

Studies on Seed Maturation in Bhendi (*Abelmoschus esculentus* (L.) Moench)*

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In the bhendi variety 'Pusa Sawani' the number of mature seeds per fruit ranged from 42 to 65. The seed moisture content which was about 85-90 per cent at the early stage of seed development got reduced to 19-24 per cent at seed maturity. The rate of reduction in seed moisture was maximum between 30-35 days. The dry weight of seeds was maximum on the 30th day. Seeds upto 10 days of development did not germinate and thereafter progressive increase in germination was observed. The seeds reached maximum vigour and germinability between 30-35 days of development when the fruits developed cracks. At this stage, the fruits should be harvested for extraction of quality seeds.

Environmental conditions under which a fertilized embryo develops and matures decide to a large extent the germination and vigour of a seed. The period of seed development and maturation vary from species to species and determination of the same provides information for seed harvesting which is very important for seed producers since early or late harvesting may affect seed quality. To have precise and detailed information in this aspect studies were initiated in the variety 'Pusa Sawani' and the results presented.

MATERIAL AND METHODS

A field trial was laid out adopting split-plot design with three replications in April, 1975. The main treatments designated as S1, S2, S3, S4, S5, S6 and S7 represent seeds collected from developing fruits of 5, 10, 15, 20, 25, 30 and 35 days maturity, while the four

subtreatments F1, F4, F7 and F10, the first, fourth, seventh and tenth fruit in a plant.

Each main plot, consisted of ten rows with 20 plants in each row; two rows from the middle eight rows were allotted randomly for each sub-plot treatment. At the time of anthesis, 40-50 flowers were labelled. Of the 40 fruits finally marked in each treatment, the fresh seeds from 10 randomly selected fruits were weighed and counted. The fresh weight of 100 seeds was arrived at. The seed moisture content was determined by drying the seeds in an air oven maintained at 105°C for 16 hrs. From this, the dry weight of 100 seeds was arrived at by dividing the dry weight of seeds by the number of seed and multiplying by 100.

With the remaining seeds dried to uniform seed moisture, the following

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observations were recorded. Fifteen seeds were picked at random, the length, breadth and thickness were measured with a screw gauge. From twenty seeds picked at random, the dry weight of seed coat and kernel was recorded. From the data, the dry weight of 100 seeds and the seed coat/kernel ratio were calculated. Germination test was conducted following the recommended procedures of the International Seed Testing Association. The length of root and shoot and dry weight of seedlings were recorded. The vigour index was arrived at by multiplying the germination percentage with the total length of root and shoot.

RESULTS AND DISCUSSION

The mean number of seeds per fruit on 35th day in F1, F4, F7 and F10 was 41.7, 57.3, 64.7 and 51.0 respectively. The increase in the number of developing seeds between 5th and 10th day of fruit development is in conformity with the reports of Manohar (1969) and Chauhan and Bhandari (1971). Slight reduction observed during the final stages of maturity may be due to insect damage (Manohar, 1969). A positive association between length of fruit and number of mature seeds was evident. Abdul Baki and Baker (1973) employed fresh weight of seeds to differentiate between seed 'development' and 'Maturation' periods. According to them, seed development is the period between fertilisation and maximum fresh weight of seeds and

seed maturation begins at the end of seed development and continues upto harvest. The fresh weight of seeds was maximum on the 15th day and thereafter it decreased (Table I). Chauhan and Bhandari (1971), Manohar (1969) and Kolhe and Chavan (1964) reported similar results. Maximum increase in fresh weight was observed between 5th and 10th day while according to Chauhan and Bhandari (1971), it was from 6th to 9th day.

According to Delouche (1973) dry weight of seed can be used as an index of seed maturity. Maximum dry weight was attained on 30th day (Table I). Chauhan and Bhandari (1971) reported similar results while according to Manohar (1967) it was on 21st day. This deviation might be due to season, variety studied, place of cultivation and cultural practices adopted. Maximum increase in dry weight was observed between 10th and 15th day irrespective of position of fruits indicating thereby that this period is the most critical period as far as dry matter accumulation is concerned. Manohar (1969) stated that the dry weight of seeds increased rapidly upto 11 days after which it continued to increase but at a decreasing rate. Maximum dry weight was recorded when the seed moisture content was between 41 to 52 per cent. Oats seeds reached a mean maximum dry weight at 45 per cent seed moisture content (Frey *et al.*, 1958)

Loss of water is a characteristic feature of seed maturation (Mayer,

1973) and may drop rapidly from about 65 per cent to about 15 per cent (Abdul-Baki and Baker, 1973). The reduction in seed moisture content was significant between 30 and 35 days. It is during this period that a reduction in the size and weight of fruits and to some extent in the weight of seeds have taken place. Chauhan and Bhandari (1971) reported similar results. Delouche (1973) has stated that the time required for seeds to decrease in moisture content from the 80 per cent level at fertilization to 14-20 per cent at harvest varied with species. In the present study, the time required was about 30-35 days after flower opening (Table I).

The seed coats during development become modified and at maturity they present a characteristic appearance (Hartmann and Kester, 1972.) In the present study, changes in seed coat colour and surface of seed coat were observed with the development of the seed and the shrivelled seeds were found to be immature ones. Development of seed coat colour was noticed as early as 15th day and was completed on 30th day. Very young seeds were white in colour. (Guppy, 1912).

The seed coat and kernel ratio was maximum in ten and minimum in 35 days old seeds (Table II) Development of seed coat was independent of the kernel. The difference in the rate of development between one tissue and another within the same seed, is a

remarkable feature of seed maturity (Abdul-Baki and Baker, 1973). The kernel weight of light seeds was less than that of heavy seeds. Arndt (1945) reported that the embryo weight of light seeds was less than those of heavy seeds. In all the stages, seed coat weight was more than that of kernel and a decrease in weight of the seed coat was observed with increase in seed maturity. Growth of the seed coat was found to be in advance of that of kernel.

The length, breadth and thickness were increasing upto 30th day (Table II). The size reached the maximum when the moisture content was between 41 and 51 per cent. The seed size reached the maximum at 40 per cent seed moisture content in *Sorghum vulgare* (Delouche, 1973). Maximum increase in length, breadth and thickness of seed were observed between 5th and 10th day during which period the seed moisture content was at the maximum level. In this period, the dry weight of seed coat and kernel was minimum. Variation in seed size was observed among fruits of different position.

According to Croker and Barton (1957) for several reasons, it is important to know the effect of the stage of maturation of the seeds on its germination. In F1 and F7, 23 per cent of the developing seeds germinated while none germinated in F4 and F10 during the same period. On 20th day,

when the germination in the former two fruits was ranging from 38 to 46 per cent, it was from 6.3 to 8.7 per cent in the later two (Table III). This difference in germination due to position of the fruits in the same plant may be due to physiological causes. Seeds were capable of germinating long before maturity. Delouche (1973) came to similar conclusions. Maturity stage influenced significantly germinability. Manahar (1969), Chauhan and Bhandari (1971) and Ravindra (1964) have arrived at similar conclusions.

A seed may germinate but the seedling may not be vigorous. Root and shoot length of seedling, vigour index and dry weight of seedlings were significantly more in 30 and 35 days old seeds over others (Table IV). Seed weight and seed vigour were found to be closely associated. The vigour index varied between seeds from fruits from different positions on the same plant. Seeds from 10th fruit attained maximum vigour on 35th day while those from other fruits attained the same on 30th day itself.

Harvesting of immature seeds followed by artificial drying would cause low vigour (Perry, 1972). Because low vigour does not have a genetic basis in most cultivars, it must be caused by conditions external to the seed and these may operate at two distinct phases in the life of the seed either during development on the parent plants, so that it is harvested in

a low vigour condition or after harvest when damage or deterioration may result from handling or from storage conditions (Perry, 1969). A complex of environmental factors acting during development and maturation of the seed has been found to relate to subsequent vigour of the seed (Roberts, 1969). Therefore, it is always advisable to harvest the fruits in this variety for seed purpose at 30-35 days maturity when the fruit would have developed hair like cracks and become light brown in colour.

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TABLE I Number, fresh and dry weight of 100 seeds, seed moisture content and seed coat weight at 5, 10, 15, 20, 25, 30 and 35 days of maturity collected from 1st, 4th, 7th and 10th fruits in variety "Pusa Sawani"

	Days after flowering							Seed moisture (%)	Seed coat weight (g)					
	5	10	15	20	25	30	35							
Number of seeds														
F1	41.1	42.7	42.3	42.3	42.3	42.0	41.7	90.00	89.86	76.83	65.60	56.26	51.10	19.37
F4	54.7	60.7	60.3	60.3	58.7	58.0	57.3	88.36	82.66	73.06	64.53	57.00	51.63	18.27
F7	68.0	73.0	72.7	72.3	67.3	64.7	64.7	88.93	88.50	73.06	63.56	55.17	41.07	21.37
F10	55.3	57.3	57.3	54.0	52.0	52.0	51.0	84.90	87.23	73.00	67.33	56.23	42.97	23.83
100 Seed weight (g) (Fresh)														
F1	2.89	12.34	13.24	12.93	12.45	12.63	7.61	—	1.06	2.21	2.57	2.82	3.16	3.14
F4	2.47	8.77	13.13	12.90	12.62	12.74	7.57	—	1.50	2.15	2.47	2.98	3.12	3.14
F7	3.35	11.88	12.15	11.40	11.25	10.38	7.73	—	1.09	2.24	2.53	2.86	3.12	3.10
F10	1.18	9.11	10.74	10.74	10.64	9.21	6.91	—	1.00	2.13	2.34	2.80	2.83	2.73
100 Seed weight (g) (Dry)														
F1	0.29	1.25	3.07	4.45	5.44	6.18	6.13							
F4	0.29	1.52	3.11	4.64	5.60	6.16	6.18							
F7	0.37	1.27	3.17	4.27	5.22	6.12	6.08							
F10	0.18	1.15	2.90	3.59	4.79	5.25	5.27							
	Number of seeds per fruit		100 seed weight (Fresh)		Dry weight of 100 seeds		Moisture		Seed coat weight					
	S.Ed.	C.D.	S.Ed.	C.D.	S.Ed.	C.D.	S.Ed.	C.D.	S.Ed.	C.D.	S.Ed.	C.D.	S.Ed.	C.D.
	(P=0.05)	(P=0.05)	(P=0.05)	(P=0.05)	(P=0.05)	(P=0.05)	(P=0.05)	(P=0.05)	(P=0.05)	(P=0.05)	(P=0.05)	(P=0.05)	(P=0.05)	(P=0.05)
Stages of fruit maturity in each position of fruit	0.5705	1.1883	0.3098	0.6401	0.122	0.246	1.3248	2.7074	0.0495	0.1032				
Position of fruits in each stage of maturity	0.5085	1.0161	0.2988	0.6030	0.109	0.223	0.9921	2.0022	0.0488	0.0999				

TABLE: II Dry weight of 100 kernels, seed coat kernel ratio and the length, breadth and thickness of seeds collected in the 1st, 4th, 7th and 10th fruits as on 5, 10, 15, 20, 25, 30 and 35 days of maturity in 'Pusa Sawani'.

	Days after flowering													
	5	10	15	20	25	30	35	5	10	15	20	25	30	35
100 Kernel weight (g)								Breadth (mm)						
F1	0.19	0.86	1.88	2.62	3.02	3.02	2.99	1.43	3.48	4.07	4.37	4.64	4.65	4.65
F4	0.21	0.96	2.17	2.62	3.04	3.04	3.04	1.42	3.38	4.23	4.24	4.50	4.65	4.65
F7	0.18	0.93	1.74	2.36	3.00	3.00	2.98	1.41	3.57	4.08	4.26	4.37	4.54	4.54
F10	0.15	0.77	1.25	1.99	2.42	2.42	2.53	1.22	3.47	3.82	4.02	4.26	4.27	4.27
Seed coat/kernel ratio								Thickness (mm)						
F1	5.59	2.56	1.37	1.08	1.05	1.05	1.05	1.40	3.47	4.05	4.35	4.37	4.37	4.37
F4	6.21	2.24	1.52	1.14	1.03	1.03	1.03	1.40	3.36	4.21	4.22	4.44	4.45	4.45
F7	6.15	2.37	1.46	1.21	1.04	1.04	1.04	1.39	3.56	4.06	4.18	4.34	4.35	4.35
F10	6.55	2.78	1.88	1.41	1.17	1.17	1.08	1.20	5.23	3.79	4.00	4.13	4.17	4.17
Length (mm)														
F1	1.96	4.44	5.01	5.03	5.05	5.05	5.05							
F4	2.06	4.25	4.99	5.03	5.06	5.06	5.06							
F7	2.05	4.24	5.01	5.03	5.05	5.05	5.06							
F10	1.74	3.70	4.78	4.80	4.95	4.95	4.85							
				Kernel weight			Seed coat/kernel ratio				Length		Breadth	Thickness
				S.Ed.	C.D.	S.Ed.	C.D.	S.Ed.	C.D.	S.Ed.	C.D.	S.Ed.	C.D.	C.D.
				(P=0.05)	(P=0.05)	(P=0.05)	(P=0.05)	(P=0.05)	(P=0.05)	(P=0.05)	(P=0.05)	(P=0.05)	(P=0.05)	(P=0.05)
Stages of maturity in each position of fruit	0.045	0.091	0.124	0.251	0.028	0.057	0.024	0.049	0.032	0.066				
Position of fruits in each stage of maturity	0.043	0.089	-	-	0.030	0.061	0.024	0.049	0.035	0.070				

TABLE: III Germination percentage and Vigour index of seedlings in Paper medium and field emergence of seeds collected from 1st, 4th, 7th and 10th fruits on 15, 20, 25, 30 and 35 days of maturity in variety 'Pusa Sawani'

	Vigour Index									
	Germination					Days after flowering				
	15	20	25	30	35	20	25	30	35	
Paper medium										
F1	2.33 (8.75)	41.00 (39.82)	54.33 (47.48)	81.67 (64.65)	82.33 (65.15)	1222	1737	2887	2914	
F4	-	8.33 (16.77)	51.33 (45.76)	81.33 (64.41)	86.33 (68.31)	226	1928	2796	2009	
F7	2.33 (8.75)	38.00 (38.06)	60.00 (50.77)	75.00 (60.23)	83.33 (65.91)	1079	1976	2646	2957	
F10	-	6.33 (14.57)	23.00 (28.65)	65.00 (53.73)	73.66 (59.12)	171	715	2167	2500	
Field emergence										
F1	2.67 (9.36)	48.33 (44.04)	58.67 (49.99)	88.33 (70.03)	88.33 (70.03)	560	729	1149	1150	
F4	-	8.67 (17.12)	59.33 (50.38)	80.67 (83.92)	86.33 (68.31)	83	695	1054	1132	
F7	3.33 (10.50)	41.33 (40.01)	61.00 (51.35)	81.33 (64.41)	83.33 (65.91)	443	708	1050	1093	
10	-	8.33 (16.77)	24.67 (29.55)	67.00 (54.94)	76.33 (60.89)	79	265	799	961	
Values in Parantheses denote angular values										
	Germination					Vigour Index				
	Paper medium		Field emergence		Paper medium		Field emergence			
Stages of fruit maturity in each position of fruit	S. Ed.	C. D. P=0.05	S. Ed.	C. D. P=0.05	S. Ed.	C. D. P=0.05	S. Ed.	C. D. P=0.05	C. D. P=0.05	
Position of fruits in each stage of maturity	0.38	0.90	0.39	0.79	23.81	55.46	8.78	19.24		
	0.34	0.68	0.40	0.81	18.70	38.60	10.13	20.92		

TABLE IV Root length, shoot length and dry weight of ten normal seedlings raised from seeds collected from 1st, 4th, 7th and 10th fruits on 20, 25, 30 and 35 days of maturity in variety "Pusa Sawani".

	Days after flowering				
	20	25	30	35	35
Paper medium					
Root length (mm)					
F1	10.43	11.15	12.91	12.91	6.52
F4	7.93	10.52	11.91	12.35	6.60
F7	9.07	11.60	12.67	12.67	6.59
F10	7.85	10.43	11.91	12.24	6.36
Shoot length (mm)					
F1	19.38	20.83	22.44	22.49	6.51
F4	19.22	21.19	22.47	22.51	6.52
F7	19.37	21.33	22.46	22.48	6.53
F10	19.22	20.65	21.44	21.71	6.23
Dry weight of 10 seedlings (mg)					
F1	133	187	220	231	491
F4	119	199	243	244	498
F7	136	164	246	246	469
F10	130	185	211	222	435
Field emergence					
Root length (mm)					
F1	5.75	6.32	6.32	6.52	6.52
F4	4.84	6.38	6.38	6.59	6.60
F7	5.41	6.17	6.17	6.44	6.59
F10	4.75	5.68	5.68	6.25	6.36
Shoot length (mm)					
F1	5.85	6.11	6.11	6.49	6.51
F4	4.79	5.34	5.34	6.48	6.52
F7	5.28	5.45	5.45	6.47	6.53
F10	4.72	5.21	5.21	5.68	6.23
Dry weight of 10 seedlings (mg)					
F1	402	467	467	476	491
F4	360	456	456	497	498
F7	402	433	433	467	469
F10	323	393	393	424	435
Paper medium					
Root length					
S.E.d.	0.14	0.30	0.22	0.30	0.26
C.D.	0.30	0.10	0.22	0.30	0.26
P=0.05					
Field emergence					
Dry weight of seedling					
S.E.d.	9.68	9.67	12.34	9.68	7.34
C.D.	9.68	9.67	12.34	9.68	7.34
P=0.05					
Shoot length					
S.E.d.	0.17	0.17	0.16	0.17	0.17
C.D.	0.17	0.17	0.16	0.17	0.17
P=0.05					
Dry weight of seedling					
S.E.d.	0.08	0.08	0.08	0.08	0.08
C.D.	0.08	0.08	0.08	0.08	0.08
P=0.05					

Stages of fruit maturity in each position

Position of fruits in each stage of maturity