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Effect of Seed Treatments and Storage Containers on Viability and Vigour of Rice (*Oryza sativa* L.) Variety ADT (R) 46 Seeds

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A B S T R A C T

Rice variety ADT (R) 46 seeds have the problem of poor storage and therefore, to increase the storability of the seeds an experiment was conducted at Tamil Nadu Rice Research Institute, Aduthurai during 2016-18 by treating the seeds with different chemicals and leaf extracts. The results showed that the seeds treated with anti-oxidant, α - tocopherol (Vitamin - E) @ 1 % for 18 h and stored in polylined gunny bag have recorded the higher germination (95 %) and seedling vigour upto six months compared to control. However, germination and vigour were reduced significantly after six months irrespective of the treatments. The varietal genetic makeup and climatic factor are the most probable causes for its poor storage.

Introduction

Rice (*Oryza sativa* L.) is an important stable food crop for about 60% of the world's population. The production and supply of quality seed in rice plays a vital role to meet the growing population. It has been shown experimentally that only by using good quality healthy seed, rice yield could be increased by 10-15% (Akter *et al.*, 2015). In rice, there is no much problem in seed storage if the crop is well maintained during production period. Paderes *et al.*, (1997) reported that the germination of rice varieties in storage does not suffer much as compared to other cereals. However, rice seed stored for long-term is invariably exposed to different climatic adversities like extreme summer, winter and monsoons etc. requires a great deal of effort to safeguard it.

Therefore, seed storage is an important aspect of any sound seed program, because badly stored seeds are not much helpful to yield healthy and vigorous plant. A good quality seed may also be seriously deteriorated if stored under sub optimal condition. Considerable amount of works have been done on storage of rice seeds in relation to varied storage conditions in different parts of the

world (Purushattam *et al.,* 1996; Khalid *et al.,* 2001). However, the seed viability and vigour largely depends on the genotypes, production and post-harvest conditions. During the storage, several aspects have a direct effect on the seeds feasibility, such as seed water content during storage, conservation packages, temperature and relative humidity of the air and the storage environment, gas exchange and characteristics of the seed skin (Caldwell *et al.,* 2005; Toledo *et al.,* 2009). Marques *et al.,* (2014) found that the rice seeds that stored in natural environment without controlling temperature and relative humidity showed lower physiological quality. The tropical climate with high temperature and high relative humidity along with unscientific storage conditions adversely affect the preservation of cereal grains, oilseeds, etc., which lead to the total loss of seed quality (Begum *et al.,* 2013).

It is incontestable that proper seed treatment and storage methods can substantially improve the quality of seed and significantly increase the yield. Sultana *et al.,* (2016) found zero germination in rice seeds stored in earthen, tin and plastic containers after six months of storage with minimum germination in gunny bag. The antioxidant substances like ascorbic acid, tocopherol and glutathione had a positive effect on the seedling vigour (Basra *et al.,* 2006; Draganic and Lekic, 2012). Similarly, seed treatment with biofungicide has been found as superior in increasing germination and vigour in rice seeds (Akter and Hossain, 2015). Therefore, an experiment was conducted in the rice variety ADT (R) 46 seeds by treating with different antioxidants as to manage its poor storage behavior.

Materials and Methods

The storage experiment in rice variety ADT (R) 46 seeds was conducted at Tamil Nadu Rice Research Institute, Aduthurai (India) for two years during 2016 and 2017. Usually, ADT (R) 46 rice variety is raised during *Thaladi* season (September - October) and harvested during January - February in Cauvery Delta region of Tamil Nadu.

Accordingly, the present experimental seed material was harvested during February and used for conducting the storage experiment. The freshly harvested seeds were given the following pre-storage seed treatments *viz*., T_1 - Untreated control, T_2 - Seed soaking in water for 18 h, T_3 - Seed fortification in KH_2PO_4 @ 1 % for 18 h, T_4 - Seed fortification in *Prosopis juliflora* leaf extract @ 1 % for 18 h, T_5 - Seed fortification in α - tocopherol (Vitamin - E) @ 1 % for 18 h, T_6 - Seed fortification in ascorbic acid (Vitamin - C) @ 1 % for 18 h, T_7 - Seed treatment with halogen mixture ($CaOCl_2$+$CaCO_3$+*Albezia amara* @ 5:4:1 ratio) @ 3 g kg^{-1} and T_8 - Seed treatment with halopolymers @ 3 ml kg^{-1} of seeds.

Then, the treated seeds were packed in the storage containers *viz*., gunny bag (C_1) and polylined gunny bag (C_2) and stored under ambient condition. The seed samples were drawn at bimonthly intervals for the evaluation of moisture content, germination and seedling vigour.

The germination test was conducted in four replications by placing the 100 seeds in each replication and evaluated at 14^{th} day of test (ISTA, 1999). The seedling vigour index was computed by multiplying the germination percentage with seedling length (Abdul-Baki and Anderson, 1973). The data collected in two years were pooled and analyzed (Panse and Sukhatme, 1967) at 5 % probability level.

Results and Discussion

The pooled analysis results indicated that the significant increase in seed moisture content was recorded in both gunny bag and polylined

gunny bag during the 10 months storage. However, the rate of increase was lesser in polylined gunny bag than the gunny bag. In this regard, the initial moisture content of 11.1 and 10.1 per cent was increased to 12.0 and 11.0 at 10 months storage in gunny bag and polylined gunny bag (Table 1). Regarding the seed viability, initial seed germination (97 %) was reduced drastically (39 %) during 10 months storage irrespective of treatments and containers. Among the containers, polylined gunny bag have performed better in maintaining the germination. In which, the seed fortification in α - tocopherol @ 1 % for 18 h and stored in polylined gunny bag has recorded higher germination (95 %) upto six months storage when compared to control (80 %). However, the germination of this treatment was declined severely and recorded 52 per cent at eight months storage. Other treatments were also showed similar trend of rapid decline in germination. In this regard, viability and vigour of the seeds decreased slowly upto six months and thereafter, drastic decline was recorded irrespective of the seed treatments (Table 2). Similar findings of germination and vigour reduction in rice seed during storage were recorded by many workers (Biradar Patil and Shekhargouda, 2007; Marques *et al.,* 2014; Sultana *et al.,* 2016; Anil Sebastian and Selvaraju, 2017).

Moisture difference due to relative humidity might have resulted in wetting of paddy seed (Kad *et al.,* 2016) and it can be minimized by storing the seeds in proper containers like gunny bag (Sultana *et al.,* 2016), polythene bag (Pameri *et al.,* 2016) or vacuum polythene bag (Jyoti, 2017). Kameswara Rao and Jackson (1996) found the significant differences among the cultivar in seed storage longevity and therefore, it is advisable during storage to monitor more frequently the viability of accessions with intrinsically poor storage characteristics. This variation in storability among the genotypes was obviously due to the genetic control to resist deterioration during storage (Yogalakshmi *et al.,* 1996). Marques *et al.,* (2014) found the seeds of cultivar *Seleta*, regardless of the environment, maintained germination above the minimum required for commercialization until six months of storage.

The decline in viability percentage may be attributed to ageing effect leading to depletion of food reserves and decline in synthetic activity of embryo. The free radical formation contributes much in the ageing of the seeds and it can be minimized by seed treatment with the antioxidant substances like ascorbic acid, tocopherol and glutathione (Draganic and Lekic, 2012). Basra *et al.,* (2006) found that the aqueous solution of ascorbic acid improved the germination and seedling vigour in rice during seed storage.

Similar findings were also observed in the present study in which the anti-oxidant, α - tocopherol have maintained the germination and seedling vigour upto six months. However, the poor storability of the rice variety ADT (R) 46 seeds is presumably due to the genetic makeup of the variety.

While observing the environmental factors, the higher relative humidity (88 and 90.2 %) was recorded during the seed storage period in both the years at Aduthurai region (Table 6). Also, the humidity was more than 80 per cent in all the months except few cases.

The rainfall during North East Monsoon season particularly during September to December was higher which ultimately increased the relative humidity to more than 90 per cent. This higher relative humidity might have contributed faster deterioration of the seeds even though it is treated with anti-oxidants.

Table.1 Effect of seed treatment and storage container on moisture content (%) in rice variety ADT (R) 46 (pooled data)

Treatments	Initial			2 MAS			4 MAS			6 MAS			8 MAS			10 MAS			Mean
	C_1	C_2	M	C_1	C_2	M	C_1	C_2	M	C_1	C_2	M	C_1	C_2	M	C_1	C_2	M	
T_1	11.3	10.1	10.7	11.4	10.1	10.8	11.3	10.2	10.7	12.2	11.2	11.7	12.5	11.5	12.0	12.1	11.1	11.6	11.2
T_2	10.9	10.2	10.6	11.1	10.3	10.7	11.3	10.3	10.8	12.1	11.4	11.7	12.5	11.4	11.9	12.1	11.0	11.5	11.2
T_3	11.1	10.2	10.6	11.1	10.2	10.6	11.4	10.1	10.7	12.5	11.2	11.8	12.6	11.7	12.1	12.4	11.0	11.7	11.3
T_4	11.1	10.0	10.5	11.2	10.1	10.6	11.4	10.2	10.8	12.5	11.3	11.9	13.1	11.5	12.3	12.0	11.0	11.5	11.3
T_5	11.2	10.2	10.7	11.1	10.3	10.7	11.6	10.7	11.2	12.7	11.6	12.1	12.9	12.0	12.4	11.4	11.6	11.5	11.4
T_6	11.2	10.0	10.6	11.2	10.1	10.6	11.2	10.4	10.8	12.8	11.5	12.1	12.6	11.7	12.2	11.9	10.5	11.2	11.2
T_7	11.1	10.1	10.6	11.1	10.2	10.6	11.0	10.5	10.8	12.5	11.5	12.0	13.2	12.0	12.6	11.9	11.1	11.5	11.3
T_8	11.0	10.1	10.5	11.2	10.2	10.7	11.1	10.3	10.7	12.9	12.1	12.5	13.1	11.9	12.5	12.4	10.7	11.6	11.4
Mean	11.1	10.1	10.6	11.1	10.2	10.6	11.3	10.3	10.8	12.5	11.5	12.0	12.8	11.7	12.2	12.0	11.0	11.5	11.3
		P	C	T	PC	CT	PT	PCT											
SEd		0.3	0.1	0.3	0.4	0.5	0.8	1.2											
CD (P=0.05)		0.6	0.3	NS	NS	NS	NS	NS											

(MAS - Months after storage; M - Mean; P - Storage period; C - Container; T - Treatment)

Table.2 Effect of seed treatment and storage container on germination (%) in rice variety ADT (R) 46 (pooled data)

Treatments	Initial			2 MAS			4 MAS			6 MAS			8 MAS			10 MAS			Mean
	C_1	C_2	M	C_1	C_2	M	C_1	C_2	M	C_1	C_2	M	C_1	C_2	M	C_1	C_2	M	
T_1	95	96	95	88	91	89	84	86	85	78	80	79	39	42	40	33	35	34	70
T_2	97	98	97	94	96	95	88	87	87	81	79	80	43	45	44	35	37	36	73
T_3	96	97	97	91	94	92	85	85	85	75	80	77	41	43	42	36	36	36	71
T_4	95	95	95	90	93	91	80	90	85	76	69	72	47	46	46	37	38	37	71
T_5	98	99	99	96	98	97	93	97	95	89	95	92	50	52	51	40	41	41	79
T_6	95	96	96	90	90	90	80	84	82	74	74	74	40	43	41	35	35	35	69
T_7	96	96	96	91	93	92	90	92	91	85	86	85	43	45	44	36	36	36	74
T_8	98	98	98	96	97	96	88	94	91	76	85	80	69	63	66	59	56	57	81
Mean	96	97	97	92	94	93	86	89	88	79	81	80	46	47	47	39	39	39	74
		P	C	T	PC	CT	PT	PCT											
SEd		0.1	0.09	0.2	0.2	0.2	0.4	0.6											
CD (P=0.05)	0.3	0.19	0.4	0.4	0.5	0.9	1.3												

(MAS - Months after storage; M - Mean; P - Storage period; C - Container; T - Treatment)

Table.3 Effect of seed treatment and storage container on shoot length (cm) in rice variety ADT (R) 46 (pooled data)

Treatments	Initial			2 MAS			4 MAS			6 MAS			8 MAS			10 MAS			Mean
	C_1	C_2	M	C_1	C_2	M	C_1	C_2	M	C_1	C_2	M	C_1	C_2	M	C_1	C_2	M	
T_1	17.6	18.0	17.8	16.9	16.6	16.7	16.8	14.0	15.4	16.1	14.5	15.3	8.0	8.2	8.1	7.7	8.0	7.9	13.5
T_2	16.9	17.0	17.0	16.0	16.8	16.4	17.1	15.8	16.4	16.9	15.7	16.3	9.1	9.3	9.2	8.5	8.8	8.7	14.0
T_3	16.6	17.0	16.8	17.4	17.3	17.3	17.6	17.5	17.5	17.7	17.4	17.6	9.1	9.3	9.2	8.5	8.7	8.6	14.5
T_4	17.9	18.1	18.0	16.3	16.8	16.5	18.4	16.4	17.4	17.8	18.5	18.1	15.8	9.4	12.6	9.0	9.1	9.1	15.3
T_5	18.4	18.0	18.2	16.5	16.9	16.7	18.4	17.7	18.0	18.0	17.8	17.9	15.3	14.5	14.9	11.1	12.8	11.9	16.3
T_6	17.0	17.8	17.4	16.0	15.2	15.6	16.9	16.2	16.6	16.6	15.9	16.3	8.5	9.1	8.8	8.4	8.5	8.5	13.8
T_7	17.7	17.8	17.7	16.6	16.7	16.6	15.9	17.7	16.8	15.3	16.1	15.7	9.1	9.4	9.2	8.5	8.8	8.6	14.1
T_8	17.1	17.2	17.1	16.2	16.3	16.2	15.5	13.5	14.5	15.5	16.8	16.1	13.4	15.3	14.4	8.6	11.0	9.8	14.7
Mean	17.4	17.6	17.5	16.5	16.5	16.5	17.1	16.1	16.6	16.7	16.6	16.6	11.0	10.5	10.8	8.8	9.5	9.1	14.5
		P	C	T	PC	CT	PT	PCT											
SEd		0.02	0.01	0.02	0.03	0.03	0.06	0.08											
CD (P=0.05)		0.04	0.02	0.05	0.06	0.07	0.12	0.16											

(MAS - Months after storage; M - Mean; P - Storage period; C - Container; T - Treatment)

Table.4 Effect of seed treatment and storage container on root length (cm) in rice variety ADT (R) 46 (pooled data)

Treatments	Initial			2 MAS			4 MAS			6 MAS			8 MAS			10 MAS			Mean
	C_1	C_2	M	C_1	C_2	M	C_1	C_2	M	C_1	C_2	M	C_1	C_2	M	C_1	C_2	M	
T_1	18.5	18.3	18.4	19.0	17.8	18.4	15.2	13.9	14.5	15.2	14.2	14.7	8.5	8.7	8.6	14.4	8.5	11.4	14.3
T_2	18.1	17.7	17.9	18.0	18.5	18.2	18.7	15.7	17.2	17.9	16.3	17.1	9.2	9.4	9.3	15.3	8.8	12.0	15.3
T_3	18.6	18.6	18.6	18.3	18.5	18.4	18.0	15.8	16.9	16.8	15.1	15.9	9.2	9.5	9.3	15.4	8.5	11.9	15.2
T_4	19.3	19.6	19.5	18.5	18.7	18.6	17.3	15.4	16.3	17.0	16.0	16.5	12.8	9.6	11.2	15.9	9.2	12.5	15.8
T_5	19.4	20.1	19.7	18.0	18.8	18.4	18.3	17.2	17.7	18.1	17.1	17.6	14.6	16.1	15.3	17.3	12.5	14.9	17.3
T_6	17.8	18.0	17.9	18.1	18.8	18.4	16.2	16.6	16.4	16.1	16.8	16.5	8.9	9.2	9.0	15.2	8.7	11.9	15.0
T_7	19.2	19.5	19.3	18.1	18.1	18.1	16.9	15.1	16.0	16.2	15.3	15.8	9.2	9.5	9.4	15.3	9.1	12.2	15.1
T_8	18.3	18.5	18.4	17.8	18.3	18.0	14.8	17.3	16.0	15.4	16.0	15.7	15.4	16.5	16.0	16.3	10.6	13.4	16.2
Mean	18.6	18.7	18.7	18.2	18.4	18.3	16.9	15.8	16.4	16.6	15.8	16.2	11.0	11.0	11.0	15.6	9.5	12.5	15.5
		P	C	T	PC	CT	PT	PCT											
SEd		0.02	0.01	0.02	0.03	0.04	0.07	0.1											
CD (P=0.05)		0.04	0.02	0.05	0.07	0.08	0.14	0.2											

(MAS - Months after storage; M - Mean; P - Storage period; C - Container; T - Treatment)

Table.5 Effect of seed treatment and storage container on vigour index in rice variety ADT (R) 46 (pooled data)

Treatments	Initial			2 MAS			4 MAS			6 MAS			8 MAS			10 MAS			Mean
	C_1	C_2	M	C_1	C_2	M	C_1	C_2	M	C_1	C_2	M	C_1	C_2	M	C_1	C_2	M	
T_1	3461	3379	3420	3117	3171	3144	2727	2457	2592	2465	2359	2412	1320	1428	1374	1074	1167	1121	2344
T_2	3393	3467	3430	3426	3327	3286	3197	2835	3016	2832	2633	2732	1568	1692	1630	1128	1304	1216	2552
T_3	3417	3487	3452	3271	3366	3318	3067	2909	2988	2617	2656	2636	1492	1617	1554	1215	1249	1232	2530
T_4	3550	3610	3580	3199	3237	3218	2908	2932	2920	2691	2483	2587	1707	1757	1732	1332	1431	1381	2569
T_5	3679	3755	3717	3343	3490	3416	3376	3407	3391	3180	3263	3221	1601	1819	1710	1277	1401	1339	2799
T_6	3327	3416	3371	3093	3115	3104	2860	2822	2841	2484	2502	2493	1433	1540	1486	1175	1245	1210	2417
T_7	3563	3613	3588	3201	3281	3241	2987	3071	3029	2777	2805	2791	1582	1705	1643	1238	1324	1281	2595
T_8	3368	3520	3444	3297	3368	3333	2751	2833	2792	2449	2838	2643	1656	1769	1712	1242	1263	1252	2529
Mean	3470	3531	3500	3221	3294	3257	2984	2908	2946	2687	2692	2689	1545	1666	1605	1210	1298	1254	2542
		P	C	T	PC	CT	PT	PCT											
SEd		0.1	0.08	0.1	0.2	0.2	0.4	0.5											
CD (P=0.05)		0.2	0.15	0.3	0.4	0.4	0.8	1.1											

(MAS - Months after storage; M - Mean; P - Storage period; C - Container; T - Treatment)

Table.6 Weather data during seed storage period

Year/ Months	2016				2017			
	Temp. (^{0}C)		RH (%)	RF (mm)	Temp. (^{0}C)		RH (%)	RF (mm)
January	30.7	20.4	95	0	29.7	19.8	95	176.2
February	33.4	21.3	95	0	31.4	18.3	95	0.0
March	35.3	22.9	93	0	34.0	23.2	95	27.2
April	38.0	26.3	89	0	37.9	26.0	89	0.0
May	36.4	26.0	87	113.8	37.3	26.5	81	4.8
June	34.6	25.2	87	51.2	36.1	25.4	85	115.6
July	34.8	25.3	80	12.9	35.9	25.6	83	75.6
August	35.4	25.3	78	118.4	34.4	24.9	89	122.8
September	34.7	25.1	81	38.8	33.7	24.4	89	215.6
October	35.4	24.3	86	30.8	33.0	24.6	91	134.6
November	31.1	22.3	92	86.8	29.5	23.5	96	452.2
December	29.5	20.5	93	77.7	29.3	21.6	95	163.8
Mean	34.1	23.7	88.0	44.2	33.5	23.6	90.2	124.0

The seedling vigour also showed similar trend where, it was maintained maximum upto six months and thereafter drastic decline was noticed in all the treatments. In which, the shoot length was decreased from 17.5 cm to 9.1 cm during 10 months storage.

However, the lengthiest shoot (11.9 cm) was measured in the seeds fortified with α - tocopherol @ 1 % (Table 3). Additionally, reduction in root length was recorded from 18.7 cm to 9.5 cm at 10 months storage. Nevertheless, the seed fortification with α - tocopherol @ 1 % for 18 h have maintained better root length (14.9 cm) compared to control (11.4 cm) (Table 4). Similarly, decline in vigour index (3500 to 1254) was noticed irrespective of the treatments and higher vigour index (2799) was recorded in α - tocopherol treated seed (Table 5).

Therefore, it is concluded that rice variety ADT (R) 46 seeds soaked in α - tocopherol @ 1 % for 18 h and stored in polylined gunny bag have recorded higher germination and seedling vigour upto six months compared to control. Thereafter, seed germination and seedling vigour were decreased drastically irrespective of the treatments.

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