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Changes in 'Egusi' Melon [*Citrullus lanatus* (thunb.) Matsum and Nakai] seed quality during development and maturation in different seasons

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ABSTRACT

A study was conducted at the University of Agriculture, Makurdi Nigeria on one of the most popular melon species in Nigeria known as 'egusi' melon [Citrullus lanatus (Thunb.) Matsum and Nakai]. The aim was to monitor the effect of season and days after anthesis on seed quality. Bulk planting was done in the wet and dry seasons of 2005 and 2007. Ten harvests were made sequentially at three days interval from fruits that developed from tagged flowers beginning from 20 DAA to 47 DAA in 2005 and from 14 DAA at three days interval to 41 DAA in 2007 to monitor fruit and seed development and maturation with time. Significant (P < 0.05) increases in values of fruit length, diameter and weight progressed up to 26 DAA. Dry seed weight increased with maturation and was maximum when the fruits attained between 35 and 40 DAA. Significant increases in 100-seed weight of wet season production ended at 32 DAA whereas in the dry season, significant increases in this trait ceased at 38 and 23 DAA in 2005 and 2007 respectively. The highest seed germination values of 82 and 97.5% were obtained at 47 DAA (the last harvest) in both wet and dry season productions. Seeds produced in the wet season exhibited some degree of dormancy, which was broken during the first year of storage. Fruits harvested at the more matured age (47 DAA) produced better seed longevity than those harvested at earlier ages. It was therefore concluded from the study that delayed harvest of Citrullus lanatus fruits until when all vines and leaves on the plant are dry would result to better seed quality, and that seed crop of Citrullus lanatus should preferably be produced in the wet season for high seed vigour.

Key words: Anthesis, season, dormancy, germination, longevity.

INTRODUCTION

Melon belongs to the large family of cucurbitaceae members of which are found in the warmer parts of all continents Schippers (2000). It is consumed locally on a wide range in Nigeria which is also the largest producer of the crop (van der Vosen *et al.*, 2004). Ogbonna and Obi (2000) however reported that despite the usefulness and nutritional qualities of the crop, there is paucity of information on the agronomic practices that will lead to increased production of the crop. They reported that no research has been done to identify the time of the year to grow this crop to attain optimum seed yield in the Nsukka zone.

The bedrock on which every successful crop production programme is built is the seed. One of the ways by which seed quality can be improved is correct determination of the harvest time that would give best viability, vigour and longevity. Demir *et al.* (2004) reported that optimum timing of harvest is a prerequisite for the production of high quality seeds. Gurusamy (1999) identified soil, climate, cultural practices, and more importantly timely operations from sowing to harvesting as being the major factors that determine the quality of seed produced. In addition, he explained that early harvest might result in poor germination and vigour likewise delayed harvest may lead to low germination and vigour. He identified optimum timing of harvest, as been one of the prerequisites for the production of high quality seed of watermelon (*Citrullus lanatus*).

It has been observed that farmers have over the years witnessed a wide variation in germination and emergence of melon seeds in the field and therefore target plant population densities are hardly met. Consequently, high seed rates are used and where seedling emergence is impressive, thinning to two plants per stand as recommended by NIHORT (2000) is undertaken. This practice is not only labourious but also wasteful. Melon farmers also do not handle a seed crop differently from a grain crop. Seeds are simply collected from the farm product meant to be used as grain crop. Depending on the level of the pressure on land, some farmers harvest melon fruits as soon as leaves senesce while others may not gather the fruits until much later. In ecologies in which rainfall is bimodial, 'egusi' melon crop is produced during the long and short rainy seasons.

There is paucity of knowledge in respect of when it is best to harvest egusi melon fruits in each season for optimum seed quality. Information seems lacking on the effects these different production seasons might have on the quality of *Citrullus lanatus* seeds. This study was therefore conducted to determine the effect step-wise harvesting of egusi melon might have on seed development and maturation in two different seasons.

MATERIALS AND METHODS

Early and late season crops of 'egusi' melon [*Citrullus lanatus* (Thunb.) Matsum and Nakai] were produced at the Crop Teaching and Research farm of the University of Agriculture Makurdi, Nigeria in 2005 and 2007. Makurdi is located on Latitude 07.41^0 N, Longitude 08.37^0 E and Altitude106.4 m above sea level. Planting was done on 4^{th} May and 2^{nd} September in 2005 and on 25^{th} April and 1^{st} September in 2007 for the early and late season crops respectively. Bulk crop was raised and each female flower was date tagged at anthesis to monitor fruit age. In 2005, fruits that developed from the tagged flowers were harvested at three days interval starting from 20 to 47 days, *i.e.* 20, 23, 26, 29, 32, 35, 38, 41, 44 and 47 days after anthesis (DAA). In 2007 however, harvesting was done at three days interval from 14 to 41 DAA (*i.e.* 14, 17, 20, 23, 26, 29, 32, 35, 38 and 41 DAA). The variation effected on time of harvest in 2007 was necessary to ascertain the exact point in time at which seeds acquired the capability to germinate since the 2005 study revealed that some germination was recorded at 20 DAA which was the earliest harvest age.

At each interval of harvest, fruits were allotted at random into three replicates. Measurements were then made on fruit length, diameter and weight before the fruits were broken to initiate the decomposition process. Thereafter, seeds were extracted, washed and dried. Dry seed weight per fruit, 100-seed weight and germination percentages were then determined to test the longevity of the seeds. In 2005, seed packaging was done in polyethylene bags at a moisture content of about 7% and stored at approximately 32^0 C and 40% relative humidity. Germinability was tested after one, two, and three years of storage. Germination tests made immediately before and during storage, were conducted on four replicates of 50 seeds each, spread over distilled water-moistened absorbent paper in Petri dishes and incubated at 30^0 C for 28 days. Counts were taken every other day.

RESULTS

Analysis revealed that fruit age (i.e. days after anthesis-DAA) significantly influenced fruit length, diameter and weight as well as dry seed weight per fruit, 100-seed weight and germination percentage in both years (Table 1). Season had significant effects on only dry seed weight per fruit, 100-seed weight, and germination percentage in 2005. However, in 2007 it significantly affected all parameters except the 100-seed weight and germination percentage. The interaction of fruit age and season significantly affected fruit length and 100-seed weight in 2005 and fruit length, fruit weight and dry seed weight per fruit in 2007.

Table 1 Mean squares from analysis of variance for fruit and seed attributes of *Citrullus lanatus* harvested at different days after anthesis (DAA) in the wet and dry seasons of 2005 and 2007.

Sources of variation	Fruit length	Fruit diameter	Fruit weigh	Dry seed wt./fruit	100-seed wt.	Germ. %
2005						
Replications	0.196ns	0.218ns	0.062ns	7.830ns	0.231ns	118.691ns
Fruit age (F)	2.031**	1.538**	0.090**	140.993**	28.540**	773.903**
Season (S)	0.341ns	0.068ns	0.004ns	54.626**	37.747**	9010.013**
S x F interaction	0.241*	0.104ns	0.013ns	5.027ns	0.292**	71.910ns
Error	0.101	0.162	0.022	3.033	0.097	51.906
Total	0.424	0.364	0.032	25.418	5.108	252.367
2007						
Replications	0.019ns	0.655ns	0.005ns	1.424ns	2.659ns	35.295ns
Fruit age (F)	2.216**	2.548**	0.121**	462.337**	29.419**	3433.211**
Season(S)	57.977**	36.926**	2.851**	603.498**	0.247ns	121.697ns
S x F interaction	0.213*	0.085ns	0.032**	22.214**	1.475ns	310.799ns
Error	0.086	0.245	0.007	6.707	3.818	59.053
Total	1.409	1.207	0.076	885.122	7.266	472.021

*ns, *,** = non significant, significant at P = 0.05 and P = 0.01, respectively, ANOVA*

Table 2 Length (cm) of *Citrullus lanatus* fruits harvested at different days after anthesis in the dry and wet seasons of 2005 and 2007.

2005		**2007**	
Days after anthesis (DAA)	**Fruit length (cm)**	**Days after anthesis (DAA)**	**Fruit length (cm)**
20	11.12 d	14	11.57 c
23	12.23 c	17	11.69 c
26	12.80 b	20	12.69 b
29	12.86 ab	23	12.71 b
32	12.68 bc	26	12.79 ab
35	12.73 bc	29	13.16 ab
38	13.34 a	32	13.06 ab
41	12.66 bc	35	13.22 a
44	12.60 bc	38	13.03 ab
47	12.80 b	41	13.24 a
Seasons (S)		**Seasons (S)**	
Wet	12.51 a	Wet	13.70 a
Dry	12.66 a	Dry	11.73 b
DAA x S	*	DAA x S	*

Means followed by the same alphabet in each year and DAA / S are not significantly different using DMRT at 5% probability level.

In both years, there were significant increases (P<0.05) in fruit length between 20 and 26 DAA (Table 2). Beyond this point, no further significant increases were recorded. Though significant differences were not generally recorded between seasons in 2005, Table 3 shows that fruits harvested at 23 DAA were longer in the wet than in the dry season.

Table 3 Interaction effects of season and days after anthesis on fruit length (cm) of *Citrullus lanatus* in 2005 and 2007.

2005			2007		
DAA	Fruit length (cm)		DAA	Fruit length (cm)	
	Wet season	Dry season		Wet season	Dry season
20	10.86 f	11.38 f	14	12.19 de	10.94 h
23	12.51 cd	11.95 e	17	12.40 d	10.98 h
26	12.61 cd	12.99 abc	20	13.60 c	11.78 efg
29	12.68 bcd	13.03 abc	23	13.89 bc	11.53 g
32	12.38 de	12.99 abc	26	13.91 bc	11.67 fg
35	12.81 bcd	12.65 cd	29	14.15 ab	12.17 de
38	13.49 a	13.18 ab	32	14.10 ab	12.02 def
41	12.38 de	12.94 bc	35	14.25 ab	12.20 de
44	12.55 cd	12.65 cd	38	14.08 abc	11.98 defg
47	12.80 bcd	12.80 bcd	41	14.42 a	12.05 def

Means followed by the same alphabet in each year and DAA / S are not significantly different using DMRT at 5% probability level.

Significant increases in fruit diameter were recorded in the wet season of 2005 between 20 and 23 DAA with no further significant increases afterward (Figure 1). In the dry season, a significant increase in fruit diameter was not recorded until 26 DAA. However, the value obtained at this point was not significantly different from those recorded thereafter. In 2007, Figure 2 shows that the values obtained at 26 DAA during the wet season were significantly greater than those at 14, 17 and 20 DAA but not significantly different from those of fruits harvested later. In the dry season, though there were progressive increases in fruit diameter with age, a significant increase was only recorded at 26 DAA compared to the value at 14 DAA. Fruit diameter was significantly greater in the wet season than in the dry season.

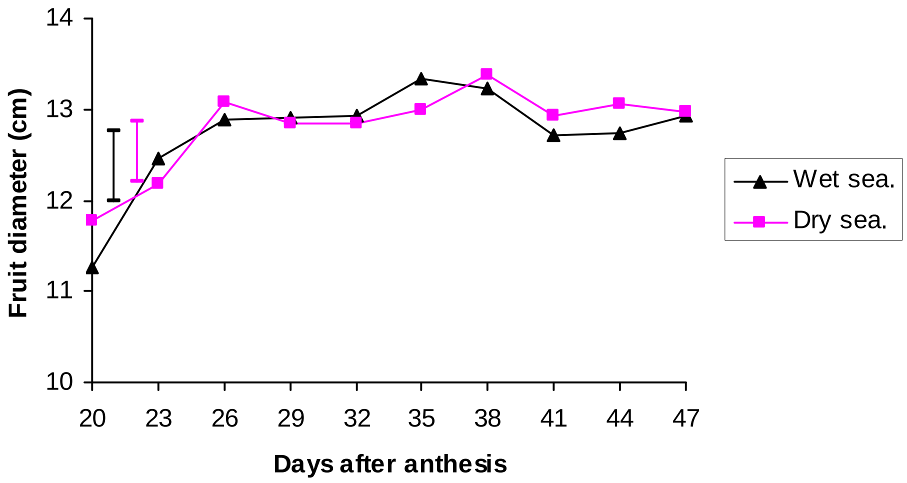

Fig. 1 Variations in average fruit diameter (cm) of *Citrullus lanatus* harvested at different days after anthesis in the wet and dry seasons of 2005.
LSD at P = 0.05

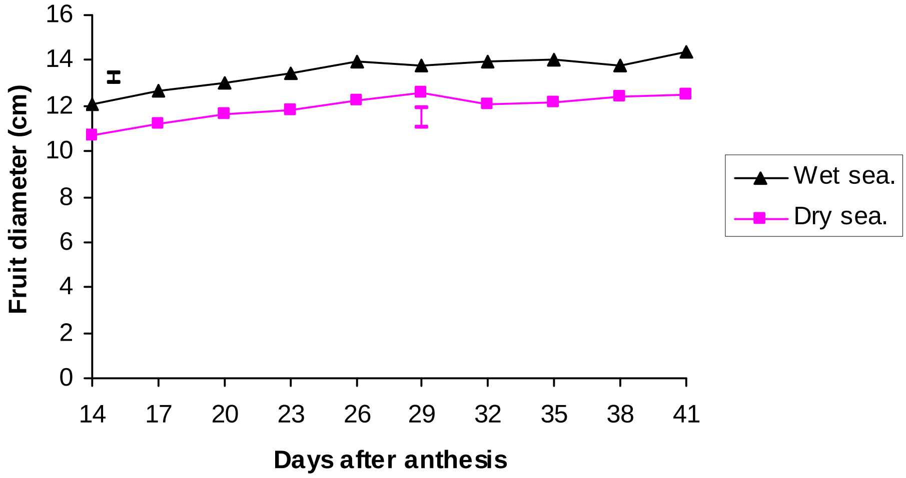

Fig. 2 Variations in average fruit diameter (cm) of *Citrullus lanatus* harvested at different days after anthesis in the wet and dry seasons of 2007.
LSD at P = 0.05

Table 4 shows that in 2005, fruits harvested at 26 DAA were heavier than those at 20 DAA but were similar in weight to those harvested later. In 2007, fruits produced in the wet season were significantly heavier compared to the dry season fruits. Also, the heaviest fruits were obtained at 41 DAA but the value was not significantly different from those at 26 to 38 DAA as shown in Table 5.

Table 4 Weight of *Citrullus lanatus* fruits harvested at different days after anthesis in the wet and dry seasons of 2005 and 2007

2005		2007	
Days after anthesis (DAA)	**Fruit weight (kg)**	**Days after anthesis (DAA)**	**Fruit weight (kg)**
20	0.83 c	14	0.77 e
23	1.00 bc	17	0.90 de
26	1.15 ab	20	1.01 cd
29	1.08 ab	23	1.07 bc
32	1.12 ab	26	1.11 abc
35	1.15 ab	29	1.20 ab
38	1.30 a	32	1.09 abc
41	1.17 ab	35	1.17 ab
44	1.09 ab	38	1.17 ab
47	1.13 ab	41	1.22 a
Seasons (S)		**Seasons (S)**	
Wet	0.88 c	Wet	1.29 a
Dry	1.00 bc	Dry	0.85 b
DAA x S	Ns	DAA x S	**

Means followed by the same alphabet in each year and DAA / S are not significantly different using DMRT at 5% probability level.

Table 5 Interaction effects of season and days after anthesis on fruit weight (kg) of *Citrullus lanatus* in 2007

	2007	
DAA	**Fruit weight (kg)**	
	Wet season	**Dry season**
14	0.90 efg	0.65 i
17	1.02 e	0.78 hi
20	1.16 d	0.85 gh
23	1.26 cd	0.88 fgh
26	1.39 abc	0.82 gh
29	1.40 ab	1.04 ef
32	1.33 bc	0.85 gh
35	1.49 a	0.84 gh
38	1.41 ab	0.92 efg
41	1.52 a	0.92 efg

Means followed by the same alphabet in the column and DAA / S are not significantly different using DMRT at 5% probability level.

In both seasons of 2005, dry seed weight increased progressively throughout the production period (Figure 3). Furthermore, fruits yielded more seeds in the dry season compared to the wet season. Contrary to what obtained in 2005 however, Table 6 shows that production during the wet season resulted in greater seed yield per fruit in 2007 though the effect of season was not significant at both 14 and 17 DAA.

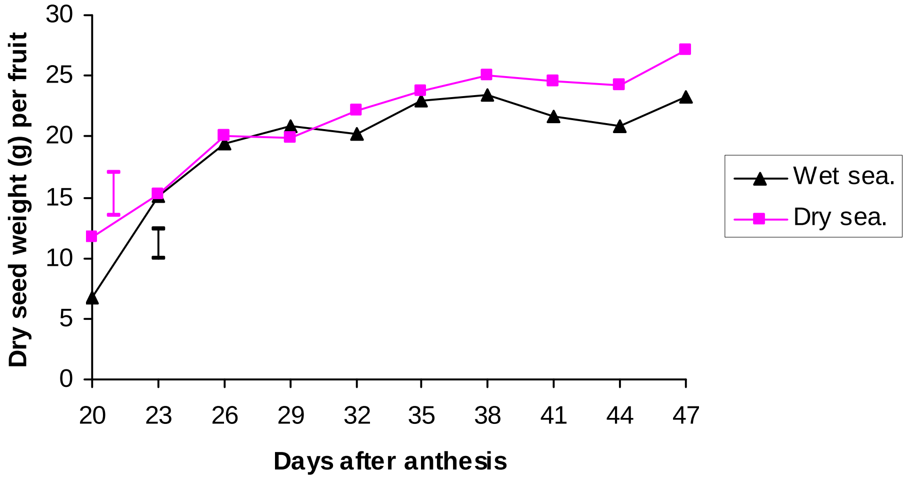

Fig. 3 Variations in dry seed weight (g) of *Citrullus lanatus* harvested at different days after anthesis in the wet and dry seasons of 2005
LSD at P = 0.05

Table 6 Interaction effects of season and days after anthesis on dry seed weight (g) per fruit of *Citrullus lanatus* produced in 2007

	2007	
DAA	**Dry seed weight per fruit (kg)**	
	Wet season	**Dry season**
14	3.000 ij	1.480 j
17	6.500 h	5.750 hi
20	12.000 g	7.760 h
23	17.60 f	11.67 g
26	24.30 d	13.72 g
29	26.70 bcd	19.48 ef
32	25.30 cd	20.56 ef
35	29.30 b	20.43 ef
38	27.60 bc	21.17 e
41	34.10 a	20.95 e

Means followed by the same alphabet in the column and DAA / S are not significantly different using DMRT at 5% probability level.

Table 7 Interaction effects of season and days after anthesis on 100-seed weight of *Citrullus lanatus* produced in wet and dry seasons of 2005.

	2005	
DAA	**100-seed weight (g)**	
	Wet season	**Dry season**
20	3.70 k	5.72 j
23	6.08 j	7.98 i
26	7.73 i	9.65 g
29	8.80 h	10.48 de
32	10.13 efg	10.69 cd
35	9.90 fg	11.19 c
38	10.11 efg	11.87 ab
41	10.58 de	11.83 b
44	10.55 de	12.35 a
47	10.17 ef	11.86 ab

Means followed by the same alphabet in the column and DAA / S are not significantly different using DMRT at 5% probability level.

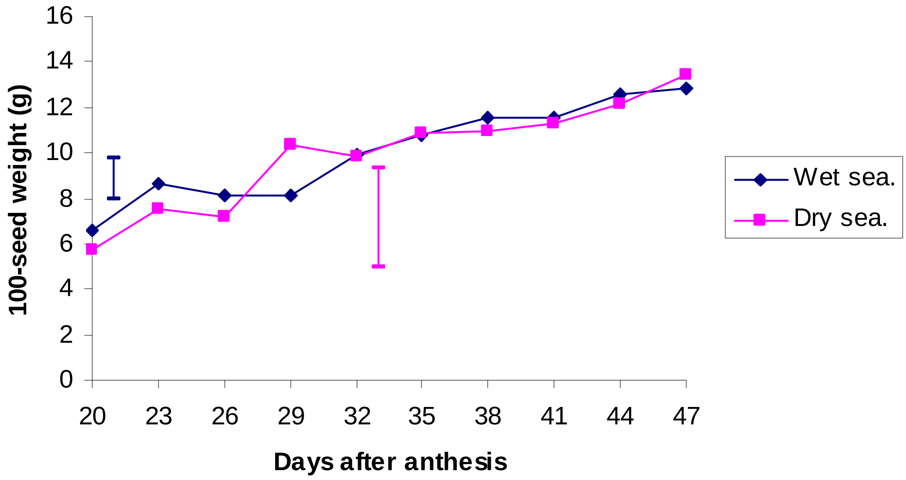

Fig. 4 Variations in 100-seed seed weight (g) of *Citrullus lanatus* harvested at different days after anthesis in the wet and dry seasons of 2007

LSD at P = 0.05

In the wet season of 2005, there was significant increase in 100-seed weight from 20 to 32 DAA; the changes thereafter were generally insignificant (Table 7). In the dry season, significant increases in 100-seed weight were still recorded up to 38 DAA. Seeds therefore filled for longer period in the dry season than in the wet season. Seeds produced during the dry season were also significantly heavier than the ones produced during the wet season. Furthermore, the Table shows that seed development appeared faster in the dry season. In 2007, Figure 4 reveals that 100-seed weight also increased all through the production period in both seasons but there was no significant difference between seasons. However, during the wet season the differences among the 100-seed weight values obtained from fruits harvested from 32 to 41 DAA were significant. In the dry season, significant increase in 100-seed weight was only obtained at about 29/35 DAA. Seeds harvested beyond this stage were not significantly different in weight.

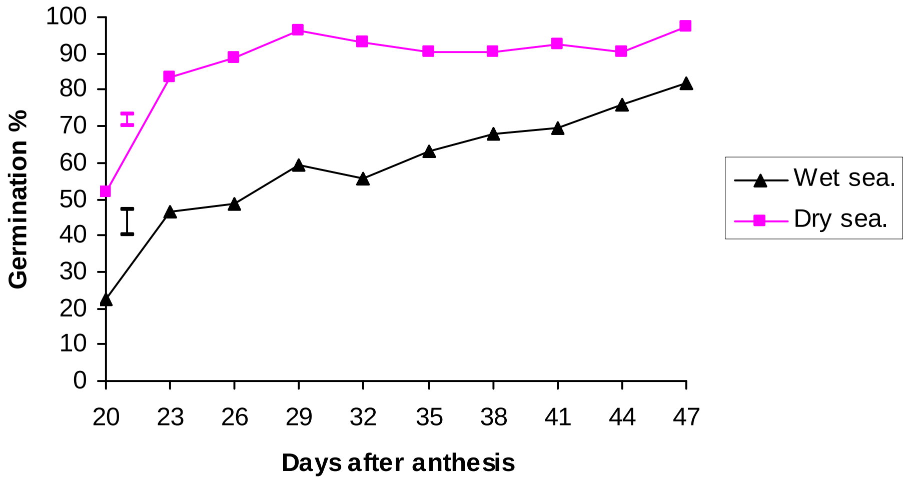

Fig. 5 Variations in germination percentage of *Citrullus lanatus* harvested at different days after anthesis in the dry and wet seasons of 2005.

LSD at P = 0.05

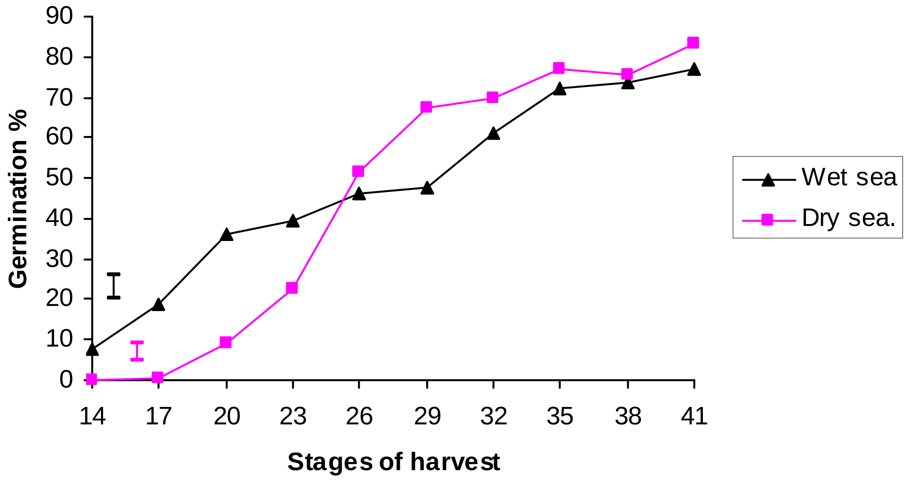

Fig. 6 Variations in germination percentage of *Citrullus lanatus* harvested at different days after anthesis in the dry and wet seasons of 2007.
LSD at P = 0.05

A general progressive improvement in germination was observed throughout seed development period in the wet season of 2005 (Figure 5). In the dry season, significant increases in germination were recorded from 20 up to 29 DAA with a further significant increase between 44 and 47 DAA. Seed produced in the dry season germinated better than those produced during the wet season. In 2007, seed germination generally improved with DAA (Figure 6) in both seaons; however, contrary to the trend recorded in 2005, there was no consistent effect of season on germination level.

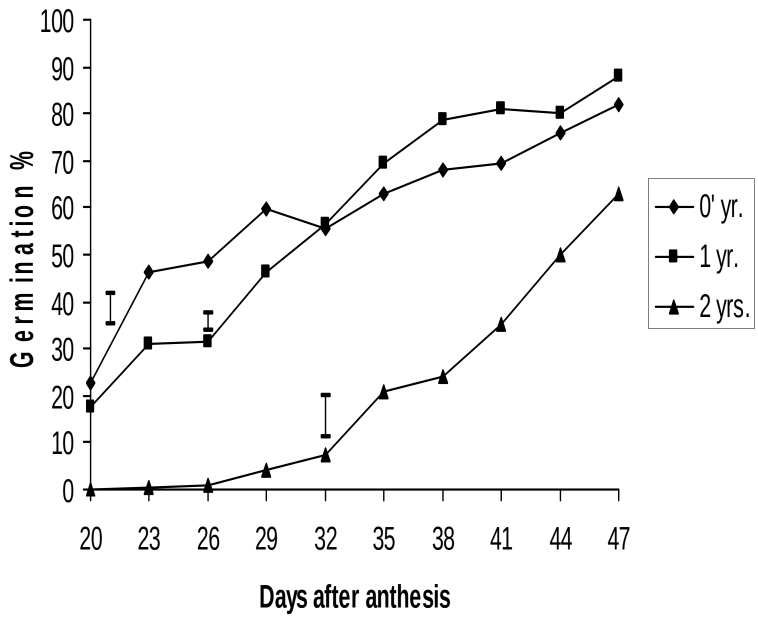

Fig. 7 Variations in germination of wet season *Citrullus* Variations in germination of dry season *Citrullus lanatus* harvested in 2005 at different days after anthesis and tested before and after storage for one and two years respectively under ambient conditions.
LSD at P = 0.05

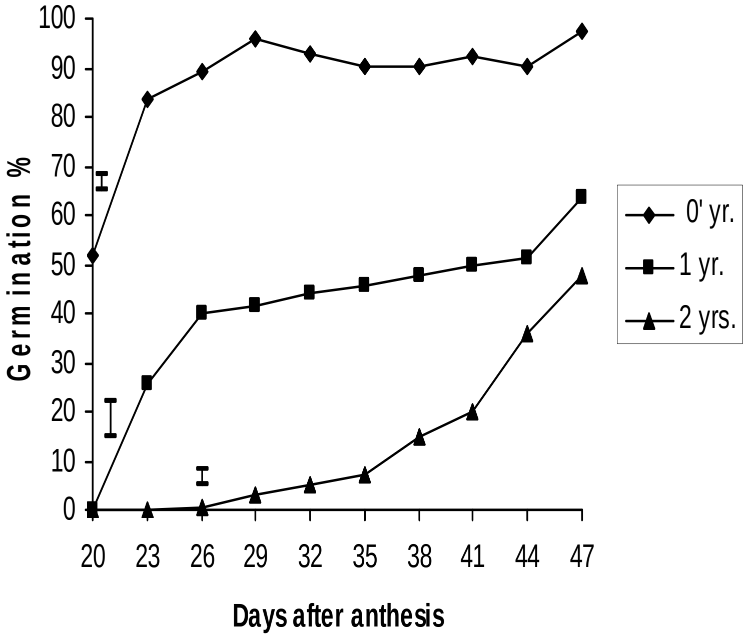

Fig. 8 Variations in germination of dry season *Citrullus lanatus* harvested in 2005 at different days after anthesis and tested before and after storage for one and two years respectively under ambient conditions.
LSD at P = 0.

Germination of fresh and stored seeds

Figures 7 and 8 show the germination percentage of freshly harvested and stored seeds of *C. lanatus* produced during the wet and dry seasons in 2005. A decline in germination was recorded following one and two years of storage irrespective of DAA or season. After one year of storage, only seeds produced during the wet season and harvested at 44 and 47 DAA gave about 70% germination which is the least allowable germination percentage acceptable in egusi melon seed trade.

DISCUSSION

The increase in the values recorded for fruit and seed traits as time progressed up to 26 and 38 DAA irrespective of season in this study, is an indication of progressive increase in the accumulation of assimilates during fruit/seed maturation. This is in agreement with reports by Mayer *et al.* (1991), Goldberg *et al.* (1994), Raz *et al.* (2001) and Bentsink and Koornneef (2008). Natrajan and Srimathi (2008) also reported that increase in Petunia pod weight with increase in DAA was supported by increase in pod length and width due to the development from zygote to matured seeds.

Seed yield per fruit and 100-seed weight were higher in the dry season than in the wet season in 2005. In 2007, scores of all *Citrullus lanatus* fruit attributes measured were greater in the wet season compared to those in the dry season. The higher precipitation recorded during the first two months of production in the dry season months of 2007 must have been responsible for the poorer fruit development recorded during that season compared to the performances in the wet season during which precipitation was lower. Cucurbit growers are warned to always avoid periods of plentiful precipitation, as they are known to result in the production of poor fruit yield (De Lannoy, 2001).

According to Thuzar, *et al*. (2010), higher temperature during crop development shortened soybean seed filling duration (SFD). The faster seed development recorded for *Citrullus lanatus* in 2005 in this study during the dry season compared to the wet season could be linked to the higher temperature recorded in the former. However, contrary to what was reported for lettuce by Gray *et al*. (1988) and for soybean by Thuzar *et al.* (2010), higher temperature did not result in the production of lighter seeds in this study. The current observation is also contrary to that reported by Sinniah *et al*. (1998) in which plants grown under water stress during the seed filling phase produced smaller seeds. The superiority in the germination of seeds produced during the dry season of 2005 over those produced during the wet season could be linked to the differences in seed weight. Bigger seeds are known to normally germinate higher than smaller ones. This is in agreement with Gelmond and Peles (1975) who reported that larger seeds of muskmelon germinated better than smaller ones. Pantipa *et al.* (2002) also found seeds of onion (*Allium cepa* L.) with bigger diameters to germinate better than smaller ones. Furthermore, Gabriel *et al.* (2009) reported that large seeds of cowpea (*Vigna unguiculata*) produced higher germination than small seeds. The higher seed yield recorded in the wet season of 2007 in the current study could be attributed to the lower temperature regime during fruit development. Lower temperature is known to enhance seed development (Duthion and Pigearie, 1991). The reversed trend in 2005 is an indication that other factors may be involved.

The superiority in the longevity of more matured seeds over the less matured ones in this study agrees with what has been reported by other workers. Demir and Ellis (1993) reported that the longevity of marrow seeds was best in fruits collected at the end of maturation period. Similarly, Oluoch and Welbaum (1996) working on muskmelon recorded better seed longevity in fruits harvested when plants had aged. In addition, mature watermelon seeds have been reported to retain high germinability for 10 years whereas immature and half-mature seeds declined in germinability earlier. Oladiran and Kortse (2002) and Demir *et al*. (2004) also reported the superiority of more mature seeds over immature ones. The decline in seed viability over a storage period of one to two years respectively is indicative of seed deterioration which is linked with disruption of cell organelles due to free radical production in the cells of embryos (Sung and Jeng, 1994; Sung, 1996).

It is therefore recommended that for optimum seed quality, harvesting of *Citrullus lanatus* fruits should be delayed until when all leaves on the plant are dry (about 47 DAA). Furthermore, seed crop of *Citrullus lanatus* should be preferably produced during the wet season for high seed vigour.

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