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SEED DETERIORATION DURING STORAGE AND INDUCTION OF SECONDRY DORMANCY IN GRAIN SORGHUM

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Seeds reach physiological maturity several days and often several weeks before their actual harvest. Then another lengthy period involving threshing, cleaning and transportation may elapse before proper storage. Seed quality loss at both pre– and post– havest stages may be high if seeds remain exposed to high humidity in association with elevated temperatures. And if these conditions prevail, seed deterioration continues throughout storage till a seed mass with very low planting value is left for sowing.

Sorghum cultivars were found to differ in their resistance to storage losses (AKIL and QUEIROZ, 1), and in general, seeds with greater vigor stored better. DELOUCHE ([4]) summarized that seeds with superior quality, less mechanical bruises and low preharvest deterioration, would show better storability. For predicting the storage potential of a seed lot, methods like Accelerated Ageing Test and Glutamic Acid Decarboxilase Activity (GADA) Test are getting in common use.

Seed dormancy is another possible asset which could prolong storage capacity. Seed quality losses are minimal as long as seed is in a dormant state. But many cultivated crop seeds do not carry dormancy and not much work has been done to use this characteristic for conservation of germplasm. ROBERTS ([8]) discusses the importance of enforced and induced dormancy for preservation of weed seeds deep in the soil. Evidently induced dormancy can be employed to enhance the storage quality of crop seeds. In the previous study (AKIL and QUEIROZ, 1), it was indicated that under conditions of low humidity and high temperatures, sorghum seeds probably enter into a state of dormancy.

The purpose of this paper was to further understand the presence of secondary dormancy in sorghum seed and to study extent of deterioration at various storage conditions.

MATERIALS AND METHODS

Twelve grain sorghum (SORGHUM BICOLOR (L) MOENCH) cultivars were planted at Jaguaribe, Ceará, Brazil on February 17, 1978 under dryland conditions. Plants were spaced at 0.20 m with row to row distance of 0.75 m. Four re-

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plications were used in a completely randomized block design. No fertilizer was applied and panicles were harvested on June 22, 1978, and dried in shade for 15 days before mechanical threshing. Seeds were cleaned, passed through sieves to obtain medium uniform size and stored in a cold room until used.

Germination and Speed Index

Two hundred seeds were placed in a 15 cm petri dish over a single filter paper moistened with 8 ml of water. Two replications were used and seeds were incubated at 25°C in the dark. First, second, and last germination counts were taken after 48, 72, and 120 hours of incubation, respectively. Seedlings with a minimum of 0.5 cm long healthy radicles were considered normal. Speed indices of 3, 2, and 1 were assigned, respectively, to individual seeds germinating at first, second, and last counts. Average of the two replications was reported.

Storage at Different Humidity Levels

Different humidity levels were created in large glass bottles with sealed caps according to VILLIERS and EDGCUMBE (10). Sulfuric acid dilutions giving specific gravities of 1.84, 1.425, 1.34, 1.25, 1.225, and 1.14 were used to acheive and maintain relative humidities of 0, 30, 50, 70, 75, and 90%, respectively. Seeds were placed in the bottles avoiding contact with acid solutions and still in easy access to bottle atmosphere. After storage at desired temperature and duration, the seeds were takem out and germinated as described earlier.

Cold Test

Seeds used in the cold test were first stored at 32°C and different relative humidities for a period of 30 days. One hundred and fifty seeds were placed in a large petri dish covered with 2 cm thick layer of fine-grained sand, and saturated with water up to 60% capacity. The petri dishes were first placed at 5°C for 48 hours, then incubated at 25°C for 96 hours. Emergence rate was noted. Emergence rate was also determined for the seed at optimum moisture level and without cold treatment.

Desiccation and Rehydration Treatment

Seeds of four cultivars were subjected to rapid desiccation in an atmosphere of 41°C and 0% relative humidity. After 12 days' treatment, moisture loss as well as germination percentage of the seed were calculated. At the same time some time some desiccated seeds were exposed to an atmosphere of 70% humidity for a period of one week to allow seeds to regain moisture. Germination of rehydrated seeds was compared with that of very low moisture seeds.

Water imbibition rates of these dry and rehydrated seeds were also observed for first eight hours by placing the seeds in excess of water.

RESULTS AND DISCUSSION

Seed of the 12 sorghum cultivars was tested for germination within one month after harvest. Germination was high and ranged between 65.5 and 96.5% (Table I). Cultivars EA– 3, EA– 206, EA–955 and EA– 145 were superior in germination to EA– 86, EA– 180, EA– 121 and EA– 171. AKIL *et al* (2) have observed a similar trend in germination behaviour of these cultivars harvested from different locations. Germination, therefore, appears to be pretty much a varietal character.

Seeds of these 12 cultivars were stored at 75 and 0% relative humidities for 45 days, testing germination at fortnightly intervals. At the upper humidity level, decline in germination was obvious for the four inferior cultivars i.e. EA–86, EA– 180, EA– EA– 121 and EA– 171 (Table I). This humidity level

TABLE

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Percentage Germination of different grain sorghum cultivars as affected by seed storage at different temperature and humidity levels

Cultivar	Initial germination July 15,78	75% humidity 32° C			0% humidity & 5° C*			0% humidity & 32° C		
		15–days	30–days	45–days	15–days	30–days	45–days	15–days	30–days	45–days
EA– 86	77.5	72.0	53.5	45.0	67.5	67.0	63.0	47.5	45.5	38.0
EA– 180	78.0	68.0	54.5	38.5	61.0	51.0	57.0	38.5	28.5	22.5
EA– 121	73.5	77.5	48.5	34.0	72.5	64.5	74.0	64.0	41.5	35.5
EA– 171	65.5	66.0	45.0	31.0	57.5	46.5	48.5	42.0	23.0	29.5
EA– 7	88.0	93.0	88.0	68.0	88.0	77.5	85.5	60.5	37.5	50.5
EA– 3	96.5	95.0	90.0	87.5	92.0	86.5	91.0	86.5	71.0	68.0
EA– 955	92.5	98.5	95.5	82.5	93.0	93.0	94.5	62.0	51.5	52.5
EA– 91	85.0	91.5	87.5	74.5	74.5	53.0	52.5	30.0	16.0	12.0
EA– 206	95.0	95.5	88.5	75.5	90.0	93.5	89.0	81.5	75.5	64.0
EA– 40	91.5	97.5	92.5	76.5	93.0	84.5	88.0	54.0	47.0	44.5
EA– 201	90.5	94.5	95.0	79.5	89.5	86.0	85.0	75.0	46.0	45.5
EA– 145	93.0	90.0	90.5	78.0	91.0	89.5	85.5	85.5	77.5	75.5

* Approximate temperature in the refrigerator.

is normally too high for safe storage of any seed. The decline in germination became negligible when seeds were stored at 0% humidity in the refrigerator. Seeds originally had moisture roughly between 10 and 11.5% and when stored at 0% humidity, they were losing moisture. When teh storage temperature was raised to 32°C, the decline in germination became conspicuous in all cultivars. The cause of such decline in germination appears to be associated with rate of drying. Humidity being zero, it was at 32°C, that seeds dried faster. In a previus study AKIL and QUEIROZ ([1]) attributed this quick fall in germination to incuction of secondary dormancy. VILLIERS and EDGCUMBE ([10]) observed loss of viability in lettuce seed at too low humidity levels. Probable reason for this was considered to be accumulating damage to macromolecules because of inability of repair and turnover systems to operate in tissues with low water content.

The fall in germination at low humidity and high temperature was more pronounced when germination velocity of the seed was observed (Table II). There was some retardation in germination speed even at 5° C. This clearcut decrease in both germination and speed of germination could be due to damage to the internal mechanisms in the seed, and hence a permanent loss of germination and vigor. Or it could be due to induction of secondary dormancy, a more likely phenomenon. It may be noteworthy here that BASS and STANWOOD ([3]) stored sorghum seed for 15 years and found that at low seed moisture of 4%, very little deterioration occured even when the temperature was as high as 32°C.

To understand seed deterioration and phenomenon of dormancy, seeds of six cultivars were stored at 32°C but different humidity levels. As expected, deterioration rate was high at 90% humidity (Table III). At 70%, however, there was neither loss in germination percentage nor in speed of germination during this short storage. At lower humidity levels of 50 and 30%, decline in germination was obvious at least in inferior cultivars. Germination speed was lower in all cultivars stored at 30% humidity. Hence the decline in germination at lower humidities was also apparent from this experiment. However, humidity of 0% was required to creat pronounced effect during this short period of storage.

Keeping humidity at 0%, storage temperature was raised to 41°C. Both germination and speed of germination

TABLE II

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Speed index of different grain sorghum cultivars as affected by seed storage at different temperature and humidity levels

Cultivar	Initial Speed Index July 15, 78	75% humidity & 32° C			0% humidity & 5° C*			0% humidity & 32° C		
		15–days	30–days	45–days	15–days	30–days	45–days	15–days	30–days	45–days
EA– 86	188	179	116	96	151	133	110	74	58	48
EA– 180	194	168	129	81	102	63	61	45	34	23
EA– 121	190	192	113	63	160	121	132	117	53	38
EA– 171	167	160	91	66	102	77	70	63	28	32
EA– 7	240	264	231	161	232	188	157	103	48	64
EA– 3	279	273	231	212	244	201	184	167	97n	91
EA– 955	262	270	241	187	238	226	173	144	74	71
EA– 91	199	217	191	150	143	81	65	40	20	12
EA– 206	276	267	227	179	218	217	174	147	113	85
EA– 40	234	258	229	169	247	197	194	99	65	55
EA– 201	249	257	211	165	220	184	151	120	60	55
EA– 145	266	250	237	197	227	210	187	182	140	127

* Approximate temperature in the refrigerator.

TABLE III

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Germination percentage and speed index of six grain sorghum cultivars as affected by varying storage condi

Cultivar	Initial Aug. 9, 78	% Germination; 90 % humidity			70% humidity			50% humidity			30% humidity		
		30–days	45–days	60–days	30–days	45–days	60–days	30–days	45–days	60–days	30–days	45–days	60–days
EA– 180	58	16	5	1	71	59	50	63	39	60	57	51	47
EA– 171	64	7	2	0	56	44	65	65	53	52	45	46	43
EA– 7	87	31	17	14	86	88	85	88	88	73	83	78	71
EA– 3	99	78	47	23	97	95	97	91	99	88	97	94	90
EA– 955	90	64	27	32	96	96	87	93	91	89	93	90	87
EA– 206	97	76	35	21	97	95	94	95	89	92	94	94	86
		SPEED INDEX											
EA– 180	141	35	8	2	174	140	129	146	78	131	120	103	91
EA EA– 171	156	14	4	0	126	96	151	147	87	113	79	86	90
EA– 7	230	63	33	25	237	215	245	212	209	201	200	210	181
EA– 3	290	184	86	30	283	253	273	261	251	256	267	240	223
EA– 955	252	164	65	47	266	215	248	252	196	241	245	214	202
EA– 206	283	169	66	32	261	263	270	266	212	246	242	239	200

were drastically reduced (Table IV). In this environment, rapid desiccation took place. The moisture loss within 12 days was in the range of 8.53 to 9.36% leaving seeds nearly oven dry. These dry seeds when stored at 70% humidity for a week, regained moisture as well as original level of germination. Thus loss in germination due to rapid drying was not permanent. ROBERTS ([8]) quoted VEGIS (1963) who suggested that high temperature and a limited oxygen supply were often the most important factors for inducing the secondary dormancy. He also differentiated between induced and enforced dormancy. Here sorghum under study seems to represent a type of enforced dormancy, present as long as seed moisture stays below a certain level or it may be dependent on actual rate of drying. Contrary to this while working with dormant cultivars of sorghum CRITTON and ATHINS ([6]) found that lower temperatures prolonged dormant

TABLE IV

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Effect af desiccation and rehydration of sorghum seed on its germination

Cultivar	% moist. loss with desiccation	Desiccated seeds		Rehydrated seeds	
		% germ.	Speed index	% germ.	Speed index
EA– 955	8.53	79	120	93	255
EA– 91	8.69	40	49	91	188
EA– 40	9.14	70	105	92	253
EA– 201	9.36	76	100	96	242

*Seeds were desiccated by storing at 0% humidity and 41°C for 12 days and rehydrated by transfering to 70% humidity for one week.

state of the seed. VIEIRA (9) worked with dormant strains of rice and also found that seeds lost dormancy faster at higher temperatures and drying or dehyration was not a major factor in dormancy release. There may be a possibility of using secondary dormancy in the service of preservation of sorghum germplasm over a prolonged storage.

After 30 days storage at various humidities, sorghum seeds were subjected to cold test of vigor. The fact that 90% humidity was deteriorative even during 30 days of experimental storage, was evident from low vigor ratings of all the six cultivars (Table V). Using seeds from 70, 50 or 30% humidity environment, similar vigor ratings were obtained indicating storage at 30% humidity was not detrimental compared to storage at 70% humidity. Thus decline in germination and speed of germination observed at 30% or lower humidities was not due to actual quality deterioration proving indirectly, the presence of secondary dormancy.

To study if rapid drying of the seed had any effect on seed coat permeability, both desiccated and rehydrated seeds were soaked in excess of water for eight hours and rate of imbibition was studied at two hourly intervals. No seed coat permeability differences were observed, hence the secondary dormancy in sorghum was due to modification of some other mechanism in the seed. Imbibition rate of some sorghum cultivars was reported in an earlier study (1).

Primary dormancy in sorghum is present in some cultivars and according to GRITTON and ATKINS (6) does not persist beyond 90 days after harvest. It has been attributed to the presence of inhibitory substances in the seed coat (GOODSELL), (5) and tannin content (HARRIS and BURNS) (7). The information about secondary dormancy in sorghum seed is lacking. With rapid drying and at high temperatures, some inhibitory substances may develop int he seed, arresting its germination metabolism. Further work is needed to understand dormancy situation in sorghum, which may be very useful for preservation of seed quality over a prolonged storage. Under local hot and intermittent dry conditions, seed storage through induction of secondary dormancy may be practical and more economical.

TABLE V

ESTADO DO CEARÁ
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Cold test emergence of the sorghum seed stored at different humidity levels

Cultivar	% Control emergence *	Cold test emergence (%) using seed from 90% humidity	70% humidity	50% humidity	30% humidity
EA– 180	47.3	8.0	42.7	42.0	36.0
EA– 171	53.3	10.0	43.0	44.0	40.0
EA– 7	88.7	20.0	80.7	73.3	94.6
EA– 3	91.3	59.3	81.3	88.7	87.3
EA– 955	86.7	49.3	88.0	93.3	84.7
EA– 206	84.7	46.0	78.7	82.0	86.0

* Emergence was determined in sand at optimum temperature and moisture using seed stored in the refrigerator.

SUMÁRIO

Sementes de Sorgo Granífero (SORGHUM BICOLOR (L.) MOENCH) foram armazenadas em diferentes condições de umidade relativa durante 2 meses. Houve um declínio na germinação quando a umidade relativa estava acima de 70% ou abaixo de 30%. Os processos deteriorativos operaram em alta umidade relativa, resultando numa perda permanente da viabilidade e do vigor. Nas condições de baixa umidade relativa a queda na germinação foi temporária e reversível. Algum tipo de dormência secundária foi induzido quando as sementes foram submetidas às condições de dissecação em baixa umidade. O grau de dormência foi diretamente proporcional à taxa de dissecação. Quando as condições de armazenamento foram 0% de umidade e 41°C, as sementes exibiram uma drástica redução na germinação. Esta dormência forçada não estava relacionada com as mudanças na permeabilidade no tegumento de sementes.

SUMMARY

Grain sorghum (SORGHUM BICOLOR (L. MOENCH) seed was stored at various humidity levels upto two months. There was decline in germination at humidities above 70% as well as below 30%. Deteriorative processes were operative at high humidity resulting in a permanent loss of viability and vigor. At low humidity storage, the drop in germination was temporary and reversible. Some type of secondary dormancy was induced when seeds were subjected to desiccation at low humidities. The degree of dormancy was directly proportional to the rate of drying. At 0% humidity and 41°C, seeds exhibited drastic reduction in germination. This enforced dormancy was not related to changes in seed coat permeability.

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