-16	9.00	95.44	12.66	5.41	6.34	29.55	11.41	16.01	58.20
30	TWCHO-17	9.00	71.36	12.44	3.86	4.89	12.80	4.89	4.11	38.50

Sl. No.	Genotypes	Initial weight of bulbs (kg)	Initial Bulbs (No.)	Storage loss after three months			Storage loss after four months			Overall loss of bulbs weight (%)
				Total weight loss (%)	Sprouted Bulbs (No.)	Rotten bulbs (No.)	Total weight loss(%)	Sprouted bulbs (No.)	Rotten bulbs (No.)	
31	TWCHO-18	9.00	94.71	14.71	5.87	7.24	21.73	8.61	10.75	54.99
32	TWCHO-19	9.00	69.45	8.49	3.11	2.68	13.65	3.35	5.96	32.26
33	TWCHO-20	9.00	101.45	14.04	5.91	7.68	25.72	11.02	13.87	57.87
34	TWCHO-21	9.00	148.94	15.33	9.41	12.49	29.96	18.02	24.78	63.70
35	TWCHO-22	9.00	102.45	15.11	6.47	8.31	31.94	13.04	18.21	64.40
36	TWCHO-23	9.00	103.65	15.00	6.48	8.36	33.31	13.84	19.10	67.74
37	TWCHO-24	9.00	71.85	15.97	4.35	6.88	37.06	11.31	14.75	69.69
38	TWCHO-25	9.00	72.45	19.53	6.33	7.09	24.12	7.09	9.48	65.50
39	TWCHO-26	9.00	107.49	15.34	6.87	8.64	24.77	10.82	14.23	59.33
40	TWCHO-27	9.00	81.22	15.63	4.78	7.14	30.82	10.70	12.81	64.24
41	TWCHO-28	9.00	97.65	14.28	5.68	7.71	26.31	10.58	14.09	57.60
42	TWCHO-29	9.00	78.61	9.31	3.47	3.69	18.27	5.67	8.38	37.70
43	TWCHO-30	9.00	105.56	14.65	6.78	8.55	32.81	14.49	19.85	65.93
44	Satara Garva	9.00	94.89	10.90	5.11	5.22	21.43	8.37	11.93	47.50
Mean		9.00	100.42	13.39	5.70	7.72	23.52	10.50	13.51	52.64
C.D. at 5%				0.56	0.31	0.42	1.26	0.48	0.74	
SE(m)				0.24	0.10	0.12	0.37	0.17	0.19	
SE(d)				0.26	0.21	0.14	0.41	0.24	0.25	
C.V.				2.89	2.16	3.27	9.80	5.90	6.25	

TWCHO-25 followed by female parent OFP-3 (15.04). The highest number of sprouted (15.89) and rotten bulbs (17.24) were observed by male parent OMP-1 with 11.78 per cent weight loss. The data presented in Table 2 recommend that the three-way hybrid TWCHO-5 showed good ability to store bulbs for two months with its minimum per cent weight loss (5.92) as well as number of sprouted (1.56) and rotten bulbs (2.14). There were no similar findings on three- way cross hybrids, however, the results for storage loss of bulbs was obtained alike study of [6], where the scale quality affect the storage of onion bulbs.

3.3 Per Cent Loss of Bulbs after Three Months of Storage

The perusal of data on per cent loss of bulbs presented in Table 3 reveals that the three-way hybrid TWCHO-14 had least per cent weight loss (7.68), number of sprouted bulbs (2.12) and rotten bulbs (2.68) followed by the hybrid TWCHO-5 (7.73, 2.15 and 2.67, respectively). The most per cent weight loss showed by female parent OMP-6 (22.55) with 8.12 number of sprouted bulbs and 19.68 rotten bulbs. However, the highest number of sprouted (16.67) and rotten bulbs (27.68) were recorded in the parent OMP-1. The significant differences were recorded for the mean values of dry matter content, total Soluble Solids (TSS), weight loss, rotting, sprouting and total per cent losses of bulbs after 3rd month of storage [11].

3.4 Per Cent Loss of Bulbs after Four Months of Storage

The experimental data exposed that the after four month of storage the three- way cross hybrid TWCHO-5 showed minimum loss of storage bulbs by its per cent weight loss (9.26), number of sprouted (2.98) and rotten bulbs (2.81) followed by TWCHO-15 (9.64, 2.98 and 2.96, respectively). The onion bulbs, which has inherent potential, dry matter content and a greater number of dried scales are found to be better for it prolong shelf life [12]. The maximum per cent weight loss (41.00) was recorded in parental male line OMP-6 with 24.70 number of sprouted and 25.85 rotten bulbs. However, the highest number of sprouted and rotten bulbs were noted in OMP-1 with average number of 34.64 and 41.12, respectively (Table 3). The deterioration in bulb weight is correlated with the occurrence of more sprouted, rotten and decreases the bulb size, which is probably due to higher respiration rate [13,14]. They found most of the varieties showed 80-90 per cent storage losses in four months, when the bulbs kept in naturally ventilated condition and simple structure of storage chamber.

3.5 Overall Loss of Bulbs Weight (%)

The overall loss of per cent bulbs weight was calculated after sum of first, second, third and fourth month of data, which is presented in the Table 3. The maximum per cent bulbs weight loss was recorded about 82.74 (omp-6) followed by 77.42 (omp-10) and twcho-24 (69.69), whereas, minimum noted about 26.91 (twcho-15). In storage, per cent losses of bulbs increase with duration, but less harm of the bulbs was found in naturally aired structure [15]. The results of present study were also accordance with the [10], where they found various results for storage losses and quality by the parents and hybrids.

4. CONCLUSION

The experiment entitled “Evaluation of three- way cross hybrids and their parents for storage losses in onion (*Allium cepa* L.)” has carried out to find the superlative genotypes among forty-four entries including check for keeping long storage of bulbs. Based on priority of per cent bulbs weight loss then the number of sprouted and rotten bulbs; It was observed that the three-way hybrids TWCHO-15 (26.91) had least loss in per cent weight bulbs followed by TWCHO-5 (27.02), TWCHO-14 (28.83) and TWCHO-4 (29.98). Finally, it is concluded that these genotypes can be best suitable for higher shelf-life of bulbs.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Kukanoor L. Post-harvest studies in onion Cv. N-53. Ph.D. (Hort.) Thesis, University of Agricultural Sciences, Dharwad; 2005.

2. Sharma S. Economic analysis of post-harvest losses in onion in Jodhpur district of Rajasthan. International Journal of Research in Business Management. 2016;4(3):119-124.
3. Anonymous. Horticultural Statistics at a Glance-2018. Ministry of agriculture and farmers welfare, Department of agriculture, Cooperation and farmers welfare, Horticulture statistics division, Government of India, New Delhi. 2018;10.
4. Tripathi PC, Lawande KE. Onion storage in tropical region: A review. Current Horticulture. 2019;7(2):15-27.
5. Tucker WG, Drew RLK. Post- harvest studies on autumn- drilled bulb onions. The effect of harvest date, conditioning treatments and field drying on skin quality and on storage performance. Journal of Horticultural Science. 1982;57:339-348.
6. Apeland J. Effects of scale quality on physiological processes in onion. Acta Horticulturae. 1971;20:72-79.
7. Habil DR, Kepka AK, Sypien MA. The influence of some factors on the keeping quality of onions. Acta Horticulturae. 1971;20:65-71.
8. Narina Satya SS, Singh N, Chakrabarti AK, Singh RP, Deshmukh PS, Pal N. Post-harvest storage quality of onion F_1 hybrids produced using cytoplasmic-genic male-sterility. Acta Scientific Nutritional Health. 2020;4(4):116-142.
9. Sargent SA, Talbot MT, Brecht JK. Evaluating precooling methods for vegetable packinghouse operations. Florida Cooperative extension Service. Proc. Fla. State Horticultural Society. 1988;101:175-182.
10. Patil RS, Kale PN. Screening of onion cultivars for storage quality. Vegetable Science. 1989;16(1):56-61.
11. Ahmad T, Bari A, Khan M. Assessment of post-harvest losses of onion bulbs during storage at room condition. Sarhad Journal of Agriculture. 2005;21:189-191.
12. Agic R, Gjorgjievska MC, Mrtinovski G, Jevtic S, Tevtic S, Lazic B. Dynamics of losses during bulb storage from semi-arid onion cultivar. Acta Horticulturae. 1997;462:565-570
13. Rajkumar R, Lalouette JA, Bachraz DY, Sukudeep, Seebaluck BD. Selection of onion cultivars for yield, early maturity and storage potential in Mauritius. Proceedings of the Second Annual Meeting of Agricultural Scientist Reduit,12-13 August, Mauritius; 1998.
14. Rajkumar R. Selection of onion cultivars for yield, early maturity and storage potential in Mauritius. Food and Agricultural Research Council, Reduit, Mauritius. 1997;153-159.
15. Endalew W, Getahun A, Demissew A, Ambaye T. Storage performance of naturally ventilated structure for bulb onion. Agricultural Engineering International: CIGR Journal. 2014;16(3):97-101.

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