Studies on Variability in Seed Longevity of Castor *(Ricinus communis* L.) in Relation to Seed Morphological Characters

Anjula Pandey and J Radhamani
National Bureau of Plant Genetic Resources, Pusa Campus, New Delhi-110 012

The castor seeds under the present investigation showed wide variation in the seed morphological characteristics *viz.*, seed size, length and breadth ratio, caruncle size, mottling, colour and thickness of the seed coat and seed surface. Presence of caruncle did not show any additive effect on seed germination. Based on the size, the seeds were classified into three categories viz. small, medium and bold. Different sized seeds showed significant differences in their seed viability and vigour pattern during storage. The desiccated seeds of medium size at 4.0 % moisture on fresh weight basis showed maximum survival of 65- 70 percent after storage of five years at ambient temperature.

Key words: Castor, *Ricinus communis* L, Variability, Storage behaviour, Seed morphological characters, Oilseed

Ex-situ seed storage is a complementary strategy for preserving crop genetic resources. Seeds can remain viable for extended periods if kept under low temperature and moisture conditions. However, experiments using a number of different species have shown that longevity may be improved if seeds are dried to less than the recommended value with altered storage conditions (Ellis *et al.*, 1990, 1995), Castor *(Ricinus communis* L.) is an important oilseed crop of India and is widely grown in tropical, sub-tropical and temperate parts of the world, it is extremely variable in habit, colour, amount of waxy bloom, flowering habit, inflorescence type, fruit and seed characters (Singh, 1976). The medium and small are the two groups to which most of the cultivated varieties of the Indian castor belong. There is a great range of variation in seed size (Kulkarni and Ramanamurthy, 1977) and oil contents (45-57 %). The large fruits usually contain big seeds and have low oil content. The seed viability also varies in different accessions, which decreased gradually during storage. However, the extent of loss in viability varies from crop to crop, and even amongst the accessions of the same crop, depending on the seed morphology and its composition.

In castor, the domestication trend is not well defined. Even today most of the seed is collected from wild population. The semi- wild plants with taller habit and few racemes are available very frequently in different areas of the country. Long-term human selections from wild types have tended towards an annual, dwarf, herbaceous, indehiscence and less spiny capsules with synchronized maturing (Singh, 1976; The Wealth of India, 1972). The only representative in this genus is probably originated as dump heap-camp following species has come up as an oilseed crop, a drug and an ornamental plant (Anderson, 1952). Besides its use in manufacture of lubricants, soaps and paints, the oil has great industrial and medicinal value (Watt, 1892, The Wealth of India, 1972).

The present investigation was undertaken to study the morphological variation in the castor seeds of different sizes and the impact of seed size on the their storage pattern.

Materials and Methods

Indigenous variability in castor was assembled from Himalayan region and Trans-gangetic plains. The diversity from these regions has been least represented in the Genebank collections of National Bureau of Plant Genetic Resources (NBPGR), New Delhi. The diversity collected represented wild and cultivated forms from diverse habitat as road side, riverside, garbage land, around farmers field and courtyard/backyard cultivation located in Western Himalaya (Himachal Pradesh, Jammu and Kashmir) and Trans-gangetic plains (Punjab and Haryana) (Duhoon *et al.*, 1996). The variability was recorded and data was analysed using Non-Hierarchical Euclidean Cluster Analysis.

Seed morphological diversity of 73 accessions was studied for seven seed morphological characters (hundred seed weight, length/breadth ratio (L/B ratio), caruncle size, seed mottling, seed coat colour, seed coat thickness and seed coat surface) in relation to storability under ambient conditions. All the accessions were tested for viability by germinating the seeds. The standard germination test was conducted by placing the seeds in replicates of 50 seeds each in between the moist rolled

paper towel (BP) and kept at 27 ± 2°C with 80-90 per cent relative humidity (RH) in the seed germinator. The moisture content was determined by low constant temperature oven method. The seeds were assessed from 10-15 days after plating for the germination when both radical and plumule emerged completely to form a seedling. The normal and the abnormal seedlings were also counted separately for calculating the viability percentage (ISTA, 1985). All the seeds meeting the Gene Bank Standards (> 80% viability) were selected and desiccated to low moisture levels (4 % on fresh weight basis). The seeds were made into three subsets and were hermetically sealed and stored at three different temperatures, *viz.*–20°C, +10°C and ambient temperature. The samples were monitored at regular intervals for viability. The seed viability pattern in the sub-samples stored at ambient temperature was correlated with the seed morphological characters to find out if any correlation existed. Two accessions representing each category were used for detailed investigations and all the experiments were carried in replications of three with block design and the results were analyzed by ANOVA.

Results and Discussion

Total seed collections (73 accessions) comprised of small seeded types, medium size and bold seeds (Fig. 1). The small seeded types were mainly collected from wild or abandoned, disturbed habitats and roadsides. The capsules were smaller with more spiny fruits and shattering type with narrow spikes. The medium seeded types were largely from the abandoned areas near human habitations, farmer's fields, representing semi-spreading habit and smooth spiny fruits but long spike. The bold seeded types on the other hand had non-spiny (smooth) fruits and compact large and showy spikes. They were mainly fetched from fence or borders of fields mainly under the rainfed conditions.

Enormous variability was observed in hundred seed weight (9.40- 63.30 g), length/ breadth ratio (0.04-1.82), caruncle size (1.95-4.90 mm), mottling (dull-whitish grey-darkly mottled), seed coat colour (light, medium, dark), seed coat thickness (thin, medium, thick), seed surface (shiny-dull). Using Non Hierarchical Euclidean Cluster Analysis they were grouped into ten clusters. Cluster I contained 5 genotypes; cluster II contained 6 genotypes; cluster III contained 8 genotypes; cluster IV contained 6 genotypes; cluster V contained 7 genotypes; cluster VI contained 10 genotypes ; cluster VII contained 7 genotypes; cluster VIII contained 9 genotypes; cluster IX contained 5 genotypes; and cluster X contained 10 genotypes. Inter-cluster distances were highest between cluster I and VIII (5.148), followed by cluster V and VIII (4.307) and cluster 1 and IX (4.172). Inter-cluster distance was lowest between cluster III and VII (2.299) followed by clusters II and IV (2.305) and X and VII (2.305).

Generally on an average the castor seeds weigh about 300g/100 seeds but the samples under the present investigation showed a wide range of variation starting from as low as 20 g/100 seeds to as high as 70g/100 seed weight. Seeds of medium size category weighed about 30-50 g/100 seeds. Based on their size and weight the seeds were mainly categorized as small, medium and bold.

The study conducted on the diversity of seed morphological characters showed the maximum representation of small sizes seed type (less than 30 g/ 100 seed) in clusters I, II III, V, VII and IX where the seeds had mixed mottling on seed coat, medium thick seed coat, with both dull and shiny type of seed surface. This category was followed by medium sized seeds represented in cluster IV, X seeds having seed weight 30-45 g/100 seeds of longer size, medium seed coat and wide variation in seed mottling, thickness of seed coat and surface. The third category comprised of bold seeded types represented by cluster VI and VIII with more than 45 g/ 100 seeds and big caruncle size and wide variation in seed coat characters. Amongst the 73 accessions taken for present investigation, 38 (52.5%) were of small size, 16 (21.9%) were of medium size and 19 (26.02%) were in the range of medium to big category (Table 1).

Within the clusters maximum variability was observed in cluster VI representing large-medium seeded types, longer-broader seed ratio, big caruncle, mix mottling, medium colour of seed coat, medium thickness

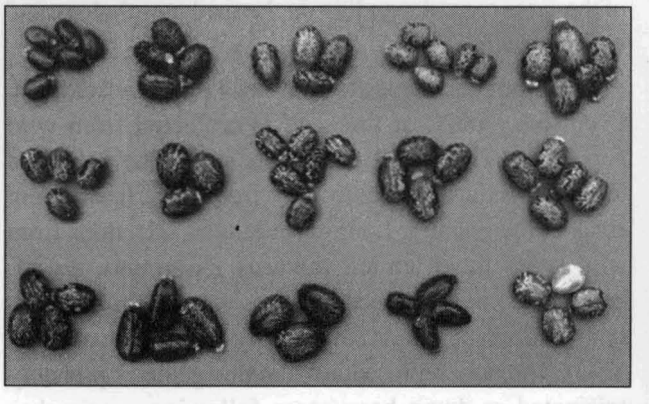

Plate I: Variability in castor seeds

and dull seed surface. This represented most heterogeneous group of accessions collected from Trans-Gangetic Plains of India.

Among the morphological characters positive correlation was observed in seed weight and mottling (0.452), mottling and seed coat (0.341), caruncle and L/B ratio; negative correlation was observed in seed characters, seed colour and seed surface (–0.423), mottling and seed surface (–0.348), seed coat thickness and 100 seed weight (–0.324) (Table 2). In the present investigation, the caruncle was well developed in most of the seeds irrespective of size. However, in bigger size seeds the shape of the caruncle varied from flat to a conical shape while in smaller seeds it was pointed-small and conical in shape (Table 1).

The seed length and breadth varied from 0.82-1.85 cms and 0.47-1.47 cms respectively. Similar trends in seed variability has been reported earlier (Anjani *et al.* 1993, Atsmon 1989, Duhoon *et al.* 1996). The seed structure plays a major role for classification of different *Ricinus* genotypes (Singh, 1954)

In the Indian types generally the caruncle is present. The absence of the caruncle was found to be due to mechanical damage. The seeds without caruncle did not show any significant difference in germination compared to the seeds with caruncle (data not shown). Therefore the role of the caruncle, which protrudes at the tapering side of the seed, might be in attracting insects (mostly ants), and helping in seed dispersal (Kulkarni and Ramanamurthy, 1977). The wild castor seeds with a small caruncle usually shatter and germinate in clusters directly beneath the mother plant.

Thus the diversity rich areas in India *viz.* Indo-gangetic plains which are the centres of botanical variability in castor (Stuhlmann, 1909, Kulkarni and Ramanamurthy, 1977, Moshkin, 1986) needs to be fully explored for assemblage of additional genetic variability available in castor. Targeted explorations, characterization and utilization of genetic resources are required to develop this important crop to its full potential for the benefit of mankind.

Table 3 depicts the seed viability, vigour and oil content in three different categories of castor seeds. All category seeds differed significantly in their 100 seed weight but there was no significant difference in their oil content, which showed an average value of 45.7, 46.7 and 47.1 per cent in small, medium and bold seeds. The viability in all the accessions was found to be in the range of 88-98 per cent, whereas the bolder seeds recorded maximum viability compared to the small and medium size seeds. The viability was directly proportional to the vigour index. Higher the viability, more was the vigour index (Table 3).

Table 1. variation in seed morphological characters of castor

Cluster (no. of genotypes)	100 seed weight (g)	L/B ratio	Caruncle size (mm)	Seed mottling	Seed coat colour	Seed coat thickness	Seed surface
I(5)	Small	Broader	Small-medium	Light-mix	Light	Thick	Dull
II(6)	Small	Longer	Small	Light	Medium-dark	Medium	Shiny
III(8)	Small	Longer	Small	Light-mix	Dark	Medium-thick	Dull
IV(6)	Medium	Longer	Medium	Mix	Medium-Dark	Thin-medium	Dull
V(7)	Small	Longer	Big	Light	Medium	Thick	Dull
VI(10)	Bold	Longer-	Big	Mix	Medium	Medium	Dull
VII(7)	Small	Longer	Big	Mix	Medium	Medium-Thick	Shiny
VIII(9)	Bold	Longer	Big	Dark	Dark	Thick-Medium	Shiny
IX(5)	Small	Longer-Broader	Big	Mix-	Dark	Medium-thick	Shiny
X(10)	Medium	Longer	Big	Dark	Medium	Thick	Shiny

Table 2. Correlation matrix for seven seed morphological characters of castor

100 seed weight (g)	L/B ratio	Caruncle size (mm)	Seed mottling	Seed coat colour	Seed coat thickness	Seed surface
1.0000						
–0.0654	1 .0000					
–0.0597	0.3173	1.0000				
0.4517	0.0842	0.1510	1.0000			
0.0742	0.2537	0.0267	0.3405	1. 0000		
–0.3241	–0.1756	0.0836	–0.1063	–0.1651	1.0000	
0.0360	–O.S098	–0.1146	–0.3484	–0.4237	–0.0980	1.0000

Table 3. Characteristics and viability pattern in different sizes of castor seeds

Seed type	National Identity	100 Seed wt (g)	Oil content	Viability (%)	Vigour index
Small	IC240528	13.0	44.0	90	270
	IC240536	15.0	45.0	89	268
	IC240538	16.5	44.5	90	294
	IC240577	15.3	47.0	90	310
	IC240590	17.0	48.2	88	340
	CD (0.05%)	**0.82**	**1.65**	**2.55**	**5.97**

Seed Type	National Identity	100 Seed wt (g)	Oil content	Viability (%)	Vigour index
Medium	IC240519	37.9	42.5	92	370
	IC240523	38.0	46.0	94	460
	IC240524	43.8	47.0	98	420
	IC240525	36.4	46.5	90	390
	IC240532	38.0	46.8	96	480
	CD (0.05%)	**1.00**	**1.16**	**1.78**	**15.33**

Seed type	National identity	100 Seed 1M	Oil content	Viability(%)	Vigour index
Bold	IC240513	54.6	46.0	92	520
	IC240520	56.8	50.0	98	580
	IC240521	54.6	46.0	95	542
	IC240591	53.9	46.8	96	563
	IC240592	54.8	46.7	92	520
	CD (0.05%)	**2.49**	**2.49**	**1.98**	**8.63**

Table 4. The effect of storage temperature on seed viability of different sized seeds

Seed size	Storage temperature	Accession No.	0 M	12M	24 M	36M	48M	60 M
Small	-20°C	IC240577	90	90	89	88	89	88
	10° C	IC240577	80	80	78	76	72	65
	Ambient	IC240577	78	60	30	12	0	0
	-20°C	IC240590	89	88	88	86	85	85
	10° C	IC240590	88	85	80	70	70	50
	Ambient	IC240590	80	05	41	20	15	0
Medium	-20°C	IC240523	98	98	98	98	98	98
	10° C	IC240523	94	90	90	90	90	80
	Ambient	IC240523	92	90	90	80	72	65
	-20°C	IC240525	98	98	98	98	96	97
	10° C	IC240525	98	95	90	90	85	80
	Ambient	IC240525	96	90	85	80	75	70
Bold	-20°C	IC240521	98	97	96	96	95	94
	10° C	IC240521	98	95	90	90	86	70
	Ambient	IC240521	98	90	84	70	65	49
	-20°C	IC240592	98	98	98	96	96	96
	10°C	IC240592	96	95	86	82	80	70
	Ambient	IC240592	95	90	89	75	62	50

M: months after storage

CD at 0.05%		
Size	0.79	0.70
Time	1.12	0.99
Size x Time	1.95	1.71
Temperature	0.79	0.70
Temp x Size	1.38	1.21
Temp, x Time	1.95	1.71
Size x Time x Temp.	3.38	2.97

The freshly harvested seeds in all the accessions were kept directly for drying for a period of 15-20 days for good germination which is in agreement with the earlier report made by Atsmon (1958). The freshly harvested seeds showed moisture content of 15 to 18 per cent on fresh weight basis which could be easily lowered down to 5 per cent without any effect on the seed viability and vigour (ISTA, 1985, 1993, Heit, 1949) thereby showing a typical orthodox nature. The germination of the seeds in case of fresh lot was found to be 90-98 per cent (Table 3).

Table 4 depicted the effect of storage time on the seed viability of all three categories. The seed viability was maintained well under the long-term storage conditions of –20°C in all the accessions whereas the seeds lost viability significantly with storage time at 10°C and ambient temperature. A significant decline in seed viability of 78 and 80 per cent was recorded in the small seeds stored at ambient temperature followed by 49 and 45 per cent in bold seeds .The medium size seeds showed the best survival at ambient temperature where the decline was minimum of only 32 and 26 per cent even after storage for a period of five years (Table 4). A similar trend was observed at 10° C but the extent of deterioration was less as compared to the ambient temperature. Viability declined at a much faster rate at ambient temperature, wherein the decline was observed at the third year itself and at 10° C the decline started at 4^{th} year of storage. The smaller seeds lost viability earlier followed by larger size and bold seeds whereas the medium size seeds showed a significant level of higher germination percentage in all the treatments.

Not only the viability but also the rate of growth was affected with storage period at ambient temperature. In the experimental lot, seed size had a good correlation with the storability. The medium size seeds survived longer than the smaller and the bold seeds (Table 4) which is in contradiction with the earlier studies made by Singh and Rai (1988) where large seeds showed better germinability, field emergence and productivity as compared to the medium and small size seeds in cowpea.

Genetically inhibited germination, associated with small seed size and low lipase activity, has been reported in isolated cases (Varier *et al.*1999). Germinability drops drastically after 2 to 3 years unless the seeds are stored under cool and dry conditions. Germination does not occur at temperatures below 15°C (Atsmon, 1989). Castor seed is very hard and does not require much care during storage. Under ordinary storage conditions in jute /gunny bags the oil and free fatty acid content of the seeds are not affected even after three years of storage. In warehouses, castor seed is generally stored in gunny (jute) bags. Sometimes under high humidity or rainfall condition, the seeds may become slightly mouldy but this does not affect the oil content or viability of seeds (Kulkarni and Ramanamurthy, 1977).

The genetic diversity is a prerequisite for any crop improvement programme and forms the basis for meaningful and effective conservation. The characters prominent in wild forms such as small seededness, seed scattering habit, low germinability and storability might have been lost consequent upon the processes of domestication. While in selection for larger seed size, loss of seed scattering habit associated with better storability seems to be an adaptive character desirable or the long-term storage in Gene Banks. Therefore, the selection of lines with rich potential valuable trails and significant morphological differences would help in quickly identifying the cultivars from diversity rich areas for effective conservation and also for future utilisation. Variation in the caruncle may be one of the most important parameters for distinguishing the castor accessions. This important crop from the Indian region has been least worked out with respect to various morphological parameters in relation to the storability. Thus, a preliminary investigation of this kind would not only help in proper storage of the seed but also in developing cost effective conventional storage techniques in widely distributed species.

Acknowledgement

The authors wish to thank Director, National Bureau of Plant Genetic Resources, New Delhi for his constant encouragement and timely suggestions. Thanks are also due to Dr BS Dabas, Former Head, Division of Plant Exploration and germplasm Collection for providing the research material and also for the facilities required.

References

Anderson H (1952) Plants, Man and Life. University of California Press. p. 251.

Anjani K, M Ramacharanami and JB Tomer (1993) Collecting castor (*Ricinus communis* L.) Germplasm in Bihar, Indian. *IBPGR Newsletter for Asia and Pacific and Oceania* **11:** 15.

Atsmon D (1958) Germination inhibition in castor beans, *Bull. of the Research Council of Israel* 60260.

Atsmon D (1989) Castor In: Robbelen G, Downey A (eds). Oil Crops of the World. New York: McGraw-Hill Inc.

Chien Chien-Te and Lin Tsan-Piao (1999) Effects of moisture contents and temperature on the storage and germination of *Cinnamomum comphorum* seeds. *Seed Sci and Technol.* **27:** 315-320.

Duhoon SS, K Anjani and MN Koppar (1996) Collecting Castor *(Ricinus communis L.)* and Jatropha germplasm in Indo-Gangetic Plains. *Indian J. Genet. Resour.* **9(1):** 171-174.

Ellis RH, TD Hong and EH Roberts (1995) Survival and vigour of lettuce and sunflower seeds stored at low and very low moisture contents. *Annals of Botany* **76:** 521-534

Ellis RN, TD Hong, EH Roberts and KL Tao (1990) Low moisture contents limits to relations between seed longevity and moisture. *Annals of Botany* **65:** 493-504.

Heit CE (1949) Germinating castor bean seeds in the laboratory. *Proc of the Assoc of Official Seed Analyst* **39:** 114-117.

ISTA (1985) International Seed Testing Association. International rules for seed testing. Rules (1985) *Seed Science and Technol.* **13:** 299-513.

ISTA (1993) International Seed Testing Association. International rules for seed testing. Rules (1993) *Seed Science and Technol.* 21 Supplement. 296 p.

Kulkarni LG, V Ramamurthy (1977) Castor-A monograph (II ed.), Indian Council of Agricultural Research Pub. p.105.

Moskin VA (1986) History and Origin of Castor. In: Castor-A monograph. 105 p.

Purseglove JW (1968) *Ricinus communis* L. In: *Tropical Crops-Dicotyledons* **I:** 180-186. Longmans, London.

Singh D. (1976) Castor-*Ricinus communis* (Euphorbiaceae). In: NW Simmonds (eds) Evolution of Crops Plants. Longman Group Limited. London. 339p.

Singh RP (1954) Structure and development of seeds in Euphorbiaceae *R. communis* L. *Phytomorphology* **4:** 118-123.

Singh SP and PN Rai (1988) Effect of seed size upon germination and early stages of plant growth of cowpea (*Vigna unguiculata* L.), *Acta Hort (ISHS)* **218:** 71-76.

Stuhlmann, F (1909) Beitrage Zur Kulturges Chichte Von Ostafnka, Berlin, Germany.

The Wealth of India (1972) Vol 9, Publications and Information Directorate, Council of Scientific and Industrial Research, New Delhi, India. p. 26-46.

Varier A, R Agarwal, U Singh and SP Sharma (1999) Characterisation of castor (*Ricinus communis* L.) hybrids and inbreads by seed morphology and electrophoresis of seed proteins and isoenzymes. *Seed Sci. and Technol.* **27:** 11-21.

Watt G (1892) A Dictionary of Economic Products of India. **6(1):** 706-757.