

Effect of seed moisture content on seed longevity under ambient storage in senna and muskdana

UDAYA BHASKAR K.*, S.S. PARIHAR, M. DADLANI, SHIV K. YADAV, RADHIKA C.¹
AND RAJENDRA PRASAD S.¹

Division of Seed Science and Technology, IARI, New Delhi-110 012
udaya9252@gmail.com

ABSTRACT Seed longevity and desiccation sensitivity at different targeted moisture contents under ambient storage conditions were studied in this experiment. Seeds were equilibrated to targeted moisture contents (10 %, 7.5 % and 5 % MC), by the use of silica gel (for drying) and glycerol (for humidification) and sealed in plastic containers with parafilm, followed by storage under ambient temperature (Delhi conditions). A sharp fall in all seed quality attributes (germination percent, seedling length, seedling dry weight and vigour indices) in the other seed moisture regimes (7.5 and 5 %) at 10 % MC was noticed, while viability was not adversely effected (even after 15 months of storage). But there was no significant difference in germination percentage with respect to moisture regimes (7.5 % and 5 %), indicating the fact that both are equally good. Other significant finding of this study was both senna and muskdana can withstand low moisture content up to 5 %. The results of the study conducted in senna where storability of acid scarified seed was compared with control (un-scarified) had shown that abnormal seedlings and dead seeds percent increased significantly during observation period (3, 6, 9, 12 and 15 months). The experiment clearly established the fact that it is a futile exercise to store scarified seed in senna. This study also confirmed the orthodox seed storage behaviour of the two medicinal plants (Senna and Muskdana) and the capability of seeds to withstand ultra dry storage conditions.

Keywords: Medicinal plants, targeted moisture content, seed longevity, desiccation sensitivity, senna and muskdana

The importance of seed storage has been recognized ever since humans began to domesticate plants. The duration of successful storage depends upon both the objectives and the species concerned. Seed longevity varies greatly among species. It may also vary among accessions within a species because of differences in genotype and provenance. Not all species of seeds respond to the environment before and during storage in the same way. There are three main categories of seed storage behaviour. Two categories of seed storage behaviour have been defined [1-3], orthodox and recalcitrant, the recent introduction was a third category intermediate between the orthodox and recalcitrant categories [4]. Literature is not available on the actual seed storage behaviour and desiccation tolerance in senna (*Cassia angustifolia*) and muskdana (*Abelmoschus moschatus*).

Hence, the following study was aimed at filling the existing gap relating to seed storage behaviour and desiccation tolerance in senna and muskdana.

MATERIALS AND METHODS

This study was carried out in Division of Seed Science and Technology, IARI, New Delhi during the period of 2006 to 2008. Pure fraction of seeds of both crops were taken and their moisture content determined by hot air oven method at 130 °C for 2 hours. Targeted moisture contents (10%, 7.5% and 5%) were achieved by use of either silica gel (for drying) or saturated salt solutions of glycerol (for humidification) as suggested by Sun protocol [5]. Measured amount of seeds were kept in petri plates and dried or humidified by silica gel or glycerol, respectively depending on initial moisture content of the seeds in glass desiccators. Time to time their final weight

*Corresponding author

¹ICAR- Directorate of Seed Research, Mau, UP.

Received: November 2013

Revised: May 2014

Accepted: June 2014

was determined as per the formula given below to ascertain moisture content. Once they reached the targeted moisture content, they were sealed in plastic containers with parafilm, which were stored under ambient conditions for 15 months. Seed viability and vigour was estimated at 3 months interval up to 15 months and observations such as seed germination percentage (normal seedlings, abnormal seedlings, hard seeds and dead seeds) and vigour indices were recorded in both the crops.

Formula for determination of Moisture equilibrium

$$W_f = \frac{W_i \times 100 - M_i}{100 - M_f}$$

Where, W_f = Final weight of sample; W_i = Initial weight of sample; M_i = Initial moisture content of sample; M_f = Final moisture content of sample.

Ratio of glycerol and water (by volume) for maintaining different relative humidities [5]:

Glycerol (ml)	H ₂ O (ml)	RH (%)
10	90	98.2
52	48	80.0
79	21	61.2
88	12	36.5

Effect of scarification on seed viability during storage in senna

The effect of seed scarification on seed viability during storage was studied for 15 months by comparing with seed viability under control (un-scarified) during storage in two seed lots in case of senna. For scarification purpose, seeds were scarified with conc. sulphuric acid for 30 minutes. Later on excess amount of acid was removed by keeping the seeds in running water and seeds were dried under shade to reduce the moisture content. Then seeds were kept in plastic bottles and sealed with parafilm for storage purpose

along with control. The germination data was recorded periodically at an interval of 3, 6, 9, 12 and 15 months along with control (no scarification) to ascertain the effect of scarification on seed viability in storage.

RESULTS AND DISCUSSION

Senna and Muskdana seeds were brought down to 10%, 7.5% and 5% MC and stored under ambient temperature. As per Harrington's thumb rule, the storability should increase in lower moisture contents (MC). In this experiment also, similar results were obtained germination percent and vigour indices are better at 5% MC when compared to 10% MC. However, there was no significant difference among 7.5% and 5% MCs with respect to the above mentioned parameters.

Effect of storage period and moisture content on germination parameters of senna

The seed moisture contents of 5% and 7.5% proved better and on par with respect to germination percent, even after 15 months of storage. When compared to 10 % seed moisture content, 5% and 7.5% MC were superior in senna indicating the fact that storage is enhanced at low moisture contents and seeds can withstand ultra low moisture conditions.

The germination percent without scarification treatment were 66, 64 & 69 (Table 1a) and the corresponding hard seed percent were 18, 22 & 25 (Table 1a) at 10, 7.5 and 5 % targeted moisture content (TMC), respectively at the initiation of this storage study. There was a clear cut indication that at low TMC, the hard seed percent was more even at the initial stages of experimentation. The germination after dormancy breaking treatment was also significantly higher at lower TMC, i.e. 80 at 5 % and 81 at 7.5% when compared with germination percent at 10 % TMC i.e. 78 (Table 1a). Later on, the germination percent gradually decreased and hard seed per cent gradually increased during

Table 1a. Effect of targeted moisture contents on seed germination in senna during storage

(Months of storage)							
TMC	0M	3M	6M	9M	12M	15M	Mean
10%	66 (54.3)	64 (53.3)	62 (51.7)	57 (48.8)	58 (49.6)	56 (48.6)	60.50 (51.07)
7.50%	64 (52.9)	63 (52.3)	58 (49.8)	56 (48.4)	56 (48.6)	51 (45.4)	57.94 (49.57)
5%	59 (50.2)	59 (50.4)	56 (48.4)	51 (45.7)	51 (45.6)	48 (44.0)	54.17 (47.38)
MEAN	62.89 (52.47)	62.11 (52.00)	58.67 (49.98)	54.67 (47.66)	55.11 (47.92)	51.78 (46.00)	
CD	M	1.99 (1.16)	T	1.41 (0.82)	M*T	N.S. (N.S.)	
Hard seeds (%)							
10%	18 (25.0)	18 (25.3)	19 (26.1)	21 (27.0)	22 (27.7)	22 (28.0)	20.00 (26.52)
7.50%	22 (27.9)	22 (28.0)	24 (29.5)	24 (29.5)	25 (30.0)	26 (30.8)	24.00 (29.30)
5%	25 (30.2)	26 (30.8)	26 (30.6)	27 (31.3)	29 (32.6)	29 (32.8)	27.17 (31.38)
MEAN	21.78 (27.72)	22.22 (28.04)	23.22 (28.75)	24.00 (29.28)	25.22 (30.09)	25.89 (30.53)	
CD	M	1.86 (1.28)	T	1.32 (0.90)	M*T	N.S. (N.S.)	
Normal seedlings after sulphuric acid treatment (%)							
10%	78 (62.3)	78 (62.0)	77 (61.3)	75 (60.2)	73 (58.7)	71 (57.4)	75.44 (60.32)
7.50%	81 (64.4)	80 (63.7)	80 (63.7)	78 (62.2)	76 (60.9)	76 (60.4)	78.72 (62.54)
5%	80 (63.7)	80 (63.7)	80 (63.4)	79 (62.7)	77 (61.3)	76 (60.9)	78.83 (62.62)
MEAN	80.00 (63.43)	79.56 (63.12)	79.11 (62.82)	77.56 (61.72)	75.00 (60.30)	74.33 (59.57)	
CD	M	1.95 (1.35)	T	1.38 (0.95)	M*T	N.S. (N.S.)	

Note: M=Months; TMC= Targeted moisture content

storage. After 15 months of storage, the germination percent without scarification treatment were 56, 51 & 48 (Table 1a) and the corresponding hard seed percent was 22, 26 & 29 at 10, 7.5 & 5% TMC, respectively. The actual germination percent with scarification after 15 months of storage also followed the similar trend where germination percent were significantly higher at low TMC i.e. 76 at both 5 and 7.5% TMC, when compared with germination percent at 10% TMC i.e. 71.

The interaction effect of seed moisture content (TMC) and storage period on the seedling length was not significant at $P = 0.05$ ($CD = 0.098$) having a range from 12.75 cm at 10 % TMC and 3 months storage to 11.95 cm at 7.5 % TMC, stored for 15 months (Table 1b). There was also no significant difference in seedling length among different TMCs, but there was a significant difference in seedling length with respect to different storage periods. The seedling length was 12.69 at 10 % TMC and 0 months storage and there was no significant difference in seedling length up to 9 months of storage i.e. 12.36. There was a significant reduction in seedling length from 12 months of storage (12.17) and it was 12.16 after 15 months of storage. Whereas, at 7.5% TMC and 0 months storage, the seedling length was 12.55 and there was no significant difference in seedling length up to 9 months of storage i.e. 12.33. There was a significant reduction in seedling length from 12 months of storage (12.16) and it was 11.95 after 15 months of storage. And finally at 5 % TMC and 0 months storage the seedling length was 12.55 and there was no significant difference in seedling length up to 6 months of storage i.e. 12.23. There was a significant reduction in seedling length from 9 months of storage (12.09) and it was 12.04 after 12 months of storage and 12.00 after 15 months of storage (Table 1b).

The interaction effect of seed moisture content (TMC) and storage period on the seedling dry weight was not significant at P

$= 0.05$ ($CD = 0.098$). In both the factors i.e. TMC and months of storage, there was no significant difference among seedling dry weights and their interaction effect was also non significant. The seedling dry weights were having a range from 172 (10% TMC and 9 months storage) to 167 (10% TMC and 15 months storage) (Table 1b). The results for vigour indices, VI-I and II for this experiment were significant for the two factors (TMC and months of storage) individually but their interaction effect was not significant. (Table 1b).

Effect of scarification on seed germination during storage in senna

The germination results clearly indicated that there was a significant difference between lots, treatments (scarification & control) and months of storage. With respect to interaction effects, the interaction between lots (L) and treatments (T), treatments (T) and months of storage (M) were significant, whereas interaction between lots (L) and months of storage (M), lots (L), treatments (T) and months of storage (M) were not significant at $P = 0.05$.

In lot 1, the germination percent (82) was same in both treatments even up to 3 months of storage. Thereafter, a significant reduction in germination percent (79) of scarified seed at 6 months of storage was observed and it declined drastically at 12 months (59) & 15 months of storage (53). In control, there was a significant reduction in germination percent (78) after 9 months of storage and the final germination percent after 15 months of storage was 72. In lot 2 also the germination percent (87) was same in both treatments even up to 3 months of storage. Subsequently, there was a significant reduction in germination percent (82) of scarified seed at 6 months of storage and it declined drastically at 12 months (64) and 15 months of storage (56). In control, there was a significant reduction in germination percent (85) after 9 months of storage and the final

Table 1b. Effect of targeted moisture contents on seedling length, seedling dry weight and vigour indices in senna during storage

		Seedling length(cm)												Seedling dry weight(mg)											
		(Months of storage)												(Months of storage)											
TMC		OM	3M	6M	9M	12M	15M	MEAN	TMC	OM	3M	6M	9M	12M	15M	MEAN	OM	3M	6M	9M	12M	15M	MEAN		
10%		12.7	12.8	12.5	12.4	12.2	12.2	12.44	10%	169	169	171	172	171	167	169.8	169	169	171	172	171	167	169	169.8	
7.50%		12.6	12.6	12.4	12.3	12.2	12.0	12.33	7.50%	168	170	169	169	169	169	169.1	168	170	169	169	169	169	169	169.1	
5%		12.6	12.5	12.2	12.1	12.0	12.0	12.24	5%	169	172	171	169	168	169	169.7	169	172	171	169	168	169	169	169.7	
MEAN		12.60	12.62	12.39	12.26	12.12	12.04	MEAN	168.8	170.3	170.6	170.1	169.3	168.1			168.8	170.3	170.6	170.1	169.3	168.1			
CD	M	0.34							CD	M	N.S.						M	N.S.							
	T	N.S.								T	N.S.						T	N.S.							
	M*T	N.S.								M*T	N.S.						M*T	N.S.							
		Vigour index I												Vigour index II											
TMC		OM	3M	6M	9M	12M	15M	MEAN	TMC	OM	3M	6M	9M	12M	15M	MEAN	OM	3M	6M	9M	12M	15M	MEAN		
10%		993	995	964	931	888	863	939	10%	13208	13199	13167	12955	12479	11863	12812	13208	13199	13167	12955	12479	11863	12812		
7.50%		1021	1011	997	966	928	905	971	7.50%	13692	13629	13605	13238	12925	12760	13308	13692	13629	13605	13238	12925	12760	13308		
5%		1008	1007	979	955	927	916	965	5%	13604	13814	13709	13377	12910	12875	13382	13604	13814	13709	13377	12910	12875	13382		
MEAN		1007	1004	980	951	914	895	MEAN	13501	13547	13494	13190	12772	12499			13501	13547	13494	13190	12772	12499			
CD	M	37						CD	M	369							M	369							
	T	26							T	261							T	261							

Note: M=Months; TMC= Targeted moisture content

germination after 15 months of storage was 77 percent (Table 2).

Effect of scarification on abnormal seedlings during storage in senna

In lot 1, the abnormal seedlings percent was significantly different even from 3 months of storage onwards which was 3 in control & 5 in scarification treatment. However, there was not much difference in control and abnormal seedling percent was 4 after 15 months of storage; whereas, in scarification treatment abnormal seedlings percent was significantly increased and was 15 after 15 months of storage. In lot 2 also, the abnormal seedlings percent was significantly different even from 3 months of storage onwards which was 1 in control and 6 in scarification treatment. Later, there was not much difference in control and abnormal seedling percent was 3 after 15 months of storage; whereas, in scarification treatment abnormal seedlings percent was significantly increased and was 19 after 15 months of storage (Table 2).

Effect of scarification on hard seeds and dead seeds during storage in senna

In lot 1, the hard seed percent was 20 at 3 months after storage and it increased gradually and reached to 29 after 15 months of storage in control without any scarification treatment at the time of germination; whereas, in scarification treatment, hard seeds were not observed even after 15 months of storage. The same trend was observed in lot 2 also where hard seed percent was 45 at 3 months after storage and it increased gradually and reached to 50 after 15 months of storage in control without any scarification treatment at the time of germination. Also, no hard seeds were observed in scarification treatment even after 15 months of storage (Table 2).

In lot 1, the dead seeds percent was same at 3 months of storage which was 13 in both control and scarification treatments. Therefore, not much difference in control was

observed and dead seed percent was 12 after 15 months of storage; whereas, in scarification treatment dead seed percent was significantly increased and was 32 after 15 months of storage. In lot 2 also similar trend was observed (Table 2).

Effect of storage period and moisture content on germination percent of muskdana

In case of muskdana, the seed moisture contents of 5% and 7.5% were proved superior and on par with respect to germination percent even after 15 months of storage. As compared to 10% seed moisture content, 5% and 7.5% MC showed enhanced longevity in muskdana indicating the fact that storage is better at low moisture contents and seeds can withstand ultra low moisture conditions.

The germination percent without scarification treatment were 52, 49 and 47 and the corresponding hard seeds percent were 40, 44 and 46 (Table 3a) at 10, 7.5 and 5% TMC, respectively at the initiation of this storage study. There was a clear cut indication that at low TMC, the hard seed percent was more even at the initial stages of experimentation. The germination percent after dormancy breaking treatment were almost on par in all the three TMCs, i.e. 90 at 10%, 91 at 7.5% and 90 at 5% (Table 3a). Later on, the germination percent gradually decreased and hard seed percent gradually increased during storage. After 15 months of storage, the germination percent without scarification treatment were 47, 41 and 39 and the corresponding hard seed percent was 38, 49 and 50 at 10, 7.5 and 5% TMCs, respectively. The actual germination percent with scarification after 15 months of storage also followed the similar trend where germination percent were significantly higher at low TMCs i.e. 87 at 5% and 86 at 7.5% TMC, when compared with germination percent at 10% TMC i.e. 81 (Table 3a). The interaction effect of seed moisture content (TMC) and storage period on the seedling length was not significant at $P = 0.05$, having a range from

Table 2. Effect of scarification on seed germination in senna during storage

	Normal seedlings										Abnormal seedlings				
	(Months of storage)										(Months of storage)				
	3M	6M	9M	12M	15M	Mean	3M	6M	9M	12M	15M	Mean			
Lot 1	Control	82 (65.1)	81 (63.9)	78 (62.2)	77 (61.6)	72 (58.2)	78 (62.2)	Control	3 (9.9)	3 (9.3)	3 (10.4)	3 (9.6)	4 (11.3)	3 (10.1)	
Scari.		82 (64.9)	79 (62.9)	74 (59.1)	59 (50.2)	53 (46.5)	69 (56.7)	Scari.	5 (12.4)	6 (14.0)	10 (18.7)	14 (21.6)	15 (22.8)	10 (17.9)	
Lot 2	Control	87 (68.9)	86 (68.3)	85 (66.9)	81 (64.2)	77 (61.6)	83 (65.9)	Control	1 (5.4)	2 (7.3)	2 (8.7)	3 (9.3)	3 (9.6)	2 (8.1)	
Scari.		87 (69.1)	82 (64.9)	74 (59.1)	64 (52.9)	56 (48.6)	73 (58.9)	Scari.	6 (13.7)	9 (17.7)	11 (19.7)	16 (23.5)	19 (25.8)	12 (20.1)	
CD	L	0.89 (0.62)	T	0.89 (0.62)	M	1.41 (0.99)		L	NS (NS)	T	0.84 (1.18)	M	1.33 (1.87)		
	L*T	1.26 (0.88)	L*M	N.S. (N.S.)	T*M	1.99 (1.40)		L*T	1.19 (1.67)	L*M	N.S. (NS)	T*M	1.88 (2.64)		
	L*T*M	N.S. (N.S.)						L*T*M	N.S. (N.S.)						
Hard seeds															
Dead seeds															
Lot 1	Control	20 (26.6)	22 (28.2)	24 (29.1)	26 (30.4)	29 (32.3)	24.1 (29.3)	Control	13 (21.1)	12 (20.2)	13 (21.1)	13 (21.0)	12 (20.5)	12 (20.8)	
	Scari.	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0.0 (0.0)	Scari.	13 (21.3)	15 (22.5)	16 (23.5)	27 (31.5)	32 (34.6)	20.7 (26.7)	
Lot 2	Control	45 (41.9)	47 (43.3)	48 (43.6)	49 (44.6)	50 (44.8)	47.7 (43.6)	Control	8 (16.7)	9 (17.8)	11 (19.0)	10 (18.7)	15 (23)	10.8 (19)	
	Scari.	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0.0 (0.0)	Scari.	7 (15.1)	9 (17.1)	15 (22.7)	20 (26.8)	25 (29.8)	15.1 (22.3)	
CD	L	0.61 (0.37)	T	0.61 (0.37)	M	0.97 (0.59)		L	1.22 (1.00)	T	1.22 (1.00)	M	1.92 (1.58)		
	L*T	0.87 (0.53)	L*M	N.S. (NS)	T*M	1.37 (0.84)		L*T	1.72 (1.41)	L*M	N.S. (NS)	T*M	2.72 (2.23)		
	L*T*M	N.S. (NS)						L*T*M	3.84 (NS)						

Note: M=Months; Control = un-scarified; Scari. = Scarified

Table 3a. Effect of targeted moisture contents on seed germination in muskdana during storage

TMC	(Months of storage)							Mean
	OM	3M	6M	9M	12M	15M		
10%	52 (46.1)	50 (45.0)	49 (44.4)	48 (44.0)	48 (43.6)	47 (43.5)	49.06 (44.44)	
7.50%	49 (44.6)	49 (44.4)	47 (43.3)	47 (43.1)	43 (41.1)	41 (40.0)	46.11 (42.75)	
5%	47 (43.3)	45 (42.1)	45 (42.1)	41 (39.8)	41 (39.8)	39 (38.6)	43.00 (40.95)	
MEAN	49.44 (44.66)	48.00 (43.83)	47.00 (43.26)	45.33 (42.30)	44.00 (41.53)	42.56 (40.69)		
CD	M	2.03 (1.17)	T	1.44 (0.83)	M*T	N.S. (N.S.)		
Hard seeds (%)								
10%	40 (39.2)	40 (39.0)	39 (38.6)	40 (39.4)	38 (38.2)	38 (37.8)	39.17 (38.72)	
7.50%	44 (41.5)	43 (41.1)	44 (41.7)	45 (41.9)	48 (43.6)	49 (44.2)	45.44 (42.37)	
5%	46 (42.9)	46 (42.7)	48 (44.0)	49 (44.4)	49 (44.6)	50 (45.0)	48.17 (43.93)	
MEAN	43.44 (41.21)	43.00 (40.95)	43.89 (41.46)	44.67 (41.91)	45.11 (42.16)	45.44 (42.35)		
CD	M	1.73 (1.00)	T	1.22 (0.71)	M*T	3.00 (1.73)		
Normal seedlings after sulphuric acid treatment (%)								
10%	90 (71.6)	88 (69.4)	85 (67.2)	84 (66.7)	81 (64.2)	81 (63.9)	84.78 (67.16)	
7.50%	91 (72.2)	90 (71.9)	89 (70.6)	87 (68.9)	87 (68.9)	86 (68.0)	88.33 (70.08)	
5%	90 (72.0)	90 (71.6)	90 (71.2)	89 (70.9)	89 (70.6)	87 (69.1)	89.28 (70.91)	
MEAN	90.33 (71.92)	89.33 (70.96)	87.89 (69.71)	86.89 (68.82)	85.67 (67.88)	84.67 (67.02)		
CD	M	1.61 (1.42)	T	1.14 (1.00)	M*T	2.79 (N.S.)		

Note: M=Months; TMC= Targeted moisture content

12.01 cm at 7.5% TMC and 0 months storage to 11.24 cm at 10% TMC, stored for 12 months. There was also no significant difference in seedling length among different TMCs, but there was a significant difference in seedling length with respect to different storage periods (Table 3b). The interaction effect of seed moisture content (TMC) and storage period on the seedling dry weight was not significant at $P = 0.05$. There was also no significant difference in seedling dry weight among different TMCs, but there was a significant difference in seedling dry weight with respect to different storage periods. The seedling dry weights were having a range from 97 (10% TMC and 3 months storage) to 86 (10% TMC and 15 months storage). The results for VI-I and II for this experiment were significant for the two factors (TMC and months of storage) individually, but their interaction effect was not significant (Table 3b).

In current study, senna and muskdana seeds were equilibrated to targeted moisture contents and stored under ambient temperature. Harrington's thumb rule, says that the storability should increase as the moisture content decreases. For every one percent reduction in moisture content, the shelf life is to be doubled within a range of 5 to 15%. It was reported that, there was a negative logarithmic relation between moisture content and longevity [6]. The present experimental, results were in conformity with the above rule. We noticed a sharp fall in all seed quality attributes (germination percent, seedling length, seedling dry weight and vigour indices) at 10% MC, while seed viability was not affected in the other seed moisture regimes (7.5 and 5%) even after 15 months of storage.

However, there was no significant difference in germination with respect to moisture regimes (7.5% and 5%) indicating the fact that both are equally good. Other

significant finding of this study was both senna and muskdana can with stand low moisture contents up to 5%. It has been observed that seeds from 25 accessions of Brassicaceae family, which were preserved at temperatures between 5°C and 10°C in flame sealed vials containing dehydrated (blue) silica gel with seed moisture content ranged between 0.3 and 3% maintained high germination percent (91-100) even after 38-40 years of storage [7].

The most interesting aspect was that even the accessions remained at room temperature also showed germination percentages that were similar to those preserved in the cold room. This result suggests that temperature might not be as important as expected at least for medium-term preservation and supports the possibility of using ultra-dry methods as substitute for cold storage. Study where storability of acid scarified seed was compared with control (un-scarified) have shown that the abnormal seedlings and dead seeds had increased significantly during observation period (3, 6, 9, 12 & 15 months), which clearly established the fact that it is a futile exercise to store scarified seed in senna. Similar findings were observed earlier [8].

CONCLUSION

The seeds of senna as well as muskdana can be effectively stored at 7.5 % seed moisture content under ambient conditions. Moreover, senna and muskdana can with stand low moisture contents even up to 5% during storage. The results of the storage of acid scarified seed in senna indicated seed coat plays a significant role in retaining seed viability. As scarified seed deteriorated rapidly, it is suggested that making seed coat permeable to water/gases reduce the life span of seeds and hard seed coat plays an important role in retaining seed viability for a longer period of time.

Table 3b: Effect of targeted moisture contents on seedling length, seedling dry weight and vigour indices in muskdana during storage

TMC	Seedling Length(cm)										Seedling dry weight(mg)									
	(Months of storage)										(Months of storage)									
	OM	3M	6M	9M	12M	15M	MEAN	TMC	OM	3M	6M	9M	12M	15M	MEAN					
10%	11.8	11.99	11.63	11.4	11.24	11.54	11.6	10%	96	97	95	91	88	86	92.1					
7.50%	12.01	11.71	11.59	11.33	11.29	11.72	11.61	7.50%	96	95	94	91	90	86	92.1					
5%	11.88	11.7	11.62	11.45	11.6	11.36	11.6	5%	95	95	92	90	89	88	91.6					
MEAN	11.9	11.8	11.61	11.39	11.38	11.54	MEAN	95.9	95.8	93.7	90.6	89	86.7							
CD	M	0.28					CD	M	3.21											
	T	N.S.						T	N.S.											
	M*T	N.S.						M*T	N.S.											
Vigour Index I																				
Vigour Index II																				
TMC	OM	3M	6M	9M	12M	15M	MEAN	TMC	OM	3M	6M	9M	12M	15M	MEAN					
10%	1062	1051	989	961	911	931	984	10%	8665	8479	8082	7646	7156	6909	7823					
7.50%	1089	1058	1031	986	982	1008	1026	7.50%	8701	8613	8363	7944	7800	7425	8141					
5%	1074	1053	1042	1023	1033	993	1036	5%	8602	8579	8251	8011	7920	7686	8175					
MEAN	1075	1054	1021	990	975	977	MEAN	8656	8557	8232	7867	7626	7340							
CD	M	33					CD	M	297											
	T	23						T	210											
	M*T	N.S.						M*T	N.S.											

Note: M=Months; TMC= Targeted moisture content

REFERENCES

1. ROBERTS EH (1973a). Predicting the storage life of seeds. *Seed Sci Technol* **1**: 499-514.
2. ROBERTS EH (1972). Storage environment and the control of viability. **In:** Viability of seeds (Roberts, E.H. ed. London, UK: Chapman and Hall.): 14-58.
3. ROBERTS EH (1973b). Loss of seed viability: chromosomal and genetic aspects. *Seed Sci Technol* **1**: 515-27.
4. ELLIS RH, HONG TD AND ROBERTS EH (1990a). An intermediate category of seed storage behaviour? I. Coffee. *J Exptl Bot* **41**:1167-74.
5. SUN WQ (2002). Methods for the study of water relations under desiccation stress. **In:** Desiccation and survival in plants drying without dying (eds.). M. Black, H.W. Prichard, CABI: 48-91.
6. ELLIS RH, HONG TD AND ROBERTS EH (1990c). Moisture content and the longevity of seeds of *Phaseolus vulgaris*. *L. Ann Bot* **66**: 341-8.
7. PEREZ GARCIA, GONZALEZ BENITO F AND GOMEZ CAMPO C (2007). High viability recorded in ultra-dry seeds of 37 species of *Brassicaceae* after almost 40 years of storage. *Seed Sci Technol* **35**: 143-53.
8. OMOKANYE AT, ONIFADE OS AND AMODU JT (1995). Effect of post scarification storage period on seed germination of *Leucaena leucocephala* Lam. De. Wit. *Seed Res* **23**(2): 88-90.