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Influence of Packaging and Storage Conditions on Different Seed Quality Parameters in Paddy

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ABSTRACT

The study was conducted to find out the influence of packaging and storage conditions on different seed quality parameters of paddy. Paddy seeds were stored in different packaging materials viz; vacuum packed bags (C_1), polythene bags (C_2), cloth bags (C_3) and gunny bags (C_4) stored at room temperature (25 ± 2º C) and cold storage (4 ± 1º C) for a period of 18 months. Among the storage conditions, cold storage recorded better seed quality, physiological and biochemical parameters over room temperature, irrespective the storage containers throughout the storage period of 18 months. Among the containers, the seeds stored in vacuum packed bags maintained the quality. the quality with least deterioration compared to sample stored in gunny and cloth bags due to rate of absorbance of moisture content is more in gunny bags and cloth bags because these are not air tight container while vacuum packaged bags maintained constant moisture content.

Key words: *Seed quality parameters, Paddy, Vacuum Packaging, Storage*

INTRODUCTION

Paddy is the most important and extensively grown food crop in the world and is the staple food of more than 60 per cent of the world population. India has the largest area under paddy in the world and ranks second in production after China. In paddy, upon storage, many enzymatic changes, oxidation and respiration occur. If the viability and vigor is not maintained properly during storage period, it will be difficult to sell it as a seed material for the next season. Post harvest storage life of paddy largely depends on the genotypes, treatment, packaging material and storage conditions. In storage, viability and vigour of the seeds is regulated by many physio-chemical factors as the seed is hygroscopic in nature, seed quality is affected by variation in moisture content, relative humidity and temperature. To combat these factors, it is better to store the seeds in moisture vapour proof containers like polythene bag, aluminium foil, tin or any sealed container to maintain the quality for longer period.

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MATERIALS AND METHODS

A storage experiment was carried out for a period of 18 months at Department of Crop Physiology, University of Agricultural Sciences, Dharwad. Freshly harvested paddy seeds (BPT-5204) were dried under sun and stored under different storage conditions and containers. The temperature maintained in the cold storage was around (4 °C ± 1°C) and relative humidity was 85 to 90 per cent. For ambient storage, bags were stored in the laboratory at room temperature (25 ± 2 °C). Paddy seeds were packed in 100 g vacuum packed bags (The machine used for vacuum packaging of different seeds was OLPACK 501/V manufactured by INTERPRISE–BRUSSELS S.A., BRUXTAINER DIVISION, Belgium) and polythene bags while 5 kg paddy was packed in cloth bags and gunny bags. After packaging of all the seeds in different containers, 50% bags were stored properly in the iron racks without stacking so that all the bags were uniformly exposed to the particular treatment condition; while 50% bags were stored under cold storage. Fisher's method of analysis of variance was applied for the analysis and interpretation of the experimental data as suggested by Panse and Sukhatme[8]) and level of significance used in 'F' and 't' test was P = 0.01. The treatment consisting of different containers viz., vacuum packed bags, polythene bags, cloth bags and gunny bags were replicated thrice in both cold and ambient storage conditions in completely randomised design with factorial concept. Observations recorded on root length, shoot length, seedling dry weight and mobilization efficiency. At the time of germination count, 10 normal seedlings were selected at random from each replication and used for measuring the root length. Root length was measured from the point of attachment of seed to the tip of primary root. The mean values were calculated and expressed in cm. The same 10 normal seedlings used for the measuring root length were used for measuring shoot length. The shoot length was measured from the point of attachment of seed to tip of the leaf and the mean values were expressed in cm. The same 10 normal seedlings used for measuring root and shoot length were put in butter paper packets and dried in hot air oven maintained at 80 ± 1°C for 24 hours. After drying, seedlings were kept in desiccators for cooling, then weighed and expressed in milligrams[1]. Mobilization efficiency is defined as mobilization and utilization of food reserves during seed germination and expressed in per cent. It was calculated by the following formula[9].

$$\text{Mobilization efficiency (\%)} = \frac{\text{Dry weight of seedlings}}{\text{Dry weight of seeds}} \times 100$$

RESULTS AND DISCUSSION

The observations on root length indicated significant differences between treatments from 4 months of storage and continued up to 18 months of storage (Table 1). Up to 2 months of storage, no significant differences between storage containers, storage conditions and their interaction was observed. In general, the reduction in root length was observed with advancement in storage period. The decline in root length was minimum in vacuum packaged bags (C_1) as compared to polythene bags (C_2) followed by cloth bags (C_3) throughout the storage period under both ambient storage (S_1) and cold storage (S_2). The root length in vacuum packaged bags (C_1) did not differ significantly among themselves under ambient storage (S_1) and cold storage (S_2). But, significant differences were observed in gunny bags (C_4) and cloth bags (C_3) up to 18 months. Among the storage containers, root length was maximum in vacuum packaged bags (C_1), which was significantly higher over all other treatments. Significantly lower root length was observed in gunny bags (C_4), which was significantly lower compared to all other treatments throughout the storage period. However, no significant differences were observed at this stage. At 10th month of storage, maximum root length (13.60 cm) was observed in vacuum packed bags stored under cold storage (S_2C_1) followed by vacuum packed bags stored under ambient storage (S_1C_1) (13.53 cm), However, both did not differ significantly among themselves. Significantly lower root length (13.07 cm) was observed in gunny bags stored under ambient storage (C_4S_1), which was significantly lower compared to all other treatments throughout the storage period. A similar trend continued from 12 months of storage and upto 18 months of storage. The treatments polythene bags stored under ambient storage (C_2S_1), polythene bags stored under cold storage (C_2S_2), cloth bags stored under ambient storage (C_3S_1), cloth bags stored under cold storage (C_3S_2) and gunny bags stored under cold storage (C_4S_2) were on par with each other. During 18 months of storage, vacuum packaged bags (C_1) recorded significantly higher root length (12.83 cm) over all other containers under both ambient storage (S_1) and cold storage (S_2). However, no significant differences were observed between ambient storage (S_1) and cold storage (S_2) under vacuum packaged bags (C_1). It was further observed that cold storage (S_2) recorded significantly higher root length compared to ambient storage (S_1) among all the containers throughout the storage period. Significantly lower root length (10.21 cm) was observed in gunny bags stored under ambient storage (C_4S_1), which was significantly lower compared to all other treatments. Similarly, cloth bags stored under cold storage (C_3S_2) and gunny bags stored under cold storage (C_4S_2) did not differ significantly among themselves. It was further observed from the results that vacuum packaged bags (C_1) maintained the higher root length over polythene bags (C_2) followed by cloth bags (C_3) at all the stages of storage period. The results of shoot length as influenced by storage containers and storage conditions presented in Table 2 indicated significant differences between the treatments at all the stages of storage period, except at 2 months of storage. A gradual decrease in shoot length was observed with a progress in storage period. Among the containers, decline in shoot length was minimum in vacuum packaged bags (C_1) compared to polythene bags (C_2) followed by cloth bags (C_3) throughout the storage period under both ambient storage (S_1) and cold storage (S_2). Significantly lower shoot length was observed in gunny bags (C_4), which was significantly lower compared to all other treatments. However, no significant differences were observed among themselves. The maximum shoot length was observed in vacuum packaged bags (C_1) under both ambient storage (S_1) and cold storage (S_2), which was significantly higher compared to other treatments. But, no significant differences were observed among interactions of storage conditions and storage containers (SxC) throughout the storage period. At 6th months of storage, higher shoot length (8.83 cm) was observed in vacuum packed bags stored under cold storage (S_2C_1) followed by vacuum packed bags stored under ambient storage (S_1C_1) (8.81), However, both did not differ significantly among themselves. The treatments polythene bags stored under ambient storage (C_2S_1), polythene bags stored under cold storage (C_2S_2), cloth bags stored under ambient storage (C_3S_1), cloth bags stored under cold storage (C_3S_2) and gunny bags stored under cold storage (C_4S_2) were at par with each other. Significantly lower values of shoot length (8.34 cm) was noticed in gunny bags stored under ambient storage (C_4S_1), which was significantly lower compared to all other treatments. A similar trend continued at 8, 10, 12, 14, 16 and 18 months of storage. During 18 months of storage, significantly higher shoot length (8.03 cm) was observed in vacuum packaged bags (C_1) and lower shoot length was in gunny bags (C_4) (6.48 cm) compared to other containers under both ambient storage (S_1) and cold storage (S_2). However, no significant differences were observed between ambient storage (S_1) and cold storage (S_2) under vacuum packaged bags (C_1). It was further noticed that, significantly higher shoot length was recorded in cold storage (S_2) compared to ambient storage (S_1). Significantly lower shoot length was observed in gunny bags stored under ambient storage (C_4S_1), which was significantly lower compared to all other treatments, except cloth bags stored under ambient storage (C_3S_1). Similarly, cloth bags stored under cold storage (C_3S_2) and gunny bags stored under cold storage (C_4S_2) did not differ significantly among themselves.The data on seedling dry weight indicated significant differences due to storage period (Table 3). Among the storage conditions, cold storage (S_2) recorded significant differences higher seedling dry weight compared to ambient storage (S_1) at all the stages of storage period. Among the storage containers, vacuum packaged bags (C_1) recorded significantly higher seedling dry weight compared to polythene bags (C_2). But, significantly lower seedling dry weight was observed in gunny bags (C_4) followed by cloth bags (C_3), which was significantly lower compared to all other containers. As the storage period advanced, the values of seedling dry weight showed declining trend among all the treatments throughout the storage period.During 8th month, significant differences were noticed due to interaction of storage containers and storage conditions (SxC). Higher values of seedling dry weight were found in vacuum packed bags stored under cold storage (S_2C_1) (78.3 cm) followed by vacuum packed bags stored under ambient storage (S_1C_1) (74.6 cm). Lower values of seedling dry weight were observed in gunny bags stored under ambient storage (C_4S_1) (64.6 cm) followed by cloth bags stored under ambient storage (C_3S_1) (68.3 cm), which was lower compared to all other treatments and did not differ significantly among themselves. A similar trend continued from 10 months of storage and up to 18 months of storage. Among interactions, cloth bags stored under ambient storage (C_3S_1), cloth bags stored under cold storage (C_3S_2), gunny bags stored under ambient storage (C_4S_1) and gunny bags stored under cold storage (C_4S_2) and polythene bags stored under ambient storage (C_2S_1), polythene bags stored under cold storage (C_2S_2), vacuum packed bags stored under ambient condition (C_1S_1) and vacuum packed bags stored under cold storage (C_1S_2) were at par with each other. At 18 months of storage, vacuum packaged bags (C_1) recorded significantly higher seedling dry weight (71.0 cm) compared to gunny bags (C_4) (52.1cm) under both ambient storage (S_1) and cold storage (S_2). However, no significant differences were observed between ambient storage (S_1) and cold storage (S_2) under vacuum packaged bags (C_1) and gunny bags (C_4). Lower seedling dry weight found in gunny bags stored under ambient storage (C_4S_1), which was significantly lower compared to all other treatments, except gunny bags stored under cold storage (C_4S_2). Similarly, cloth bags stored under cold storage (C_3S_2) and polythene bags stored under ambient storage (C_2S_1) and polythene bags stored under cold storage (C_2S_2) and polythene bags stored under ambient storage (C_2S_1) did not differ significantly among themselves. It is clear from results that vacuum packaged bags (C_1) maintained higher values of seedling dry weight compared to all other containers at all the stages of storage period.The influence of different packaging and storage conditions on mobilization efficiency presented in Table 4 indicated significant differences between the treatments at all the stages of storage, except at two months of storage. Among storage containers, vacuum packaged bags (C_1) recorded significantly higher values of mobilization efficiency over all other treatments under ambient storage (S_1) and cold storage (S_2). Among the interactions, maximum mobilization efficiency was observed in vacuum packed bags stored under cold storage (S_2C_1) followed by vacuum packed bags stored under ambient storage (S_1C_1). But, both did not differ significantly among themselves and were significantly higher compared to all other treatments. Significantly lower mobilization efficiency was observed in gunny bags (C_4), which was significantly lower compared to all other treatments. As the storage period progressed, the mobilization efficiency decreased among all the containers at all the stages of storage.At sixth months of storage, significantly higher values of mobilization efficiency (51.1%) were observed in vacuum packaged bags (C_1) under both ambient storage (S_1) and cold storage (S_2) compared to polythene bags (C_2) (48.9%) followed by cloth bags (C_3) (47.6), respectively. A similar trend was noticed from 8 months of storage and up to 18 months of storage. Lower mobilization efficiency was observed in gunny bags stored under ambient storage (C_4S_1) (44.1%), which was lower over all other treatments. It was further observed that, cold storage (S_2) recorded significantly higher values of mobilization efficiency compared to ambient storage (S_1) throughout the storage period. However, treatment combinations polythene bags stored under ambient storage (C_2S_1), polythene bags stored under cold storage (C_2S_2), cloth bags stored under ambient storage (C_3S_1), cloth bags stored under cold storage (C_3S_2) and gunny bags stored under cold storage (C_4S_2) were at par with each other. At 18 months of storage, vacuum packaged bags (C_1) recorded significantly higher mobilization efficiency (46.1%) over all other containers under both ambient storage (S_1) and cold storage (S_2). However, no significant differences were observed between ambient storage (S_1) and cold storage (S_2) under vacuum packaged bags (C_1). Significantly lower mobilization efficiency (%) was observed in gunny bags stored under ambient storage (C_4S_1) (41.1), which was significantly lower compared to all other treatments, except gunny bags stored under cold storage (C_4S_2). Similarly, cloth bags stored under cold storage (C_3S_2), polythene bags stored under ambient storage (C_2S_1) and polythene bags stored under cold storage (C_2S_2) did not differ significantly among themselves. It was also further observed from the results that vacuum packaged bags (C_1) maintained significantly higher mobilization efficiency throughout the storage period compared to all other treatments at all the stages of storage.Seed quality is judged by seedling vigour parameters like root and shoots length, mobilization efficiency and seedling dry weight. Generally, higher the seedling length, vigour index and seedling dry weight, higher is the seed quality. Seeds preserved in cold storage recorded higher root length and shoot length compared to ambient condition which may be due to lower respiration rate and metabolic activity at lower temperature, Similar results were reported by Das *et al*[4]. Higher seedling length is an indication of maintenance of vigour in the seeds preserved in cold storage. At the end of 18 months of storage, vacuum packed bags recorded significantly higher root length, shoot length, mean daily germination, seedling dry weight and seedling length compared to polythene bags followed by gunny bags and cloth bags stored under both ambient (S_1) and cold storage (S_2). Among the interactions also vacuum packed bags had higher seedling vigour parameters over all other containers at all the stages of storage. There was a gradual decrease in seedling vigour parameters with a progress in storage period. As vacuum packed and polythene containers experience lesser moisture fluctuation, reduced depletion of food reserves, besides providing protection against external damage due to attack by micro and macro organisms thereby lower pest and fungal activity and hence the decline in all the seedling vigour parameters was less. Similar findings have been reported by Ellis[5]; McDonald[6]; Chiu *et al*[3].,; Bailly[2] and Ellis and Hong[6].

Table 1: Influence of packaging and storage conditions on root length (cm) at different periods of storage in paddy

Treatments	Storage period (months)									
	0	2	4	6	8	10	12	14	16	18
Storage conditions mean (S)										
S_1	14.0	13.7	13.5	13.4	13.2	13.1	12.7	12.5	12.2	11.0
S_2	14.0	13.8	1.76	13.6	13.4	13.3	13.1	13.0	12.7	12.2
Storage containers mean (C)										
C_1	14.0	14.0	13.8	13.7	13.6	13.5	13.4	13.3	13.0	12.7
C_2	14.0	13.9	13.8	13.6	13.4	13.3	13.2	13.1	12.6	12.5
C_3	14.1	13.6	13.5	13.4	13.2	13.1	12.8	12.6	12.4	11.9
C_4	14.0	13.5	13.4	13.2	12.9	12.8	12.2	11.9	11.7	10.8
Interaction mean (S x C)										
S_1 x C_1	14.0	13.9	13.8	13.6	13.5	13.5	13.3	13.3	12.8	12.7
S_1 x C_2	14.1	13.9	13.7	13.6	13.4	13.3	13.2	13.0	12.6	12.5
S_1 x C_3	14.0	13.5	13.4	13.3	13.1	13.1	12.6	12.5	12.3	11.8
S_1 x C_4	13.9	13.5	13.3	13.0	12.6	12.5	11.8	11.4	11.0	10.2
S_2 x C_1	14.0	14.0	13.9	13.8	13.7	13.6	13.4	13.4	13.1	12.8
S_2 x C_2	14.0	13.9	13.8	13.6	13.5	13.4	13.2	13.2	12.7	12.5
S_2 x C_3	14.1	13.8	13.7	13.5	13.3	13.2	13.1	12.8	12.6	12.0
S_2 x C_4	14.0	13.6	13.5	13.3	13.2	13.1	12.7	12.5	12.4	11.5
Grand Mean	14.0	13.8	13.6	13.5	13.3	13.2	12.9	12.8	12.4	12.0
S.Em±										
S	0.03	0.09	0.08	0.06	0.04	0.04	0.06	0.06	0.06	0.06
C	0.06	0.12	0.11	0.08	0.06	0.06	0.09	0.08	0.08	0.09
S×C	0.08	0.18	0.16	0.11	0.08	0.08	0.12	0.12	0.12	0.12
C.D. (1%)										
S	NS	NS	NS	0.17	0.13	0.12	0.19	0.18	0.18	0.19
C	NS	NS	0.33	0.24	0.18	0.18	0.27	0.26	0.25	0.27
S×C	NS	NS	NS	NS	NS	0.26	0.37	0.37	0.35	0.38

Table 2: Influence of packaging and storage conditions on shoot length (cm) at different periods of storage in paddy

Treatments	Storage period (months)									
	0	2	4	6	8	10	12	14	16	18
Storage conditions mean (S)										
S_1	9.05	8.79	8.63	8.50	8.32	8.13	7.87	7.67	7.46	7.12
S_2	9.03	8.92	8.83	8.68	8.46	8.31	8.11	7.91	7.69	7.41
Storage containers mean (C)										
C_1	9.08	9.00	8.97	8.82	8.66	8.55	8.43	8.33	8.20	7.97
C_2	9.03	8.86	8.77	8.60	8.38	8.23	8.07	7.97	7.83	7.57
C_3	9.05	8.82	8.60	8.50	8.28	8.08	7.83	7.56	7.28	6.86
C_4	9.01	8.73	8.58	8.42	8.23	8.02	7.62	7.30	7.00	6.65
Interaction mean (S x C)										
S_1 x C_1	9.10	8.97	8.93	8.81	8.65	8.57	8.40	8.30	8.17	7.90
S_1 x C_2	9.06	8.77	8.63	8.47	8.23	8.07	7.93	7.83	7.70	7.40
S_1 x C_3	9.08	8.74	8.53	8.37	8.20	7.93	7.67	7.41	7.22	6.69
S_1 x C_4	8.96	8.67	8.42	8.34	8.20	7.93	7.48	7.13	6.76	6.48
S_2 x C_1	9.05	9.03	9.01	8.83	8.67	8.53	8.47	8.37	8.23	8.03
S_2 x C_2	9.00	8.95	8.91	8.73	8.53	8.40	8.20	8.10	7.97	7.73
S_2 x C_3	9.02	8.90	8.67	8.63	8.37	8.22	8.00	7.70	7.33	7.04
S_2 x C_4	9.06	8.80	8.73	8.50	8.27	8.10	7.77	7.47	7.23	6.82
Grand Mean	9.04	8.85	8.73	8.59	8.39	8.22	7.89	7.79	7.58	7.26
S.Em±										
S	0.02	0.05	0.05	0.04	0.04	0.05	0.05	0.06	0.06	0.07
C	0.04	0.07	0.06	0.06	0.06	0.07	0.08	0.08	0.09	0.10
S×C	0.07	0.09	0.09	0.09	0.08	0.10	0.11	0.11	0.12	0.14
C.D. (1%)										
S	NS	NS	0.14	0.14	0.12	0.15	0.16	0.17	0.19	0.21
C	NS	NS	0.20	0.19	0.17	0.21	0.24	0.24	0.26	0.30
S×C	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 3: Influence of packaging and storage conditions on seedling dry weight (mg/10 seedlings) at different periods of storage in paddy

Treatments	Storage period (months)									
	0	2	4	6	8	10	12	14	16	18
Storage conditions mean (S)										
S_1	80.9	79.5	74.8	71.9	70.1	68.9	67.1	64.3	60.8	57.5
S_2	80.8	80.2	76.2	74.5	73.2	71.5	69.9	68.4	67.0	61.4
Storage containers mean (C)										
C_1	80.9	81.5	80.2	77.4	76.5	75.1	74.3	72.3	70.8	67.2
C_2	80.6	79.6	78.3	74.5	73.3	72.1	71.0	69.6	66.0	61.7
C_3	81.0	80.0	72.5	71.5	69.5	68.7	66.0	64.0	63.2	58.6
C_4	80.9	78.5	71.2	69.3	67.3	64.9	62.8	59.5	55.6	50.2
Interaction mean (S x C)										
S_1 x C_1	81.2	81.3	80.1	76.2	74.6	74.2	73.3	70.6	68.4	63.3
S_1 x C_2	80.4	78.8	77.6	73.5	73.0	71.3	70.6	69.5	64.6	60.3
S_1 x C_3	80.8	79.7	71.3	69.6	68.3	67.0	64.3	60.6	60.3	58.0
S_1 x C_4	81.1	78.3	70.2	68.0	64.6	63.2	60.3	56.3	50.0	48.4
S_2 x C_1	80.5	81.6	80.3	78.7	78.3	76.0	75.3	74.0	73.3	71.0
S_2 x C_2	80.8	80.4	79.0	75.3	73.6	73.0	71.3	69.6	67.3	63.1
S_2 x C_3	81.2	80.3	73.6	73.2	70.5	70.3	67.8	67.3	66.1	59.3
S_2 x C_4	80.7	78.6	72.1	70.6	70.1	66.7	65.3	62.6	61.3	52.1
Grand Mean	80.8	79.9	75.5	73.1	71.6	70.2	68.5	66.3	63.9	59.4
S.Em±										
S	0.30	0.51	0.47	0.54	0.59	0.63	0.66	0.69	0.70	0.72
C	0.48	0.71	0.67	0.77	0.84	0.89	0.94	0.98	0.99	1.02
S×C	0.67	1.01	0.94	1.09	1.19	1.26	1.33	1.39	1.40	1.44
C.D. (1%)										
S	NS	NS	NS	1.65	1.80	1.91	2.01	2.11	2.12	2.18
C	NS	NS	2.02	2.33	2.55	2.71	2.85	2.98	3.00	3.08
S×C	NS	NS	NS	NS	NS	NS	NS	NS	4.24	NS

Table 4: Influence of packaging and storage conditions on mobilization efficiency (%) at different periods of storage in paddy

Treatments	Storage period (months)									
	0	2	4	6	8	10	12	14	16	18
Storage conditions mean (S)										
S_1	52.1	51.6	46.2	46.6	45.5	44.7	43.6	41.7	39.5	37.3
S_2	52.4	52.1	49.5	48.3	47.5	46.4	45.4	44.4	43.5	39.8
Storage containers mean (C)										
C_1	52.8	52.9	52.0	50.3	49.6	48.7	48.2	46.9	46.0	43.6
C_2	52.2	51.7	50.8	48.3	47.6	46.8	46.1	45.2	42.8	40.1
C_3	52.3	51.9	47.0	46.4	45.1	44.6	42.9	41.5	41.0	38.1
C_4	51.8	50.9	41.6	45.0	43.7	42.1	40.8	38.6	36.1	32.6
Interaction mean (S x C)										
S_1 x C_1	52.7	52.8	52.0	49.5	48.4	48.1	47.6	45.8	44.4	41.1
S_1 x C_2	51.9	51.1	50.4	47.8	47.4	46.3	45.8	45.2	41.9	39.1
S_1 x C_3	52.2	51.7	46.3	45.2	44.3	43.5	41.8	39.3	39.1	37.6
S_1 x C_4	51.8	50.8	36.4	44.1	41.9	41.0	39.1	36.6	32.5	31.4
S_2 x C_1	52.8	53.0	52.1	51.1	50.8	49.3	48.9	48.0	47.6	46.1
S_2 x C_2	52.4	52.2	51.3	48.9	47.8	47.4	46.3	45.2	43.7	41.0
S_2 x C_3	52.4	52.1	47.8	47.6	45.8	45.6	44.0	43.7	42.9	38.5
S_2 x C_4	51.9	51.0	46.8	45.8	45.5	43.3	42.4	40.6	39.8	33.8
Grand Mean	52.2	51.8	47.8	47.5	46.4	45.5	44.4	43.0	41.4	38.5
S.Em±										
S	0.23	0.34	0.38	0.37	0.36	0.35	0.34	0.29	0.28	0.27
C	0.32	0.49	0.54	0.53	0.51	0.49	0.48	0.42	0.39	0.38
S×C	0.44	0.69	0.76	0.74	0.72	0.69	0.68	0.59	0.55	0.54
C.D. (1%)										
S	NS	NS	1.15	1.13	1.10	1.05	1.03	0.89	0.84	0.81
C	NS	NS	1.62	1.59	1.55	1.49	1.46	1.26	1.19	1.15
S×C	NS	NS	2.30	NS	NS	NS	NS	1.79	1.68	1.62

CONCLUSIONS

Vacuum packaging has been found to be highly useful in storing paddy seeds as well as rice grains compared to polythene bags. Among the containers, various seed quality parameters *viz.*, germination per cent, root length, shoot length, total seedling length, seedling dry weight, seedling vigour index, mean daily germination and mobilization efficiency were very high in vacuum packed bags compared to gunny bags throughout the storage period of 18 months under both ambient and cold storage. At the end of storage, the germination per cent in vacuum packed bags was very high, which was much more than minimum seed certification standards. This is also a good indication that vacuum packaging can extend the shelf life of agricultural produce.

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