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Effects of Time on Water Uptake and Germination Characteristics of Scarified and Non Scarified Castor bean (Ricinus communis L.) Seeds.

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Abstract- A study was conducted at the University of Agriculture, Makurdi, to determine water uptake at 6 and 12 hour intervals, and germination characteristics of scarified and non scarified seeds of castor bean accessions in 2008 and 2009. Two hundred seeds were selected from each accession: one hundred seeds were scarified mechanically by caruncle removal using knife (seed lot 1), one hundred seeds were not scarified (seed lot 2). Each seed lot was immersed in 10ml of distilled water contained in 9cm-diameter petridish. Thereafter, seed lots were weighed at every 6 h starting from 0 to 24 h, and at every 12 h up to 108 h. Water uptake in scarified and non scarified seeds was determined by seed mass increase, and expressed as percentage increase in mass of seeds. Germination test of two hundred seeds of each accession was done by planting seeds 2cm deep in moist sandy loam soil contained in plastic containers to determine germination characteristics .Results showed that the weight and percentage weight increase of seeds at 6 and 12 hour intervals were significantly higher in scarified seeds than in non scarified seeds. Scarified seeds attained maximum saturation at 60 h and non scarified seeds at 84 h. Scarified and non scarified seeds differed significantly in water uptake and germination characteristics at 6 and 12 hour intervals, being higher in scarified seeds. Mechanical scarification improved water uptake, germination characteristics and the planting value of seeds.

Index Terms- water uptake, germination characteristics, scarified seeds, non Scarified seeds, castor bean.

I. INTRODUCTION

Castor bean *(Ricinus communins* L.*)* is an industrial crop grown for its economic seeds exploited mainly for producing oil (Onwueme and Sinha, 2001), for the manufacture of cosmetics, plastics, resins, dyes, paints, soaps, disinfectants ,lubricants, greases, hydraulic fluids, inks etc. One major limitation to its large scale production has been poor water uptake due to partial impermeability of the seed coat, manifested in slow, erratic and low germination of freshly harvested seeds. The problem of poor water uptake and germination in castor bean require systematic studies to ensure better germination characteristics and to improve the planting value of seed.

The seed testa and caruncle are reported to be the major cause of poor water uptake and germination in castor bean seeds (Lago et al., 2003). Several methods/techniques to break seed dormancy have been developed over the years depending on the seed type(Li,2000).Dormancy-breaking treatments for castor bean according to Baskin and Baskin(2000b)include:1-seeds soaked in hot water and allowed to cool at room temperature for 24h;2-mechanical scarification;3-mechanical scarification +soaking in cold water for 24h;4-seeds soaked in 15% of potassium nitrate for 24-48h;5-seeds soaked in gibberellic acid at 500-1000mg/L for 24h;6-seeds soaked in cytokinins at 100-200mg/L for 24h;7-high pressure treatments;8-ethylene bubbled into seeds for 12-24h etc . Removal of the caruncle from seeds improves water uptake and can increase the proportion of seeds germinating (Baskin and Baskin, 2005); it can also reduce fungal and bacteria growth during germination tests (Williams and Kittock, 2000).

Water uptake initiates the activation and synthesis of enzymes which function in the breakdown of storage material into simpler compounds such as sugars, which are utilized by the embryo for germination (Carneiro, 2004). According to Carneiro (2004), tropical seeds with hard seed coats have delayed and non uniform germination, causing 40% loss of genetic resources. Although the seed germination biology of many plant species has been investigated (Nikolaeva and Rasumova, 1985), however, there is paucity of information concerning water uptake and germination characteristics of castor bean seed. The objective of this study, therefore, was to determine water uptake and germination characteristics of scarified and non scarified castor bean seeds, aimed at improving the planting value of castor bean seed and at providing basic scientific knowledge.

II. MATERIALS AND METHODS

Three castor bean seeds were sown per hill on the ridge and spaced 90cmx50cm with a population density of 22,222 plants per hectare. Thinning to one seedling per stand was done three weeks after sowing(WAS).The experiment was laid out in Randomized Complete Block Design with three replications. The gross plot size was 8m x 10m ($80m^2$) with net plot size of $7.2m^2$. The plots were weeded manually twice, before and after flowering at 30 and 60 days intervals respectively. Basal application of NPK fertilizer (15:15:15) at the rate of 100kg/ha was done at 40 days after sowing. The plants were sprayed fortnightly with Vetox 85 insecticide at the rate of 1.1kg chemical per 225 litres of water starting from 9WAS to minimize insect damage by weevils, leaf rollers, grass hoppers and aphids. The plants were harvested at physiological maturity(28WAS) for water uptake and germination experiments.

Scarified and non scarified seeds of four castor bean accessions (LAF-4, LAF-11, AKW-5, AKW-7) were used as treatments. The water uptake experiment was laid out in Completely Randomized Design with three replications. Two hundred seeds were selected from each accession: 100 seeds were not scarified (seed lot 1), 100 seeds were scarified (seed lot 2). Scarification was done mechanically with knife by removal of caruncle and seed coat at caruncle. Each seed lot was immersed in 10ml of distilled water contained in 9cm-diameter Petri dish. The seeds were 7% moisture content before immersion. The seed lots were weighed at every 6 h starting from 0 to 24 h and thereafter, at every 12h up to 108 h. Water uptake in scarified and non scarified seeds was determined by seed mass increase.

Data recorded were calculated according to Brasil (1992) and expressed as percentage increase in mass of seeds as follows:

$\% Ws = [(Wi - Wd)/Wd] \times 100$
Ws = increase in mass of seeds.
Wi = mass of seeds after a given interval of water uptake
Wd = seed mass at t_o.

Two hundred non scarified seeds (seed lot 3) and two hundred scarified seeds (seed lot 4) from each castor bean accession were used to determine germination characteristics at 6 and 12 hour intervals of water uptake. The experiment was laid out in Completely Randomized Design with 3 replications. In-sand method of seed germination was adopted. The seed lots were planted 2cm deep in a uniform layer of moist sandy loam soil placed in plastic containers. Data were recorded ten (10) days after planting on: number of germinated seeds, length of radicle and plumule, percentage germination and germination speed index .

Data collected were analysed statistically using the Analysis of Variance Procedure described by Singh and Chaudhary,1979;Steel and Torrie,1980.Treatment effects were compared by the Fisher's Least Significant Difference (F-LSD) Procedure (Little and Hill,1979).The degree of precision of the experiments was estimated using coefficient of variability(Singh and Chaudhary,1979).GENSTAT Release,Version 2009 was used for analysis.

III. RESULTS

Results on weight and percentage weight increase of non scarified and scarified castor bean seeds due to water uptake at 6 and 12 hour intervals are presented in Table 1. Time of water uptake exhibited significant difference in weight and percentage weight increase of non scarified and scarified seeds. Water uptake at 6 hour intervals showed a steady increase in weight and percentage weight increase of seeds up to 24 h. At 12 hour intervals, the increase in weight and percentage weight of non scarified seeds was maximum at 84 h while it was maximum at 60 h for scarified seeds. Maximum imbibition or saturation point was attained at 84 h for non scarified seeds, and at 60 h for scarified seeds. The weight and percentage weight increase of seeds due to water uptake at 6 and 12 hour intervals was significantly higher in scarified seeds than in non scarified seeds.

The interactions between seed weight of castor bean accessions and time of water uptake at 6 and 12 hour intervals was significant (Table 2). At 6 hour interval, the interaction of 24 h and scarified seeds of LAF-11 and AKW-7 (17.70g and 17.10g respectively) produced significantly higher seed weights compared to other seed weight and time of water uptake interactions. At 12 hour intervals, 84 h and scarified seed weight of LAF-11 interaction (23.00g) was also significantly higher than other interactions.

Results on germination characteristics of non scarified and scarified castor bean seeds are summarized in Table 3. Scarified seeds were significantly higher in number of germinated seeds, percentage germination, length of radicle and plumule, and germination speed index (GSI), compared to non scarified seeds . Although, AKW-7 had tendency to produce longer radicle and plumule .

Table 4 shows effects of time of water uptake on germination characteristics of non scarified and scarified seeds of castor bean at 6 and 12 hour intervals.

Time of water uptake exhibited significant difference on germination characteristics of non scarified and scarified castor bean seeds. Germination characteristics were significantly higher in scarified than in non scarified seeds. There was an abrupt decline in values of germination characteristics(0.00) at 60h of water uptake till 84 h in scarified seeds.

IV. DISCUSSION

The increase in weight of scarified castor bean seeds at 6 and 12 hour intervals may be attributed to mechanical scarification of the seed coat and to proportional increase in the quantity of water uptake per unit time. The weight increase of non scarified seeds was low and negligible compared to that of scarified seeds indicating partial seed coat impermeability to water (Table 1). Water uptake of non scarified castor bean seeds was low leading to poor (low) germination characteristics while water uptake of scarified castor bean seeds produced better (higher) germination characteristics. Eira et al (1993) observed that water soaking of seeds of *Enterolobium contortisiliquum* for 24 hours was not effective to overcome seed dormancy. Toogood (1993) reported that mechanical scarification followed by water soaking were required for seeds of Goldenrain tree (Keelreuteria paniculata) to germinate. Mechanical scarification was also found to break dormancy of Redbud (Vercis california) seeds.

Maximum water uptake (saturation point) was attained earlier in scarified seeds (at 60 h after soaking), and later in non scarified seeds (at 84 h after soaking) due to partial seed coat impermeability to water.

The germination characteristics of scarified castor bean seeds in Table 3 recorded higher values and differed significantly from that of non scarified castor bean seeds, which could be attributed to mechanical scarification of the seed coat, increased water uptake and enzyme activation, and rapid breakdown of storage materials, which initiated early emergence of radicle and plumule. Number of germinated seeds, length of radicle, length of plumule, germination percentage and germination speed index were negligible in non scarified castor bean seeds than in scarified seeds (Table 3) indicating mechanical restraint by the coat of non scarified seeds.

Mechanical scarification of the seed coat is often used to overcome mechanical barrier in seeds with hard coat (Baskin and Baskin, 1998).

Table 4 shows that the state of germination characteristics is proportional to the quantity of water uptake per time interval and the magnitude of enzyme activation. Thus, the lower the water uptake, the lower the values of germination characteristics and enzyme activation.

V. CONCLUSION

Based on results of this study, it could be concluded that mechanical scarification of the castor bean seed coat facilitated water uptake, triggered rapid enzyme activation, produced better germination characteristics and improved the planting value of castor bean seed.

Table 1. Weight and Percentage Weight Increase of Non Scarified and Scarified Castor bean Seeds due to Water Uptake at 6 and 12 Hour Intervals in 2008 and 2009 (Combined Data).

6 hour intervals

time (Hours)	non scarified seeds weight (g)	weight increase (%)	scarified seeds weight (g)	weight increase (%)
0	10.60	0.00	10.50	0.00
6	12.10	14.15	13.30	26.67
12	12.60	18.86	14.30	36.19
18	13.00	22.64	15.40	46.67
24	13.30	25.47	16.40	56.19
lsd (0.05)	**0.051**	**0.051**	**0.011**	**0.011**
cv (%)	**3.6**	**3.6**	**1.1**	**1.1**

12 hour intervals

36	14.10	33.02	18.50	76.19
48	14.60	37.73	20.50	95.24
60	15.20	43.39	21.10	100.95
72	15.70	48.11	21.10	100.95
84	16.00	50.94	21.10	100.95
96	16.00	50.94	21.10	100.95
108	16.00	50.94	21.10	100.95
lsd (0.05)	**0.019**	**0.019**	**0.047**	**0.047**
cv (%)	**1.5**	**1.5**	**2.9**	**2.9**

Table 2. Interaction between Seed Weight of Castor bean Accessions and Time of Water Uptake in 2008 and 2009 (Combined Data).

6 hour intervals

Time (hours)	Castor Accession LAF-4		LAF-11		AKW-5		AKW-7	
	NSC	SC	NSC	SC	NSC	SC	NSC	SC
0	10.00	10.00	11.00	11.50	10.60	10.60	11.00	11.00
6	10.80	12.50	13.50	14.40	12.10	13.30	12.70	13.90
12	11.10	13.40	13.80	15.50	12.70	14.40	13.20	15.00
18	11.60	14.60	14.10	16.50	13.00	15.40	13.50	16.00
24	12.20	15.70	14.50	17.70	13.30	16.50	13.80	17.10
LSD (0.05)			**0.04**					
CV (%)			**2.69**					

12 hour intervals

36	13.50	17.60	15.10	19.90	1.37	18.60	14.70	19.20
48	14.10	19.50	15.70	22.00	1.45	20.60	15.30	21.40
60	14.70	20.20	16.30	23.00	1.51	21.30	15.90	22.20
72	15.20	20.20	16.80	23.00	1.54	21.30	16.40	22.20
84	15.60	20.20	17.30	23.00	1.57	21.30	16.90	22.20
96	15.60	20.20	17.30	23.00	1.57	21.30	16.90	22.20
108	15.60	20.20	17.30	23.00	1.57	21.30	16.90	22.20
LSD (0.05)			**0.02**					
CV (%)			**0.66**					

Key
NSC = non scarified
NC = scarified

Table 3. Germination Characteristics of Non Scarified and Scarified Seeds of Castor Beans Accession in 2008 and 2009 (Combined Data).

Germination Characteristics	LAF-4		LAF-11		AKW- 5		AKW-7	
	NS	SC	NS	SC	NS	SC	NS	SC
Number of Germinated seeds	65.00	200.00	65.60	177.8	67.00	188.40	65.40	188.20
Percentage Germination	32.50	100.00	32.80	88.90	35.50	94.20	32.70	94.10
Length of radicle(cm)	3.61	7.87	3.60	7.79	3.59	7.80	3.62	7.88
Length of Plumule(cm)	3.17	6.37	3.16	6.36	3.15	6.35	3.18	6.38
Germination Speed index	25.00	35.17	25.00	35.14	25.00	35.16	25.00	35.18

LSD (0.05)	2.31	1.70	1.90	1.89

Key
NSC = non scarified
NC = scarified

Table 4. Effects of Time of Water Uptake on Germination Characteristics of non Scarified and Scarified Seeds of Castor bean at 6 and 12 hour intervals in 2008 and 2009 (Combined Data).

6 – hour intervals

Water uptake Germination (hours)	Number of germinated seeds at day 10		Length of radicle (cm)		Length of plumule (cm)		Germination speed index	
(%)	NS	SC	NS	SC	NS	SC	NS	SC
NS SC								
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00 0.00								
6	64.60	188.40	3.43	7.90	3.18	6.39	13.23	33.61
32.30 94.20								
12	64.80	189.00	3.45	7.93	3.19	6.42	13.27	33.64
32.40 94.50								
18	65.20	189.60	3.48	7.96	3.21	6.45	13.33	33.69
32.60 94.80								
24	65.60	200.00	3.53	8.34	3.23	7.00	13.35	35.00
32.80 100.00								
LSD(0.05)	0.32		0.84		0.82		4.44	
0.32								

12 hour interval

36	66.00	191.40	3.61	8.40	3.27	6.34	13.40	35.00
33.00 95.70								
48	66.60	192.40	3.65	8.50	3.30	6.37	13.45	35.45
33.30 96.20								
60	67.00	0.00	3.68	0.00	3.33	0.00	13.55	0.00
33.50 0.00								
72	68.00	0.00	3.70	0.00	3.37	0.00	13.60	0.00
34.00 0.00								
84	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00 0.00								
LSD (0.05)	0.31		0.83		0.82		4.41	
0.32								

Key:
NS = Non scarified seeds
SC = Scarified seeds

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