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Determination of time of physiological maturity of kenaf seed and appropriate time of harvesting

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Abstract

Field experiments were carried out between July and December 2010 and 2011 at research station of the Institute of Agricultural Research and Training, Obafemi Awolowo University, Moor Plantation, Ibadan, to determine the effects of time of harvesting on kenaf seed physiological maturity and quality. Kenaf seed of 10 genotypes were collected at seven harvesting periods. Seeds were harvested at 5 day interval from 15 to 45 days after flowering (DAF). Significant variation was observed in all the kenaf genotypes for all the parameters studied. Maximum seed quality as measured by seed viability, moisture content, seed mass and germination percentage were obtained at 35 DAF. However, seed quality of kenaf genotypes reduced thereafter with age and pre-harvest sprouting on mother plant occurred. Maximum seed weight (mass maturity) was achieved at 35DAF in both years when average seed moisture contents were 20.58 and 19.28%, respectively. For high seed quality, kenaf is better harvested at 35 DAF which could be regarded as the point of physiological maturity.

Keywords: Kenaf, harvesting period, seed quality, mass maturity, physiological maturity.

INTRODUCTION

Seed development is the period between fertilization and maximum fresh weight accumulation and seed maturation begins at the end of seed development and continues till harvest (Mehta et al., 1993). The seed reaches its maximum dry weight at physiological maturity. Studies on seed development and physiological maturity become important because seeds should be harvested at proper time to ensure their quality in terms of viability and vigor. Seed quality can be limited by environmental conditions both before and after physiological maturity, the stage of development at which the seed possesses its maximum dry mass (Indira and Dharmalingam, 1996). Seeds gradually attain viability and vigor during the developmental process as seed dry weight is accumulated. Maximum seed quality may be achieved at the end of seed filling period (Harington, 1972; Browne, 1978; Tekrony and Hunter, 1995; Tekrony and Egli, 1997) or slightly after this phase (Pieta Filho and Ellis, 1991; Ellis et al., 1993; Zanakis et al., 1994; Sanhewe and Ellis, 1996; Demir and Samit, 2001; Lehner et al., 2006; Ghassemi-Golezani and Mazloomi-Oskooyi, 2008; Ghassemi-Golezani and Hosseinzadeh-Mahootchy, 2009). The end of seed filling phase is described as physiological maturity (Harington, 1972) or mass maturity (Ellis and Pieta Filho, 1992). Viability, the least discriminating measure of seed quality, is quickly gained during seed development and strongly maintained after maturity relative to germination ability.

Stage of maturity at harvest is one of the most important factors that can influence the quality of seeds (Demir et al., 2008). Harvesting too early may result in low yield and quality, because of the partial development of essential structures of seeds (Keller and Kollmann, 1999; Elias and Copeland, 2001; Ekpong and Sukprakarn, 2008; Wang et al., 2008). Whereas, harvesting too late may increase the risk of shattering and decrease the quality of seeds due to ageing. Adverse environmental conditions such as rainfall or precipitation may also result

in sprouting of seeds on mother plants (Ellis and Pieta Filho, 1992; Elias and Copeland, 2001; Wang et al., 2008). Therefore, successful seed production depends on detection and prompt harvesting at this appropriate time. This time is a pre-requisite for the production of maximum number of high quality seeds (Demir and Balkaya, 2005; Wang et al., 2008).

Physiological maturity is a genotypic character which is influenced by environmental factors (Gupta and Kole, 1982; Mahesha et al., 2001a). At this point of plant phenology, seeds attain maximum viability and vigor. Environmental conditions during seed development and maturity including temperature, water stress or excessive rain, nutrients shortage, diseases infection, and pest pressure influence seed quality (Delouche, 1980). One of the major constraints facing kenaf productivity in Nigeria is lack of high quality seeds. Inadequate seeds supply to farmers as a result of rapid decline of kenaf seed causes poor viability. Seeds are stored on kenaf plants in the field after physiological maturity until the proper time of harvest when suitable seed moisture content is attained. Any adverse conditions during this period such as heavy rainfall can affect seed viability. The need to determine the appropriate harvesting period for kenaf to enhance and ensure its quality and viability is imperative. Hence the study tried to determine the time of physiological maturity of kenaf seed and appropriate time of harvesting in order to produce qualitative kenaf seed.

MATERIALS AND METHODS

The experiments were carried out at research station of the Institute of Agricultural Research and Training, Obafemi Awolowo University, Moor Plantation, Ibadan, in the late humid months of 2010 and 2011 to determine the effects of harvesting stages on physiological maturity and kenaf seed quality. The trials set up in July both years in random block design with three replicates. Conventional cultivation practices were applied. The first harvest was performed 15 days after flowering. Subsequent harvests took place at 5 days intervals till 45 days after flowering. A total of 7 harvests were performed. Harvested capsules were carefully shelled and the seeds extracted. Germination test, seed moisture content and seed mass determination were performed on the extracted seeds immediately after harvest. Seed moisture and seed mass were determined by drying the seed at 105°C for 24 h. Seed viability was determined using water soaked filter paper. Data were collected on seed mass and viability. Meteorological data were received from Institute's meteorological station. Experimental data were statistically processed by the analysis of variance and also by regression analysis.

RESULTS AND DISCUSSION

Mean values for germination percentage at different harvesting period for both years are shown in Table 1. It can be seen that viability was lowest at 15 DAF in both years, but it increased with progressing seed development. This improvement continued until maximum seed viability was obtained at 35 days after flowering for all the genotypes. The freshly harvested kenaf seeds are capable of germinating during the period between 15 and 30 DAF but the germination capacity is low. Highest germination percentage was realized in 35 DAF (days after flowering) across all the tested kenaf genotypes in both years. Mehta et al. (1993) reported that seeds harvested at 37 days after anthesis recorded higher germination percentage while seeds harvested at 33DAA showed the lowest germination percentage. From the study, kenaf seeds reach highest viability values in both years (PM) at 35 days after flowering, a period when developing seed reaches its maximum dry weight and the quality declines thereafter. Seed maturation in kenaf is an important process during which morphological (seed size and colour), physiological (dry weight, moisture content and germination), chemical (oil, protein and carbohydrate) and functional (vigor and viability) change from the time of fertilization until the seed are ready for harvest (Demir and Balkaya, 2005).

Maximum seed quality as measured by seed viability, moisture content, seed mass and germination percentage was obtained at the point of mass maturity. These results agreed with the suggestions that seed quality is at the maximum at the end of seed filling phase (Harington, 1972; Browne, 1978; Tekrony and Hunter, 1995; Tekrony and Egli, 1997). Low seed quality at the early stages of seed development was due to immaturity while the decline in quality parameter at later stages in both years caused by seed ageing (Ghassemi-Golezani and Mazloomi-Oskooyi, 2008) and pre-harvest sprouting (Figure 3) on mother plant (Ellis and Pieta Filho, 1992; Elias and Copeland, 2001; Wang et al., 2008). From the analysis of variance in Table 1, genotype, year and genotype x year interaction had significant ($p < 0.05$) effects on viability at some of the harvesting period.

Throughout the course of development, kenaf seeds undergo changes in dry weight (Table 2). Between 15 and 35 DAF, dry weight increase very rapidly. The increase in seed dry weight is associated with the greater accumulation of photosynthates in to the sink (capsule) up to 35 DAF after which the growth remained static which may be due to decrease in photosynthesis and accumulation of photosynthates (Indira and Dharmalingam, 1996). The seed dry weight increase to its maximum at 35 days after flowering and the moisture content of the seed decline from 70.39% in 2010 and 75.18% in 2011 at 15 days after flowering to a stable values of about 20% at 35 days after flowering in both years. There was an overall reduction in seed moisture content from 15 to 35 DAF as reserve materials accumulated. Seed moisture content dropped from 70.39 and 75.18% in both years at 15 DAF to 14.39 and 13.78%, respectively at 45 DAF (Table 3). Developing seeds at early stages of formation have a relatively high water content compared with the matured seeds. Mehta et al. (1993) reported that seed harvested at 29 DAA showed the highest moisture percentage while seed harvested at 45 DAA showed the lowest moisture

Table 1. kenaf genotypes seed viability (%) at different harvest dates in 2010/2011.

Genotype	Year	Days after flowering						
		15	20	25	30	35	40	45
G-45	2010	18.67	18.00	26.67	58.67	94.67	88.00	48.00
	2011	0.00	5.00	5.00	33.33	70.00	56.67	38.33
Ex-funtua	2010	18.67	11.33	32.00	60.00	90.67	78.66	53.33
	2011	0.00	11.67	21.67	38.33	76.67	50.00	48.33
Tainung	2010	17.33	14.00	22.67	62.67	90.67	68.00	50.67
	2011	1.33	13.33	23.33	28.33	80.00	45.00	63.33
Ex-Shika	2010	17.33	22.00	8.00	46.67	86.67	80.00	34.67
	2011	0.00	15.00	15.00	36.67	65.00	63.33	60.00
S-72-78-10	2010	13.33	12.67	37.33	64.00	93.33	88.00	40.00
	2011	0.00	10.00	15.00	38.33	71.67	68.33	51.67
A-60-282	2010	12.00	20.00	32.00	48.00	93.33	90.67	48.00
	2011	0.00	15.00	25.00	40.00	76.67	61.67	60.00
Ifeken-100	2010	10.67	19.33	30.67	56.00	92.00	80.00	56.00
	2011	0.00	18.33	28.33	50.00	83.33	71.67	40.00
A-60-284	2010	6.67	30.00	24.00	53.33	96.00	78.66	40.00
	2011	0.00	8.33	18.33	30.00	65.00	38.33	53.33
Ifeken-400	2010	4.00	8.00	36.00	53.33	89.33	90.67	38.66
	2011	0.00	10.67	16.67	45.00	68.33	55.00	58.33
Local line	2010	1.33	9.33	16.00	69.33	96.00	76.00	69.33
	2011	0.00	13.33	23.33	51.66	71.67	60.00	65.00
Average	2010	12.00	16.45	26.53	62.37	92.27	81.87	47.87
	2011	0.13	12.07	19.17	39.17	72.83	57.00	53.83
F-test								
Genotype		*	*	ns	**	ns	**	**
Year		***	ns	**	***	***	***	*
G x Y		*	*	ns	*	ns	ns	**

***, ** and * significant at 0.001, 0.01 and 0.5% level of probability, respectively. Ns- not significant.

percentage. Moisture content was the highest in H_1 stage, that is, seed collected at 30 days after flowering (DAF) and the lowest moisture content in H_3 stage, that is, at 40 DAF (Mahesha et al., 2001a). The obtained results (Table 3) indicated that marked reduction in moisture occurred in the seeds of all the kenaf genotypes tested after 25 days of observation and moisture dropped abruptly 35 days after flowering. A drastic reduction in seed moisture (about 60%) is observed between 30 and 35 DAF. This is exactly the natural desiccation period for kenaf seed. The results showed that physiological maturity of field grown kenaf seeds was attained at 35 days after flowering in both years. Local line recorded low percent reduction in viability after physiological maturity in both years as compared to other genotypes. At 40 DAF and thereafter, germination percentage declined in both years with the exception of Ifeken-400 that recorded an increase in germination percentage in 2010. Thus, variation in germination percentage in the kenaf seeds obtained in two different seasons seems mainly due to

Table 2. Seed mass (g/50 seeds) of kenaf genotypes in 2010 and 2011.

Genotype	Year	Days after flowering						
		15	20	25	30	35	40	45
G-45	2010	0.61	0.90	1.20	1.23	1.30	1.19	1.29
	2011	0.68	0.86	0.98	1.14	1.18	1.17	1.17
Ex-funtua	2010	0.64	0.97	1.17	1.23	1.34	1.34	1.30
	2011	0.71	1.06	1.11	1.23	1.32	1.30	1.33
Tainung	2010	0.71	0.89	1.17	1.24	1.21	1.23	1.22
	2011	0.68	0.94	1.01	1.11	1.27	1.13	1.19
Ex-Shika	2010	0.76	0.94	1.18	1.36	1.28	1.16	1.20
	2011	0.69	0.97	1.26	1.46	1.45	1.26	1.30
S-72-78-10	2010	0.83	1.01	1.19	1.28	1.31	1.29	1.21
	2011	0.69	0.82	0.99	1.31	1.21	1.15	1.27
A-60-282	2010	0.72	0.92	1.15	1.29	1.37	1.25	1.21
	2011	0.73	0.89	1.12	1.20	1.32	1.28	1.24
Ifeken-100	2010	0.73	0.96	1.26	1.30	1.23	1.33	1.28
	2011	0.71	0.87	1.06	1.37	1.23	1.37	1.34
A-60-28	2010	0.66	0.93	1.25	1.31	1.37	1.31	1.24
	2011	0.61	0.87	1.16	1.30	1.41	1.20	1.26
Ifeken-400	2010	0.56	0.92	1.22	1.31	1.32	1.35	1.24
	2011	0.66	0.81	1.10	1.20	1.28	1.24	1.26
Local line	2010	0.71	0.91	1.05	1.23	1.28	1.24	1.22
	2011	0.71	1.03	1.01	1.20	1.32	1.24	1.24
Average	2010	0.69	0.94	1.18	1.28	1.30	1.27	1.24
	2011	0.69	0.91	1.08	1.25	1.30	1.23	1.26
F-test								
Genotype		***	*	**	***	**	***	*
Year		ns	ns	***	ns	ns	ns	ns
G × Y		**	**	*	*	*	**	ns

***, ** and * significant at 0.001, 0.01 and 0.5 % level of probability, respectively. Ns - not significant.

Table 3. Kenaf seed moisture (%) in 2010 and 2011.

Genotype	Year	Days after flowering						
		15	20	25	30	35	40	45
G-45	2010	74.03	65.13	52.20	46.99	24.55	26.29	13.43
	2011	75.33	63.06	56.62	43.44	20.50	12.46	13.77
Ex-funtua	2010	71.77	64.74	58.74	50.62	16.09	22.29	19.11
	2011	74.72	55.37	55.28	52.03	16.00	14.29	15.07
Tainung	2010	66.21	65.29	56.02	47.91	20.99	25.90	12.67
	2011	75.55	60.01	56.00	59.01	22.47	16.13	12.85

Table 3. Contd.

Ex-Shika	2010	69.92	60.64	57.02	44.41	20.35	14.88	11.94
	2011	75.61	59.61	52.62	48.77	16.35	15.95	14.56
S-72-78-10	2010	68.12	62.46	57.69	49.61	19.02	21.23	18.08
	2011	75.86	66.27	55.79	49.60	15.73	19.35	12.04
A-60-282	2010	68.76	58.43	56.16	44.93	15.99	15.31	11.26
	2011	73.89	62.12	53.91	55.75	18.07	12.87	10.89
Ifeken-100	2010	69.26	65.87	55.10	47.67	19.86	17.93	11.91
	2011	74.67	61.20	50.58	48.21	23.16	13.64	12.72
A-60-284	2010	72.90	64.51	56.45	50.25	24.89	21.98	21.33
	2011	76.57	64.53	53.44	46.03	18.27	13.58	16.17
Ifeken-400	2010	76.87	62.63	55.62	52.49	28.44	22.30	11.95
	2011	76.29	66.42	56.68	49.48	17.27	16.35	16.98
Local line	2010	66.08	61.23	55.90	46.29	15.61	19.96	12.26
	2011	73.27	56.06	55.09	47.67	24.97	16.29	12.70
Average	2010	70.39	63.09	56.09	48.11	20.58	20.81	14.39
	2011	75.18	61.47	54.60	50.00	19.28	15.09	13.74
F-test								
Genotype		***	**	ns	***	***	***	***
Year		***	*	**	**	ns	***	**
G × Y		***	**	ns	***	***	***	ns

***, ** and * significant at 0.001, 0.01 and 0.5% level of probability, respectively. Ns - not significant.

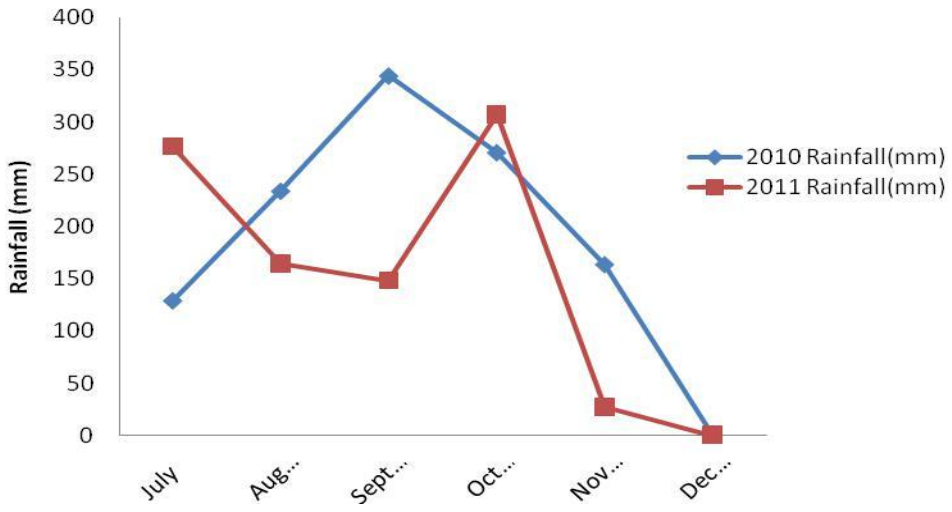

Figure 1. Rainfall data during planting.

the variation in environment during seed development (Figures 1 and 2). Pre-harvest sprouting of seeds on the mother plants occurred after 35 DAF till the point of harvest in year 2010 due to high rainfall before the

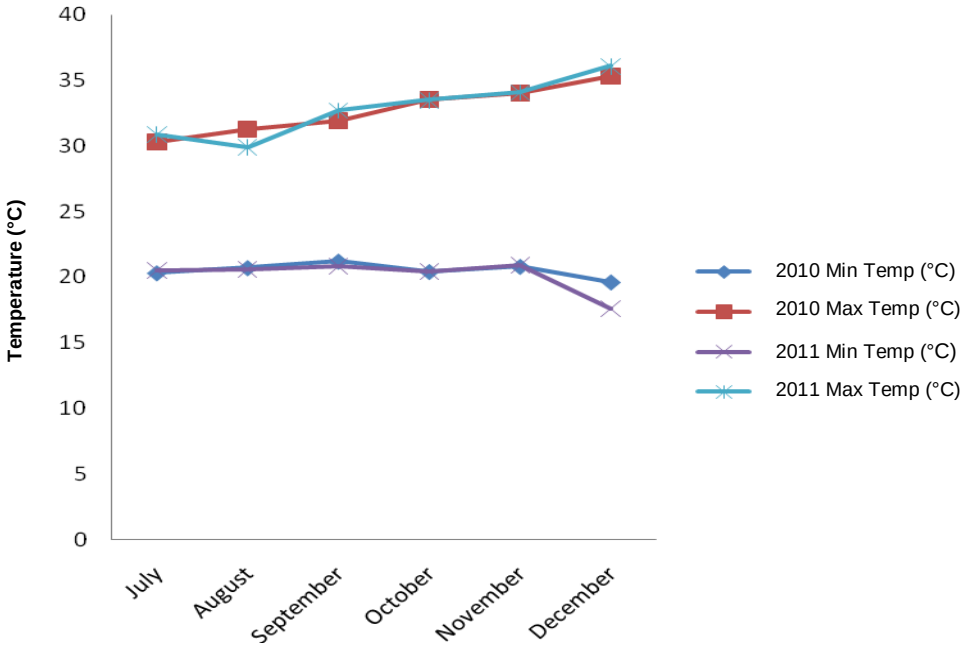

Figure 2. Maximum and minimum temperature during planting.

Figure 3. Seed germination on kenaf plant.

attainment of harvesting maturity (Figure 3).

The regression analysis showed that the theoretical maximum viability in all the kenaf genotypes tested was achieved at seed mass and moisture content of about 1.3 g/50 seeds and 20.00% in both years 2010 and 2011 (Figures 4 and 5). Coefficient of determination (0.715) was highest between moisture content and seed viability in 2011.

Conclusion

Highest values of average seed viability were registered in the genotypes A-60 284 and Local line in 2010 and Ifeken 400 in 2011. Highest values of average seed viability were registered in the seed harvested at 35 days after flowering in both years. Average seed mass was at the maximum 35 DAF in both years and this could be

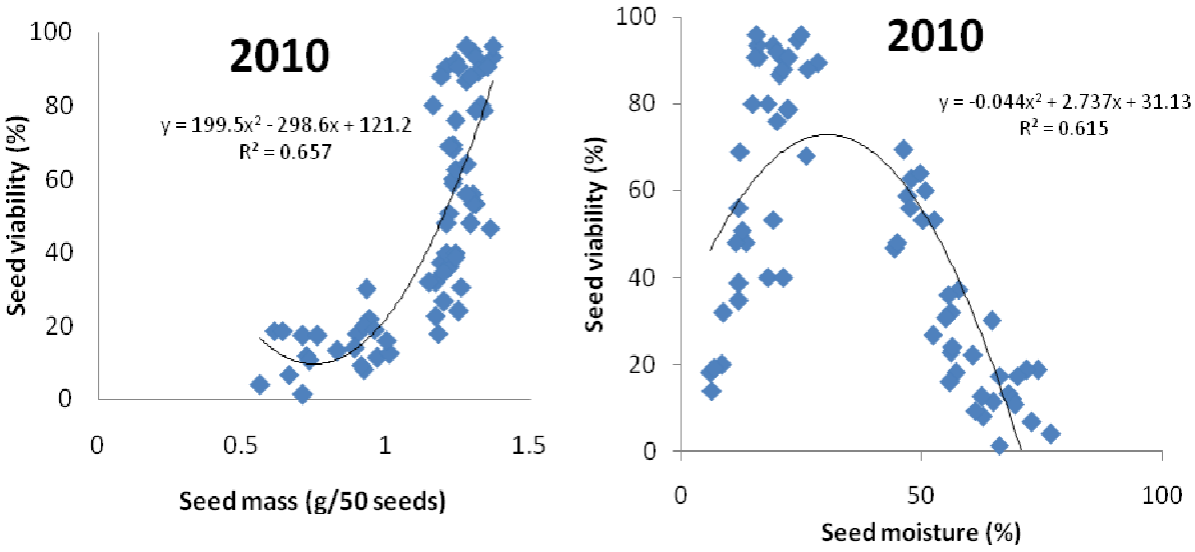

Figure 4. Relationship between seed mass and moisture content on seed viability in 2010.

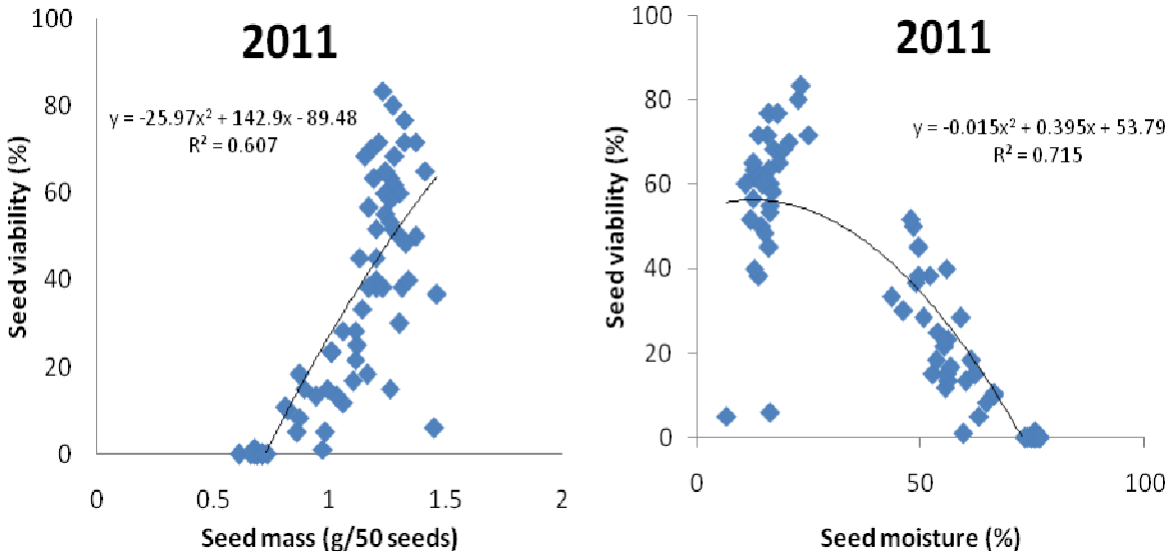

Figure 5. Relationship between seed mass and moisture content at harvest on seed viability in 2011.

regarded as the point of physiological maturity. For high seed quality, kenaf is better harvested 35 DAF. After physiological maturity, local line recorded lowest seed viability loss in both years. Therefore, this genotype can be used for future breeding program in kenaf.

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