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RESEARCH PAPER

The effect of packaging material on storability of wheat varieties

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Abstract: The experiment was carried out to evaluate the effect of packaging material on storability of seeds of wheat varieties in laboratory of Department of Seed Science and Technology, UAS, Dharwad. Among packaging materials, seeds stored in Perdue improved crop storage (PICS) bag showed good storability and among varieties, UAS 415 which belongs to *Triticum durum* stored better as compared to UAS 304 (*T. aestivum*) and DDK 1025 (*T. dicoccum*). Among interaction between packaging material and wheat varieties UAS 415 stored in PICS bag recorded higher seed germination (92.75 %), seedling dry weight (310.88 mg/10 seedlings), seedling vigour index (3242) and lower electrical conductivity of seed leachates (0.444 dS m^{-1}) and DDK 1025 stored in cloth bag recorded lower seed germination (82.75 %), seedling dry weight (299.03 mg/10 seedlings), seedling vigour index (2352) and higher electrical conductivity of seed leachates (1.406 dS m^{-1}).

Key words: PICS bag, Seed germination, Seedling vigour index, Wheat varieties

Introduction

Wheat is one of the important staple food crops of India and the world. In India, wheat is the second most important crop which contributes to 25 per cent of total food grain production, it covers an area of about 30.59 m ha with the production of 98.51 million tonnes and average productivity of 3,261 kg ha^{-1}. In Karnataka wheat covers an area of about 1.74 lakh ha with annual production of 1.56 million tonnes and productivity of 897 kg ha^{-1} (Anon., 2017).

Wheat being second most important food grain in India and also an important food grain in public distribution system, its safe storage is important. Deterioration of seed is an inevitable and irreversible process of ageing; it varies from one species to the other depending on the nature of the seed and conditions of storage. Storing seeds after harvest till the next cropping season without impairing the seed quality is of prime importance for successful seed production. Seeds are living entities their storage life is influenced by various environmental factors like relative humidity, temperature *etc.* The effect of these factors can be controlled by the use of suitable packaging material and hence selection of suitable bag for storage is of important aspect in post-harvest handling of seed material.

Perdue Improved Crop Storage (PICS) bagging technology consists of three bags nested inside each other. The inner two bags are high density polyethylene (HDPE), each measuring approximately 80 micro metre thick. The third, outer bag consists of a woven polypropylene bag, which protects the inner HDPE layers against punctures and damage and facilitates handling of the composite bag. These HDPE bags slow down the rate of oxygen exchange with surrounding environment creating hermatic storage condition (Martin, 2015).

The PICS bags used to store the seeds had internal oxygen levels that were substantially lower than woven bag, the moisture content and germination rate of seeds stored in PICS bag was consistent throughout the storage and relative humidity remained constant for the entire testing period as compared to woven bag. Seeds in PICS triple bags remained consistent for benchmarks of quality, such as stable moisture content and germination (Gopal *et al.* (2017) and Scott *et al.* (2017) in maize and Sudini *et al.* (2015) and Vijayalakshmi and Malabasari (2018) in ground nut.

Storezo bag is made from ultra-high barrier specially laminated blend of polymers. In this bags oxygen and moisture barrier property is very high, so no insect and mold growth in the bag, increased shelf life of seeds to double or triple when compared and packed in normal poly ethylene, Plastic bags, woven poly propylene bags or jute bags. Weight loss of seed is minimized, moisture is intact once the bag is sealed, maintains the quality and quantity of stored grains (Anon., 2015).

Seeds stored in polythene bag recorded significantly higher germination, seedling vigour index and lower EC of seed leachate as compared to the seeds stored in cloth bag at the end of storage period as reported by Raikar *et al.* (2011).

Material and methods

Seeds of three wheat varieties *viz*., UAS 304 (*Triticum aestivum*), UAS 415 (*Triticum durum*), DDK 1025 (*Triticum dicoccum*) were collected from ICAR-AICRP on wheat, UAS, Dharwad and were dried to 9 per cent moisture by using hot air oven at 40 °C for one hour, later they were cooled and each variety was stored in different packaging materials (Cloth bag, High density polythene bag (HDPE), Perdue improved crop storage (PICS) bag, Storezo bag) for 9 months during 2017-18 after recording initial quality parameters.

Seed germination

The germination test was conducted in four replications of 100 seeds each by following between paper method and the rolled towels were incubated in the walk-in seed germination room maintained at 25 ± 2 °C temperature and 90 ± 5 % RH. The

numbers of normal seedlings in each replication were counted on 8th day and the mean germination was calculated and expressed in per cent (Anon., 2015a).

Seedling vigour index (SVI)

The seedling vigour index was worked out by multiplying the per cent germination with sum of seedling shoot length and root length (Abdul-Baki and Anderson, 1973).

Seedling Vigour Index I = Seed germination % x (root length + shoot length in cm)

Seedling dry weight

The ten normal seedlings used for measuring root and shoot length from germination test were taken in butter paper and dried in hot-air oven maintained at 70 °C temperature for 24 h. Then, the seedlings were removed and allowed to cool in desiccator for 20 minutes before weighing in an electronic balance. The average weight was calculated and expressed in milligram per 10 seedlings.

Electrical conductivity of seed leachates

Five grams of seeds in two replications were soaked in acetone for half a minute and thoroughly washed in distilled water three times. Then, the seeds were soaked in 25 ml distilled water and kept in an incubator maintained at 25 °C ± 1 °C for twelve hours. The seed leachate was collected and the volume is made up to 25 ml by adding distilled water. The electrical conductivity of the seed leachate was measured in the digital conductivity bridge (ELICO) with a cell constant 1.0 and the mean values were expressed in deci Siemens per meter (dS m^{-1}).

Statistical analysis

The data was statistically analyzed using analysis of variance appropriate for two factor completely randomized design and treatment means were compared using LSD test at 0.01 level of probability, when the F-values were significant (Steel and Torrie, 1984).

Results and discussion

Seed germination

After nine months of storage, the seeds stored in PICS bags maintained the highest germination (91.00 %) while the lowest germination was observed in seeds stored in cloth bag (85.33 %). Seed germination per cent was higher in variety UAS 415 (90.44 %) and lower in DDK 1025 (86.31 %) at the end of storage period. Though no significant difference was recorded among interaction between packaging materials and

Table 1. Seed germination (%) of three wheat varieties as influenced by packaging materials during storage

	Initial month				1st month				2nd month				3rd month				4th month			
Treatments	V_1	V_2	V_3	Mean	V_1	V_2	V_3	Mean	V_1	V_2	V_3	Mean	V_1	V_2	V_3	Mean	V_1	V_2	V_3	Mean
P_1	96.25	97.50	94.75	96.17	95.50	96.75	94.50	95.58	94.50	95.75	93.50	94.58	93.50	94.75	92.25	93.50	92.25	93.50	90.75	92.17
P_2	96.25	97.50	94.75	96.17	96.00	97.00	94.50	95.83	95.25	96.25	93.75	95.08	94.50	95.50	93.00	94.33	93.75	94.75	92.00	93.50
P_3	96.25	97.50	94.75	96.17	96.25	97.25	94.75	96.08	96.00	97.00	94.50	95.83	95.75	96.75	94.00	95.50	95.25	96.25	93.25	94.92
P_4	96.25	97.50	94.75	96.17	96.00	97.25	94.50	95.92	95.50	96.75	94.00	95.42	95.00	96.25	93.50	94.92	94.50	95.75	93.00	94.42
Mean	96.25	97.50	94.75	96.17	95.94	97.06	94.56	95.85	95.31	96.44	93.94	95.23	94.69	95.81	93.19	94.56	93.94	95.06	92.25	93.75
	S.Em.±		C. D. @ 1 %		S.Em.±		C. D. @ 1 %		S.Em.±		C. D. @ 1 %		S.Em.±		C. D. @ 1 %		S.Em.±		C. D. @ 1 %	
V	0.27		1.04		0.38		1.47		0.42		1.62		0.44		1.71		0.48		1.84	
P	0.31		NS		0.44		NS		0.49		NS		0.51		NS		0.55		2.13	
V x P	0.54		NS		0.76		NS		0.84		NS		0.89		NS		0.96		NS	

	5th month				6th month				7th month				8th month				9th month			
Treatments	V_1	V_2	V_3	Mean	V_1	V_2	V_3	Mean	V_1	V_2	V_3	Mean	V_1	V_2	V_3	Mean	V_1	V_2	V_3	Mean
P_1	91.00	92.25	89.00	90.75	89.75	91.00	87.25	89.33	88.50	89.75	85.50	87.92	87.25	88.50	84.25	86.67	86.00	87.25	82.75	85.33
P_2	92.75	94.00	90.75	92.50	91.75	93.00	89.50	91.42	90.75	92.00	88.25	90.33	89.75	91.00	87.00	89.25	88.75	90.00	85.75	88.17
P_3	94.75	95.75	92.50	94.33	94.25	95.25	91.50	93.67	93.50	94.50	90.50	92.83	92.75	93.75	89.50	92.00	91.75	92.75	88.50	91.00
P_4	93.75	95.00	92.00	93.58	93.00	94.25	90.75	92.67	92.25	93.50	89.75	91.83	91.50	92.75	89.00	91.08	90.50	91.75	88.25	90.17
Mean	93.06	94.25	91.06	92.79	92.19	93.38	89.75	91.77	91.25	92.44	88.50	90.73	90.31	91.50	87.44	89.75	89.25	90.44	86.31	88.67
	S.Em.±		C. D. @ 1 %		S.Em.±		C. D. @ 1 %		S.Em.±		C. D. @ 1 %		S.Em.±		C. D. @ 1 %		S.Em.±		C. D. @ 1 %	
V	0.50		1.92		0.53		2.05		0.55		2.11		0.56		2.15		0.57		2.19	
P	0.58		2.22		0.61		2.36		0.63		2.44		0.64		2.48		0.66		2.52	
V x P	1.00		NS		1.06		NS		1.10		NS		1.12		NS		1.14		NS	

Factor 1: Packaging material, P_1: Cloth bag, P_2: HDPE bag, P_3: Perdue improved crop storage (PICS) bag, P_4: Storezo bag

Factor 2: Wheat varieties, V_1: UAS 304 (*Triticum aestivum*), V_2: UAS 415 (*Triticum durum*), V_3: DDK 1025 (*Triticum dicoccum*)

Table 2. Seedling vigour index I of three wheat varieties as influenced by packaging materials during storage

	Initial month				1st month				2nd month				3rd month				4th month			
Treatments	V_1	V_2	V_3	Mean	V_1	V_2	V_3	Mean	V_1	V_2	V_3	Mean	V_1	V_2	V_3	Mean	V_1	V_2	V_3	Mean
P_1	3554	3795	3432	3594	3440	3696	3341	3492	3352	3602	3242	3399	3209	3458	3153	3273	3113	3357	3025	3165
P_2	3554	3795	3432	3594	3485	3724	3352	3521	3432	3638	3272	3447	3374	3548	3190	3370	3305	3482	3105	3297
P_3	3554	3795	3432	3594	3533	3767	3403	3568	3494	3718	3357	3523	3461	3655	3264	3460	3413	3602	3208	3408
P_4	3554	3795	3432	3594	3500	3747	3369	3539	3454	3677	3292	3474	3415	3605	3214	3411	3355	3543	3148	3349
Mean	3554	3795	3432	3594	3490	3734	3366	3530	3433	3659	3291	3461	3365	3566	3205	3379	3296	3496	3121	3305
	S.Em.±		C. D. @ 1 %		S.Em.±		C. D. @ 1 %		S.Em.±		C. D. @ 1 %		S.Em.±		C. D. @ 1 %		S.Em.±		C. D. @ 1 %	
V	12		45		25		96		18		69		17		66		19		75	
P	14		NS		29		NS		21		79		20		76		23		87	
V x P	24		NS		50		NS		36		NS		34		NS		39		NS	

	5th month				6th month				7th month				8th month				9th month			
Treatments	V_1	V_2	V_3	Mean	V_1	V_2	V_3	Mean	V_1	V_2	V_3	Mean	V_1	V_2	V_3	Mean	V_1	V_2	V_3	Mean
P_1	3032	3259	2913	3068	2928	3066	2720	2905	2821	2959	2604	2795	2746	2869	2481	2699	2621	2746	2352	2573
P_2	3246	3417	3024	3229	3166	3348	2951	3155	3041	3206	2839	3029	2974	3121	2730	2941	2889	3051	2654	2865
P_3	3371	3552	3157	3360	3322	3503	3080	3302	3258	3428	2991	3226	3196	3347	2915	3153	3113	3242	2817	3057
P_4	3302	3470	3077	3283	3237	3408	2997	3214	3139	3310	2903	3117	3083	3247	2835	3055	3000	3161	2755	2972
Mean	3238	3425	3043	3235	3163	3331	2937	3144	3065	3226	2834	3042	3000	3146	2740	2962	2906	3050	2645	2867
	S.Em.±		C. D. @ 1 %		S.Em.±		C. D. @ 1 %		S.Em.±		C. D. @ 1 %		S.Em.±		C. D. @ 1 %		S.Em.±		C. D. @ 1 %	
V	19		73		21		82		20		76		20		79		20		79	
P	22		84		25		94		23		87		24		91		24		91	
V x P	38		NS		42		NS		39		NS		41		NS		41		NS	

Factor 1: Packaging material, P_1: Cloth bag, P_2: HDPE bag, P_3: Perdue improved crop storage (PICS) bag, P_4: Storezo bag,
Factor 2: Wheat varieties, V_1: UAS 304 (*Triticum aestivum*), V_2: UAS 415 (*Triticum durum*), V_3: DDK 1025 (*Triticum dicoccum*)

wheat varieties for seed germination, numerically higher values recorded in variety UAS 415 stored in PICS bag (92.75 %) and lower in DDK 1025 in cloth bag (82.75 %) (Table 1).

Higher level of germination per cent maintained in seeds stored in PICS bag may be related to lesser moisture fluctuation which further let to reduced autoxidation and depletion of food reserves, higher anti-oxidative and lowering reactive oxygen species (ROS) damage in seeds stored in PICS bag. Whereas seeds stored in cloth bag were more prone to seed deterioration because of higher moisture content which resulted in faster degradation of food reserve as reported by Asha *et al.* (2012).

Seedling vigour index (SVI)

After nine months of storage, seedling vigour index was higher in PICS (3057) and lower in cloth bag (2573). Among wheat varieties, higher values recorded in UAS 415 (3050) and lower in DDK 1025 (2645). No significant difference was recorded for seedling vigour index I but numerically maximum value recorded in variety UAS 415 stored in PICS bag (3242) while lower value in DDK 1025 in cloth bag (2352) (Table 2). Higher seed germination, shoot length and root length resulted in higher seedling vigour of seeds stored in PICS bag.

Seedling dry weight

The seedling dry weight was highest in PICS bag (308.18 mg/10 seedlings) and lowest in cloth bag (301.28 mg/10 seedlings) after the end of storage period (Table 3). Among wheat varieties, the seedling dry weight was highest in UAS 415 (307.17 mg/10 seedlings) and lowest in DDK 1025 (302.61 mg/10 seedlings). Interaction between packaging materials and wheat varieties recorded highest seedling dry weight in UAS 415 in PICS bag (310.88 mg/10 seedlings) and lowest in DDK 1025 in cloth bag (299.03 mg/10 seedlings).

Reduced degradation of food reserve resulted in higher germination per cent, seedling root length and seedling shoot length of seeds stored in PICS bag. Higher seedling root length and seedling shoot length contribute to higher seedling dry weight. The results are in agreement with Moon *et al.* (2011) and Gopal *et al.* (2017).

Electrical conductivity of seed leachates

Electrical conductivity of seed leachates was higher in cloth bag (0.833 dS m^{-1}) and lower in PICS bag (0.720 dS m^{-1}). Among varieties DDK 1025 recorded highest value (1.333 dS m^{-1}) and UAS 415 recorded lowest value (0.484 dS m^{-1}). DDK 1025 in cloth bag recorded significantly

Table 3. Seedling dry weight (mg / 10 seedlings) of three wheat varieties as influenced by packaging materials during storage

Treatments	Initial month				1st month				2nd month				3rd month				4th month			
	V_1	V_2	V_3	Mean	V_1	V_2	V_3	Mean	V_1	V_2	V_3	Mean	V_1	V_2	V_3	Mean	V_1	V_2	V_3	Mean
P_1	310.85	313.94	309.75	311.51	310.25	313.40	309.20	310.95	309.13	312.32	308.06	309.84	308.14	312.31	307.88	309.45	307.46	310.95	306.52	308.31
P_2	310.85	313.94	309.75	311.51	310.46	313.56	309.36	311.13	309.64	312.78	308.52	310.31	308.54	312.74	308.36	309.88	308.42	311.75	307.37	309.18
P_3	310.85	313.94	309.75	311.51	310.64	313.75	309.53	311.31	310.32	313.47	309.19	310.99	310.41	313.56	308.85	310.94	310.16	313.35	308.63	310.71
P_4	310.85	313.94	309.75	311.51	310.53	313.67	309.46	311.22	309.97	313.15	308.88	310.67	310.94	313.07	308.71	310.91	310.45	312.62	308.26	310.44
Mean	310.85	313.94	309.75	311.51	310.47	313.59	309.39	311.15	309.77	312.93	308.66	310.45	309.51	312.92	308.45	310.29	309.13	312.16	307.69	309.66
	S.Em.±		C. D. @ 1 %		S.Em.±		C. D. @ 1 %		S.Em.±		C. D. @ 1 %		S.Em.±		C. D. @ 1 %		S.Em.±		C. D. @ 1 %	
V	0.03		0.10		0.05		0.18		0.05		0.18		0.05		0.17		0.06		0.23	
P	0.03		NS		0.06		0.21		0.06		0.21		0.05		0.20		0.07		0.27	
V x P	0.05		NS		0.10		NS		0.10		NS		0.09		0.35		0.12		0.46	

Treatments	5th month				6th month				7th month				8th month				9th month			
	V_1	V_2	V_3	Mean	V_1	V_2	V_3	Mean	V_1	V_2	V_3	Mean	V_1	V_2	V_3	Mean	V_1	V_2	V_3	Mean
P_1	306.38	309.67	305.20	307.08	305.12	308.36	304.92	306.13	303.73	306.89	303.29	304.64	302.73	304.75	302.21	303.23	301.05	303.76	299.03	301.28
P_2	307.64	310.84	306.38	308.29	306.77	309.90	305.51	307.39	305.72	308.93	304.38	306.34	304.26	307.21	303.60	305.02	303.69	306.50	302.77	304.32
P_3	309.95	313.12	308.36	310.48	309.51	312.68	307.95	310.05	309.07	312.32	307.43	309.61	308.22	311.21	306.27	308.57	307.83	310.88	305.82	308.18
P_4	309.55	311.69	307.37	309.54	308.79	310.93	306.58	308.77	308.19	310.25	305.74	308.06	307.01	308.95	304.38	306.78	305.74	307.52	302.81	305.36
Mean	308.38	311.33	306.83	308.85	307.55	310.47	306.24	308.09	306.68	309.60	305.21	307.16	305.55	308.03	304.12	305.90	304.58	307.17	302.61	304.78
	S.Em.±		C. D. @ 1 %		S.Em.±		C. D. @ 1 %		S.Em.±		C. D. @ 1 %		S.Em.±		C. D. @ 1 %		S.Em.±		C. D. @ 1 %	
V	0.05		0.19		0.05		0.18		0.05		0.18		0.05		0.20		0.06		0.24	
P	0.06		0.22		0.05		0.21		0.05		0.21		0.06		0.24		0.07		0.28	
V x P	0.10		0.39		0.09		0.36		0.09		0.36		0.11		0.41		0.12		0.48	

Factor 1: Packaging material, P_1: Cloth bag, P_2: HDPE bag, P_3: Perdue improved crop storage (PICS) bag, P_4: Storezo bag

Factor 2: Wheat varieties, V_1: UAS 304 (*Triticum aestivum*), V_2: UAS 415 (*Triticum durum*), V_3: DDK 1025 (*Triticum dicoccum*)

highest (1.406 dS m^{-1}) and UAS 415 in PICS bag recorded significantly lowest electrical conductivity of seed leachates (0.444 dS m^{-1}) after nine months after storage (Fig. 1).

Increasing storage period and high seed moisture content increased electrical conductivity (Naguib *et al.*, 2011). Higher electrical conductivity values recorded in seeds stored in cloth may be due to higher level of seed deterioration on account of age induced membrane damage of various cell and cell organelles (Asha *et al.*, 2012). Lower electrical conductivity values recorded in seeds stored in PICS bag, storezo bag and HDPE bag packaging is mainly due to low seed moisture content, maintaining membrane integrity and lesser seed deterioration. Higher electrical conductivity of seed leachate value in DDK 1025 as compared to UAS 415 and UAS 304 in all the months of storage may be due to presence of husk (DDK 1025 seeds are stored with husk) which might have contributed more leachates.

Generally, seeds stored in moisture impervious sealed containers stored better compared to moisture pervious containers under ambient storage conditions, since the prevailing relative humidity and temperature of atmosphere influence greatly the longevity of seeds. The highest quality of seeds in storage can be maintained by minimizing oxygen concentration, seed moisture content and temperature (Raikar *et al.*, 2011).

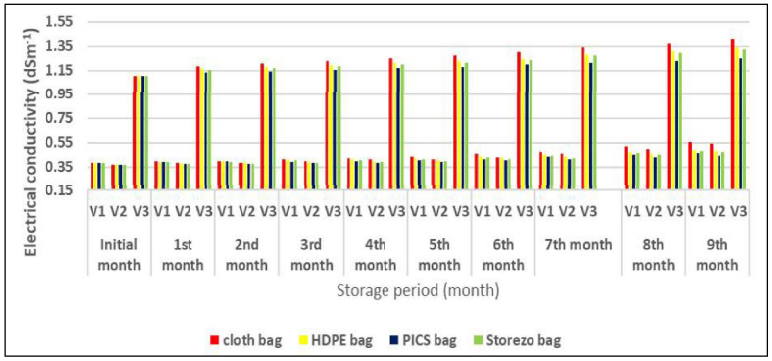

Fig. 1. Influence of packaging material and wheat varieties on electrical conductivity of seed leachates during storage. (V_1: UAS 304, V_2: UAS 415, V_3: DDK 1025)

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