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Effect of packaging materials and moisture content on seed storability of onion

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Abstract

The present investigation was carried out during 2016-2018 to study the effect of seed moisture and packaging material on seed quality of onion. The onion seeds of cv. Arka kalyan of different moisture levels *i.e.* 7, 5 and 3 per cent were packed in different packaging materials *i.e.* cloth bags, aluminum pouch, polythene bag with 700 gauge and 300 and stored at ambient conditions for 20 months. The seed quality parameters were recorded every bimonthly upto the end of the storage period. The results indicated that germination per cent and other quality parameters were higher in seed having 5 % moisture than seed having 3 and 7 % moisture. Seeds with higher moisture lost viability faster than seed with low moisture after 20 months of storage. Among the packing materials, lower seed germination and other quality parameters was recorded with cotton cloth bag. The seeds packed in cloth bags lost their complete germinability within 18 months of storage. The higher seed germination was observed with aluminum pouch. The seeds stored in aluminum foil recorded above 70 per cent of germination upto 14 months of storage. Among the various treatment combinations seeds with 5 % moisture content and packed in aluminum pouch marked above 70 per cent germination upto 16 months of storage. All other parameters were higher in this treatment than other treatments. There as a reduction in the seed quality as the storage period increased due to increased lipid peroxidation, decreases activities of free radicals and peroxide scavenging enzymes. Electrical conductivity was increased with storage period especially at higher levels in case of high moisture seeds and stored in cloth bags. Thus, adoption of appropriate packaging material and moisture content would maintain the better seed quality.

Keywords: packaging materials, moisture content, storability, onion

1. Introduction

Onion (*Allium cepa* L.) is considered as one of the important vegetable crop among bulb crops which comes under the family Amaryllidaceae. It occupies a major position in the world as it is cultivated in majority of the countries and has regular demand for its consumption. India is the country which stands first in the total area (12.25 lakh hectares) and occupies the second position in production (209.91 lakh mt) across the globe which occupies the place very next to the China, whereas the productivity of the onion in India is low (17.13 t/ha) when compared with the countries like China, Egypt, Netherland and Iran (Anon., 2016) [3]. Minimum requirement for long term storage seeds is prolonged seed viability. Majorly the initial quality of seeds, moisture level, relative humidity (RH %) and storage conditions have considerable influence on seed storability (Roberts, 1973) [20].

Maintenance of the cold storages are associated with high expenditure which are involved in facing the difficulties with electricity supply which is now a-days erratic and inconsistent. In this context, the seeds in which moisture content is reduced to lower levels exhibited more tolerance to storage even with warm temperatures. Prolonged drying under sun will not be able reduce the moisture upto the levels which are low enough for assuring the long term seed viability. The concept of drying seeds to low moisture levels has come into the existence to replace the compulsion requirement for cold storages as they have several constraints (IBPGR, 1985; Ellis *et al.*, 1988) [10, 6]. Several experiments were conducted by taking the different crop species to know the improvement in the longevity of seeds which were dried on to low moisture contents (5-7 %) for enhanced storability (Ellis *et al.*, 1988 and 1995) [6, 7]. Previous studies reported that there exists certain limits along with the involved beneficial effects of such drying in which drying the seeds to below a recommended or optimum or critical moisture level is not going to improve the longevity of the seeds and in turn there is possibility of having the detrimental effects which influences the seed storability. (Nakamura, 1975 and Vertucci *et al*., 1994 and Nassari *et al*., 2014) [15, 25, 16]. Thus, before initiation of the storage of seeds at low moisture levels, there is a need to evaluate the possible benefits as well as risk of ultra-drying technology on the quality of seeds.

The areas where high humidity prevails storage of seeds will become a challenging task especially in case of onion seeds thus packaging materials plays a major role in extending the storability of the seeds. The moisture proof containers will inhibit the exchange of the moisture between the seeds and the surrounding atmosphere manifests in enhanced storability. Deteriorative changes like reduced seedling vigour and reduced germinability occurs when seeds are stored for long periods**.** Reduction in germination is a consequence of increased defects in the metabolism of seeds like degradation of functional structures, enzymes degradation and inactivation, formation and activation of hydrolytic enzymes, inability of ribosomes to disassociate, breakdown of germination triggering mechanism, genetic degradation, starvation of meristamatic cells and subsequent accumulation of toxic compounds in genome. Possible targets with respect to oxidation damage of the Deoxyribose Nucleic Acid (DNA) chain as of the purines and pyrimidine nuclear bases along with the deoxyribose sugar complexes (Roldan and Ariza, 2008) [22]. Definite detriment to the bases leads to the strands intact, but alterations in compounds like sugar residues may leads to breakage of the strand. Standardisation of appropriate packaging material and moisture content will give the better results in the field. In the present study experiments were conducted to find out the better packaging material and moisture content to improve the storability.

2. Materials and Methods

Freshly harvested onion seeds of cv. Arka kalyan were obtained from the Seed Unit, University of Horticultural Sciences, Bagalkot. The experiments were conducted for a period of 20 months (July 2016 – March, 2018) under the ambient conditions in the laboratory of Seed Unit, University of Agricultural Sciences, Dharwad which is situated in the transitional tract of Karnataka and it lies between $15^{0}2'$ North latitude and $76^{0}7'$ East longitude at an altitude of 678 m above the mean sea level. During the investigation period (July 2016 – March 2018) the mean maximum temperature of 37.7 ^{0}C was noticed during April 2017 and the mean minimum temperature of 13.9 ^{0}C was noticed during January 2017 and 2018. The relative humidity period varied from 35 per cent (February 2016) to 91 per cent (September 2017). The experiment consisted of 12 treatment combinations which are dried by using zeolite beads involving four packaging materials (aluminum pouch, polyethylene bag (700 gauge), polyethylene bag (300 gauge), and cloth bags) and three moisture levels (7.00, 5.00 and 3.00 %). For assessing the seed quality upon storage, seed samples were collected at 2 months interval.

2.1 Germination (%)

A total of 400 seeds were randomly selected from each treatment and grouped into four replicates 100 seeds each. The germination test was conducted in the laboratory using 'between paper' method (BP) as described by ISTA Rules (Anon, 1999) [2]. One hundred seeds of four replicates were placed equidistantly on moist germination paper. The rolled towels were kept in a germination chamber maintained at 25 ± 1 ºC and 95 per cent relative humidity. The final germination percentage count was recorded on 12^{th} day of germination test for normal seedlings, abnormal seedlings, fresh ungerminated and dead seeds. The germination values was expressed in percentage based on normal seedlings.

$$\text{Germination (\%)} = \frac{\text{Number of normal seedlings}}{\text{Total number of seeds planted}} \times 100$$

2.2 Seedling vigour indices

The seedling vigour indices were calculated by using the following formula as suggested by Abdul Baki and Anderson (1973) [1] and expressed in whole number.

Seedling vigour index I = Germination (%) × (Root length (cm) + Shoot length (cm))

Seedling vigour index II = Germination (%) x seedling dry weight (g)

2.3 Electrical conductivity of seed leachate (dS/m)

Electrical conductivity of seed leachate was determined as per method given by Presley (1958) Five grams of seeds were surface sterilized by using 0.1 per cent mercuric chloride solution and washed twice with distilled water. Then 25 ml distilled water was added to the seeds and kept in the incubator maintained at 25 oC temperature for 24 hours and the seed leachate was collected. The seed leachate was collected and volume was made up to 25 ml by adding distilled water. The electrical conductivity of the seed leachate was measured in the digital conductivity bridge with a cell constant of 1.0 and the mean values were expressed in desisimons per metre (dS/m).

2.4 Speed of germination

Daily germination counts upto 12 days were made and the seedlings having minimum of two centimetres in length were considered as germinated seedlings. An index of the speed of germination was computed by adding the quotients of the daily counts divided by the number of days of germination (Maguire, 1962) [13].

$$\text{Speed of germination} = \Sigma\, (n_1/d_1 + n_2 - n_1/d_2 + \dots\dots\dots n_n - n_n - 1/d_n)$$

Where n = number of seeds germinated on day (d)
d = serial number of days

3. Results

The results on seed germination as influenced by packaging materials, moisture contents given in Table 1. As the storage period progressed, in seed germination a gradual decrease was observed from 94.53 to 33.39 per cent from initial to the end of twenty months storage period irrespective of packaging materials and moisture contents. The influence of packaging materials on seed germination was found to be significantly different throughout the storage period except at the beginning. At twenty months of storage period, significantly higher seed germination, SVI I, SVI II and speed of germination was recorded with aluminum pouch at 5.00 per cent moisture content (53.00 %, 728, 825 and 13.66, respectively) followed by polythene bag 700 gauge (50.67 % 690, 774 and13.16) while, it was complete loss with all the treatments of cloth bag. The seeds stored in aluminum pouch and polythene bag (700 gauge) at 5.00 per cent retained germination above minimum seed certification standards (70 %) upto 16 months of storage.

4. Discussion

Generally seeds stored in moisture impervious containers like aluminum foil pouch, polythene bag (700 gauge), vacuum sealed containers *etc*., have storability for longer period compared to those stored in moisture pervious containers like cloth bag, paper bag, jute bag *etc*., under ambient storage condition. The concept of storing seeds in moisture impervious sealed containers is to prevent mainly the migration of moisture content from the surrounding environment into the seeds. In sealed hermetic storage conditions, the seeds retain viability and vigour for longer period owing to lesser fluctuation of moisture content and temperature, decreased oxygen and enrichment of carbon dioxide in the containers.

The seeds are hygroscopic in nature and attain equilibrium moisture content by gaining or loosing moisture content depending upon nature of containers in which they are stored. Among the containers in general, the seeds stored in aluminum pouch recorded significantly lower moisture fluctuation in all the treatments studied, which was on par with polythene (700 gauge) followed by polythene (300 gauge), whereas higher moisture fluctuation was observed in seeds stored with cloth bag at the end of 20 months of storage. Seeds stored in aluminum pouch and polythene bag (700 gauge) are unlikely to absorb moisture and oxygen from the atmosphere due to their property of film used for packaging and maintained lower moisture and oxygen and as such they are unlikely to suffer because of higher oxidation (Hong and Kim, 2004; Netra *et al.*, 2015) [9, 17]. In case of polythene (300 gauge), which is semi-impervious container and in cloth bag the seeds gained the moisture from its environment (Table 21). Higher seed quality parameters were also reported in moisture vapour proof containers by previous researchers in different crop seeds (Rahman and Rahman 1997; Roknuzzaman *et al*., 2008; Khalequzzaman *et al*. 2012; Lambat *et al*., 2015; Mollah *et al*., 2016; Sultana *et al*., 2016) [19, 21, 14, 23].

At the end of the storage period, seeds packed in vapor proof containers maintained higher germination percentage compared to seeds stored with moisture tolerant containers and normal cloth bags. The retention of high germination is due to low moisture levels by al the three drying methods, which resulted in maintenance of the cell membrane and reduced rate of respiration rate. Doijdode, (2007) [5] indicated that onion seeds showed germination percentage of 90 and 76 per cent when stored at -20 ^{0}Cand 5 ^{0}C respectively, even after seven years of storage when stored in aluminum foil and glass containers (with silica gel). Seeds stored in cloth bag recorded seed germination below Indian Minimum Seed Certification Standards (IMSCS) (70 %) within eight months of storage, whereas, seeds stored with aluminum foil pouch and polythene bag (700 gauge) maintained above 70 % germination upto 14 months of storage under ambient conditions. This is due to fluctuating of moisture levels in case of cloth bag throughout the storage period (Table 21). The results are in agreement with the findings of Padma and Reddy, (2002) [18] in brinjal, and Tatipata, (2009) [24] in soybean. Decrease in mitochondrial respiration during storage could be associated with peroxidative changes in lipid mitochondria that lead to loss of seed vigour (Ferguson *et al*., 1990) [8]. Hence, slow growth occurrence of abnormal seedlings or ungerminated seed was the result of changes occurring in membrane cells and macromolecules (Bailly, 2004).

With the decrease in germination percentage in seeds stored with cloth bag, vigour index also showed a decline pattern to a tune of 100 %. The decreased seed quality might be due to a progressive accumulation of oxidative damage of macromolecules in aged tissues, thought to contribute to the decline in biological functions which is a characteristic of the aged seeds (Rahul *et al*., 2016). Lower SVI I, II, speed of germination was observed with seeds stored in cloth bags (0, 0 and 7.08, respectively) whereas, it was higher in case of aluminum foil pouch (647, 727 and 13.06, respectively) followed by polyethylene bag (700 gauge) (647, 727 and 12.49, respectively) at the end of the storage period.

Lipid peroxidation and oxidative stress have been widely indicated as the major causes of deterioration of seeds during ageing (Bailly 2002, 2004; McDonald 1999; Priestley, 1986) [4]. In onion seeds, the loss of seed vigour, and then seed viability during ageing is associated with a decrease in the enzymatic antioxidant potential of the cells, thus leading to lipid peroxidation. Depletion of antioxidant enzyme activities was also observed during seed ageing in soybean (Murthy *et al*., 2003), cotton (Goel *et al*., 2002, 2003) and (Pukacka and Ratajczak, 2005). The results (Table 33, 34 and 35) indicates that, loss of onion seed viability during deterioration was also related to an impairment of the enzymatic antioxidant system, *i.e.* CAT, POD and SOD activities (0.13, 1.08 and 0.16 units, respectively), which resulted in an accumulation of MDA in lipid peroxidation (23.49 units) which is dependent on the moisture content (18.33 at 7 % moisture content). Ageing resulted in a significant change in electrolyte leakage (1.990 dSm^{-1}) indicating the relationship between lipid peroxidation and electrolyte leakage (98.90 % correlation) (Rao *et al*., 2006; Tian *et al*., 2008; YiLi *et al*., 2008).

The decrease in protein content was observed as ageing advanced (20.96 to 6.13 mg/ml) in case of control, whereas in aluminum foil pouch it was not to that extent (20.96 to 12.59mg/ml) at the end of the storage period. The results of the study were in agreement with Murthy *et al.* (2003) and Radha *et al*. (2013). Protein deterioration was mainly due to condensation, rearrangement, fragmentation, strecker degradation and polymerization. There is strong evidence that proteins are the most important targets for oxidants (Tatipata, 2009) [24]. Oxidative stress reactions occurring in seeds are linked to toxic free radicals resulting from reduction of molecular oxygen and formation of toxic products. Many polyunsaturated fatty acids found in seed are highly sensitive to peroxidative degradation. As a result not only lipid degradation, but also a series of reactions that produce toxic products occurred. Lipid peroxidation and products resulting from these processes lead to DNA denaturisation, prevent translation and protein transcription, and cause oxidation of the most reactive amino acids (Pallavi *et al*., 2006). When these types of damages occur in seed, they may cause decrease in vigour and seed germination.

YiLi *et al*. (2010) reported that low moisture content combined with moisture proof containers increases the storage life of *Ammopiptanthus mangolica* seeds. In the present study, seeds dried to five per cent in all the packaging showed better results compared to the seeds stored at three and seven per cent, which indicates that optimum moisture for storage of onion seeds for longer periods was found to be five per cent, when stored in vapor proof containers under ambient conditions and the results also clearly indicated that, higher moisture levels are more deleterious to seeds rather than ultra-low moistures particularly in the crops like onion.

Table 1: Effect of packaging materials and moisture contents on germination (%) of onion seeds during storage

Treatments		Storage period (months)									
	Initial	**2**	**4**	**6**	**8**	**10**	**12**	**14**	**16**	**18**	**20**
P1	93.89	93.89	91.33	87.44	83.78	80.44	77.33	73.67	69.67	58.56	48.33
P2	93.56	93.56	90.89	87.11	82.67	79.33	76.67	72.56	68.11	57.33	46.00
P3	92.89	92.89	89.78	85.89	81.22	77.89	73.78	68.11	62.67	51.33	39.22
P4	90.44	90.44	85.11	78.89	74.67	59.67	47.44	34.44	18.33	0.56	0.00
S.Em±	0.46	0.46	0.52	0.48	0.52	0.44	0.42	0.53	0.48	0.32	0.48
C.D at 1%	1.81	1.81	2.06	1.90	2.06	1.73	1.67	2.11	1.89	1.28	1.90
M1	91.58	91.58	87.75	82.92	77.75	72.25	66.33	58.67	50.75	35.58	28.33
M2	94.17	94.17	91.42	87.42	83.17	76.58	71.00	65.08	58.17	46.67	37.00
M3	92.33	92.33	88.67	84.17	80.83	74.17	69.08	62.83	55.17	43.58	34.83
S.Em±	0.40	0.40	0.45	0.42	0.45	0.38	0.37	0.46	0.41	0.28	0.42
C.D at 1%	1.57	1.57	1.79	1.65	1.79	1.50	1.45	1.83	1.64	1.11	1.65
P1M1	92.33	92.33	89.67	84.67	80.33	78.00	74.33	69.67	65.33	50.67	42.67
P1M2	95.67	95.67	94.00	90.67	87.00	83.33	80.00	77.33	74.67	65.00	53.00
P1M3	93.67	93.67	90.33	87.00	84.00	80.00	77.67	74.00	69.00	60.00	49.33
P2M1	92.00	92.00	88.67	84.33	79.33	76.67	73.67	68.00	63.67	49.33	40.33
P2M2	95.33	95.33	93.67	90.33	85.67	82.00	79.33	76.67	73.00	63.33	50.67
P2M3	93.33	93.33	90.33	86.67	83.00	79.33	77.00	73.00	67.67	59.33	47.00
P3M1	91.67	91.67	87.33	83.67	77.00	74.33	70.33	62.33	55.67	42.33	30.33
P3M2	94.33	94.33	92.00	88.67	84.33	80.67	76.00	71.67	66.33	56.67	44.33
P3M3	92.67	92.67	90.00	85.33	82.33	78.67	75.00	70.33	66.00	55.00	43.00
P4M1	90.33	90.33	85.33	79.00	74.33	60.00	47.00	34.67	18.33	0.00	0.00
P4M2	91.33	91.33	86.00	80.00	75.67	60.33	48.67	34.67	18.67	1.67	0.00
P4M3	89.67	89.67	84.00	77.67	74.00	58.67	46.67	34.00	18.00	0.00	0.00
Mean	92.69	92.69	89.28	84.83	80.58	74.33	68.81	62.19	54.69	41.94	33.39
S.Em±	0.79	0.79	0.90	0.83	0.90	0.76	0.73	0.92	0.83	0.56	0.83
C.D at 1%	3.14	3.14	3.57	3.30	3.57	3.00	2.90	3.65	3.27	2.22	3.30

Table 2: Effect of packaging materials and moisture contents on seedling vigour index I of onion seeds during storage

Treatments		**Storage period (months)**									
	Initial	**2**	**4**	**6**	**8**	**10**	**12**	**14**	**16**	**18**	**20**
P1	1835	1785	1710	1611	1512	1412	1331	1206	1072	825	647
P2	1824	1767	1690	1595	1480	1385	1310	1176	1037	801	609
P3	1825	1746	1664	1562	1444	1348	1234	1076	931	691	498
P4	1829	1669	1547	1390	1282	989	721	509	239	0	0
S.Em±	7	13	11	11	10	10	8	10	9	7	6
C.D at 1%	26	52	44	43	38	39	30	39	34	28	25
M1	1844	1704	1605	1482	1359	1230	1082	910	737	473	355
M2	1832	1789	1715	1609	1494	1339	1203	1059	889	661	500
M3	1809	1732	1638	1527	1434	1281	1162	1005	832	603	461
S.Em±	6	11	10	9	8	8	7	8	8	6	6
C.D at 1%	23	45	38	37	33	34	26	33	30	24	22
P1M1	1847	1727	1652	1533	1429	1350	1256	1114	986	688	555
P1M2	1840	1846	1789	1701	1593	1483	1395	1295	1171	949	728
P1M3	1818	1781	1690	1600	1514	1402	1342	1208	1061	839	659
P2M1	1839	1721	1623	1516	1396	1318	1230	1072	942	664	514
P2M2	1827	1822	1772	1682	1557	1450	1380	1271	1134	917	690
P2M3	1805	1758	1676	1586	1487	1386	1321	1184	1035	822	623
P3M1	1840	1700	1594	1489	1336	1255	1130	943	784	541	350
P3M2	1832	1799	1731	1640	1526	1420	1297	1156	1009	779	582
P3M3	1804	1739	1666	1557	1470	1368	1275	1129	1000	752	561
P4M1	1849	1668	1551	1391	1276	994	713	513	239	0	0
P4M2	1829	1689	1567	1414	1301	1003	741	514	244	0	0
P4M3	1808	1649	1522	1365	1268	969	708	500	234	0	0
Mean	1828	1742	1653	1540	1429	1283	1149	992	820	579	438
S.Em±	12	23	19	19	17	17	13	17	15	12	11
C.D at 1%	46	90	77	74	66	67	52	67	60	48	44

Table 3: Effect of packaging materials and moisture contents on seedling vigour index II of onion seeds during storage

Treatments		**Storage period (months)**									
	Initial	**2**	**4**	**6**	**8**	**10**	**12**	**14**	**16**	**18**	**20**
P1	2292	2208	2091	1968	1840	1711	1527	1313	1211	969	727
P2	2279	2186	2073	1954	1805	1677	1503	1285	1170	939	683
P3	2281	2166	2037	1912	1763	1617	1421	1175	1048	807	568
P4	2281	2085	1886	1718	1577	1169	848	482	243	0	0

S.Em±	8	12	16	12	11	8	8	9	8	5	7
C.D at 1%	33	46	62	48	42	33	33	36	31	20	28
M1	2295	2117	1959	1821	1661	1473	1257	974	822	546	399
M2	2284	2219	2113	1981	1825	1617	1388	1139	1001	774	565
M3	2271	2149	1993	1863	1752	1541	1329	1078	931	716	520
S.Em±	7	10	14	10	9	7	7	8	7	4	6
C.D at 1%	28	40	54	41	37	29	28	31	26	18	24
P1M1	2298	2139	2015	1872	1737	1635	1444	1200	1102	803	609
P1M2	2294	2289	2210	2090	1938	1802	1615	1421	1333	1105	825
P1M3	2284	2197	2046	1944	1845	1695	1522	1317	1197	998	747
P2M1	2291	2126	1985	1859	1707	1598	1419	1165	1058	766	568
P2M2	2278	2257	2193	2074	1896	1761	1587	1392	1287	1070	774
P2M3	2268	2176	2041	1929	1812	1672	1503	1297	1166	982	706
P3M1	2291	2118	1945	1832	1633	1478	1326	1044	885	614	418
P3M2	2286	2223	2141	2010	1862	1718	1479	1256	1136	921	659
P3M3	2267	2157	2026	1893	1794	1656	1458	1225	1122	886	628
P4M1	2300	2083	1889	1721	1568	1179	841	485	243	0	0
P4M2	2278	2108	1909	1748	1603	1187	872	486	248	0	0
P4M3	2265	2064	1859	1686	1559	1139	833	475	238	0	0
Mean	2283	2162	2022	1888	1746	1543	1325	1064	918	679	495
S.Em±	14	20	27	21	19	15	14	16	13	9	12
C.D at 1%	56	79	107	82	73	57	57	62	53	35	49

Table 4: Effect of packaging materials and moisture contents on speed of germination of onion seeds during storage

Treatments		**Storage period (months)**									
	Initial	**2**	**4**	**6**	**8**	**10**	**12**	**14**	**16**	**18**	**20**
P1	27.17	26.31	25.70	25.19	23.73	22.03	20.94	18.90	17.07	14.64	13.06
P2	26.83	25.84	25.40	25.02	23.24	21.38	20.27	18.35	16.75	14.30	12.49
P3	26.82	25.67	25.30	24.58	22.46	20.93	19.19	17.09	15.26	13.26	11.78
P4	26.84	24.08	22.77	20.87	19.66	17.43	15.38	13.59	10.48	8.26	7.08
S.Em±	0.25	0.16	0.19	0.22	0.17	0.17	0.15	0.19	0.16	0.10	0.09
C.D at 1%	0.97	0.65	0.73	0.86	0.68	0.66	0.58	0.76	0.61	0.41	0.36
M1	27.22	24.93	24.36	23.53	21.39	19.11	17.80	15.95	13.80	11.91	10.32
M2	27.08	26.07	25.21	24.34	22.96	21.52	19.93	17.94	15.84	13.25	11.64
M3	26.44	25.42	24.81	23.88	22.47	20.70	19.11	17.05	15.02	12.69	11.34
S.Em±	0.21	0.14	0.16	0.19	0.15	0.14	0.13	0.17	0.13	0.09	0.08
C.D at 1%	0.84	0.56	0.64	0.74	0.59	0.57	0.50	0.66	0.53	0.36	0.30
P1M1	27.21	25.58	25.34	24.78	23.35	21.02	20.11	18.02	16.00	14.23	12.58
P1M2	27.83	27.17	26.03	25.87	24.27	23.04	22.05	20.11	18.19	15.32	13.66
P1M3	26.45	26.18	25.72	24.91	23.55	22.03	20.67	18.57	17.01	14.38	12.93
P2M1	27.22	25.05	24.61	24.35	22.33	19.54	18.72	17.05	15.52	13.56	11.52
P2M2	26.83	26.65	25.98	25.84	23.94	22.73	21.71	19.68	17.96	15.15	13.16
P2M3	26.43	25.82	25.62	24.86	23.47	21.88	20.38	18.30	16.76	14.20	12.79
P3M1	27.21	25.03	24.63	24.15	20.17	18.53	17.12	15.10	13.22	11.58	10.10
P3M2	26.84	26.33	25.86	24.79	23.79	22.58	20.25	18.11	16.39	14.15	12.65
P3M3	26.42	25.64	25.41	24.81	23.41	21.69	20.19	18.06	16.17	14.07	12.61
P4M1	27.24	24.08	22.85	20.85	19.70	17.34	15.25	13.64	10.47	8.28	7.09
P4M2	26.83	24.12	22.96	20.85	19.83	17.74	15.70	13.86	10.83	8.37	7.10
P4M3	26.45	24.03	22.50	20.92	19.44	17.21	15.18	13.26	10.15	8.12	7.04
Mean	26.91	25.47	24.79	23.92	22.27	20.44	18.94	16.98	14.89	12.62	11.10
S.Em±	0.42	0.28	0.32	0.38	0.30	0.29	0.25	0.33	0.27	0.18	0.16
C.D at 1%	1.68	1.12	1.27	1.49	1.18	1.14	1.00	1.31	1.06	0.72	0.63

5. Conclusions

On account of our present experiment results, it could be concluded that higher storability of onion seeds under tropical and sub-tropical Indian conditions could be achieved when seeds are dried to the extent of 5.00 per cent and sealed in aluminum pouch or polyethylene bags 700 gauge under ambient conditions.

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