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Seed Production Environment and Potential Seed Longevity of Rain-fed Sesame (*Sesamum indicum* L.) Genotypes

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ABSTRACT

Variability and adaptability of potential seed longevity were investigated in 14 sesame genotypes grown in three plant population environments in South Western Nigeria in each of the two cropping seasons. Seeds obtained from these genotypes were subjected to accelerated aging test using methanol-aging techniques. Data obtained were subjected to analysis of variation and differences, means separation at 5% probability level and stability test. The test genotypes exhibited significant differences in seed longevity in five out of the six environments. Genotype 73A-11 had distinct seed longevity potential in all the environments except in 266,667 plants ha^{-1}. The stability analysis result indicated that regression coefficients ranged from 0.05-2.06 and were statistically close to unit. Four genotypes, 73A-11, 93A-97, E8 and CK2 were desirable with high seed longevity potential in all the environments. Genotype 73A-11, 93A-97, E8 and CK2 were identified as desirable genotypes with potential for high longevity in any of the three plant population densities. The result further identified 73A-11, 93A-97, E8, CK2 and Pbtil as being most appropriate in 133,333 plants ha^{-1} and all the genotypes except 93A-97, Type A, 530-6-1 and 69B-882 in 166,667 plants ha^{-1} while all the genotypes except Type A, 530-6-1 would be appropriate in 266,667 plants ha^{-1}. The identified genotypes were superior in seed longevity potential and hence could be considered in commercial seed production and future seed improvement programme.

Key words: Seed quality, plant population, seed improvement, variability, stability

INTRODUCTION

Sesame (*Sesamum indicum* L.) is an ancient oil crop supplying seeds for confectionery purposes, edible oil, paste, cake and flour. It is typically a crop of small farmers in the developing countries. It is adapted to tropical and temperate conditions, grows well on stored soil moisture with minimal irrigation or rainfall, can produce good yield under high temperature and its grain has a high value (Delgado and Yermanos, 1979).

Sesame production areas in Nigeria have remained generally stable over the years until recently when it was introduced to South-West, Nigeria. Competition from more remunerative crops, low yield potential, poor filed establishment, problem of harvesting and high labour cost have pushed sesame to less fertile fields and to areas of higher risk, if left unchecked, production may decrease in the foreseeable future. This provides an opportunity to produce larger quantities of high quality sesame seed to farmers. One aspect of seed performance, which shows variation, is the seed longevity (Uzoh, 1998).

Wide fluctuation in the seed yield and quality of seed obtainable in sesame from year to year has been reported by Adebisi *et al.* (2003, 2004). As a consequence, target plant population densities may not be met, even when an appropriate seed rate is used. The fluctuation can be traced to the use of seed of very poor quality resulting from unfavourable environmental factors, poor nutrition of mother plant, infection of plant diseases and the level of plant protection, poor storage life, high deterioration rate among others (Adebisi *et al.*, 2005).

According to Heydecker (1972), the response of seeds to any stress will be the representative of their ability to cope with other stress while the response will differ from one condition to another. Crop genotypes are known to differ genetically in their stability across environments. An ideal variety is the one that combines high seed quality with stability of performance (which is mostly attributable to an acceptable phenotype over a wide range of environmental conditions (Allard and Bradshaw, 1964).

Stability of seed longevity is of special importance under rain-field conditions in under-developed countries where environmental conditions vary considerably and the means of modifying the environment are far from adequate and expensive. The findings of Adebisi and Ajala (2008) in seed yield and quality stability proved that the method could efficiently be used to analyse the responses of different varieties under various conditions. The data may help in choosing the best genotype for any given environment and cultivation conditions.

Therefore, this study was designed to determine the extent of variability and stability of seed longevity in some Nigerian sesame genotypes grown under different plant population densities in the southwest, Nigeria and to identify those genotypes, with high seed longevity potential under such unstable environment.

MATERIALS AND METHODS

Seeds of fourteen sesame genotypes sourced from the National Cereals Research Institute, Badeggi, Niger State, Nigeria, were evaluated in trials conducted at the Teaching and Research Farm of the University of Agriculture, Abeokuta (7° 15'N, 3° 25'E). Seeds of the 14 sesame were grown under three plant populations during the rainy seasons of 2001 and 2002 constituting six environments as follows: Environment 1 = 50-15 cm (133,333 plants ha^{-1}) and Environment 2 = 60-10 cm (166,667 plants ha^{-1}) and Environment 3 = 75-5 cm (266,667 plants ha^{-1}).

The average rainfall for the two seasons ranged from 500 mm $annum^{-1}$ in 2001 to about 800 mm annum in 2002. At each plant population and in each season, the 14 entries were arranged in randomized complete blocks with three replications. Sowing was done by hand in 4-row plots of 3m long and spaced 50-15, 60-10 and 75-5 cm. Seeds were mixed with sand and hand-dried while seedlings were thinned at three weeks after sowing to about 15, 10 and 5 cm between plants.

Following thinning, a post-emergence fertilizer application of NPK 15:15:15 was applied by drilling at the rate of 60 kg N, 30 kg P_2O_5 and 50 kg K_2O ha^{-1}. Weeding was carried out twice, before and after fertilizer application. The experimental fields were well-drained sandy-loamy soil with a pH range of 6.81 to 7.80, N status between 0.07 and 0.14%, organic matter between 1.42 and 2.86% and C status between 0.82 and 1.66%. Seeds harvested from each of the environments were evaluated in the laboratory for seed longevity using the procedure outlined by Musgrave *et al.* (1980) and Tiwari and Hariprasad, 1997. Three replicates of 100 seeds each per replicate were placed in a moist bucket chamber at room temperature for 2 days. Seeds were then soaked in 20% (v/v) aqueous solutions of methanol for 2 h followed by soaking in distilled water for 5 min. Seeds were placed in petri dishes for viability count after three days.

Data analysis: The analysis of variance (three-way ANOVA) was applied using GENSTAT statistical package to estimate and test for significance of year, plant population and genotype effects and first- and second-order interactions.

Stability parameters for each genotype were determined using the regression procedure of Eberhart and Russell (1966). Each genotype was defined by three values: (1) mean seed yield over all environments, (2) the linear regression (b values) of genotype mean seed yield in each environment and (3) the mean square deviation (S^2d value). Significance of regression coefficient (b values) was tested by the Student's t test. For the regression ANOVA, the residuals from the combined ANOVA were used as a pooled error to test the significance of the S^2d values (Osman, 1991). A significant f-value would indicate that S^2d was significantly different from zero. Co-efficient of determination (R^2 values) was computed from individual linear regression analysis (Pinthus, 1973).

RESULTS AND DISCUSSION

From the results in Table 1, the analysis of variance showed significant difference in seed longevity between plant population densities and genotypes while the season effect was not significant. The first-order interactions between population and season, genotype and season and genotype and population were highly significant revealing that the relative ranking of the sesame for seed longevity with respect to both plant population density and the season was not constant. The genotype varied in seed longevity between the seasons and the plant population density modulated seed longevity of the 14 sesame genotypes. The presence of second-order interaction of genotype×population×season indicated that there were significant changes in population effects over the season on seed longevity. These findings were in agreement with those of reported by Adebisi *et al.* (2008) for sesame seed quality in South West, Nigeria and (Ezzat *et al.*, 2010) in agronomic performance, genotype×environment interaction and stability analysis of grain sorghum.

The results presented in Table 2 shows that the 14 sesame genotypes recorded significant variation in seed longevity potential in five out of the six environments examined. From Table 2, genotype 93A-97, 73A-11 as well as E8 with seed longevity values of 80, 81 and 74%, respectively was significantly higher at 133,333 plants ha^{-1} during 2001 season while

Table 1: Analysis of variance of seed potential longevity of 14 sesame genotype harvested from six environments

Source of variation	df	Snm of squares	Mean square	F_{cal}
Replicate	2	698.32	349.16	24.74
Season (S)	1	55.25	55.25 ns	3.91
Error (a)	2	13.04	6.52	0.46
Population (Popl)	2	1758.34	879.17**	62.31
Popl×season	2	4057.62	2028.81**	143.78
Error (b)	8	415.04	51.88	3.68
Genotype (Gen)	13	4539.08	349.16**	24.74
Gen×season	13	2406.56	185.12**	13.12
Gen×popl	26	5148.00	198.00**	14.03
Gen×popl X Season	26	4662.58	179.33**	12.70
Error (c)	156	2201.16	14.11	
Total	251			
CV (%)			5.70	

*, **Significant at 5, 1% level, respectively, ns: Not significant

Table 2: Seed longevity of sesame genotypes grown at three plant population densities during 2001 and 2002 cropping season

	133,333 plants ha^{-1}		166,667 plants ha^{-1}		266,667 plants ha^{-1}	
Genotypes	S1	S2	S1	S2	S1	S2
Yandev 55	52^{d}	73^{ab}	81^{a}	76^{ab}	75^{b}	70^{a}
93A-57	80^{a}	76^{a}	78^{ab}	55^{e}	75^{b}	72^{a}
Goza	65^{c}	57^{d}	73^{bc}	68^{b}	79^{a}	67^{ab}
Type A	52^{d}	73^{ab}	44^{e}	68^{b}	78^{a}	56^{c}
73A-11	81^{a}	74^{ab}	79^{a}	75^{ab}	80^{a}	71^{a}
530-6-1	56^{d}	59^{d}	66^{c}	66^{cd}	80^{a}	53^{c}
73A-94	47^{e}	72^{ab}	79^{a}	73^{ab}	80^{a}	62^{b}
69B-88Z	51^{d}	65^{c}	62^{d}	61^{d}	75^{b}	70^{a}
E8	74^{ab}	74^{ab}	71^{b}	71^{b}	77^{ab}	67^{a}
Domu	49^{de}	78^{a}	68^{c}	73^{ab}	80^{a}	70^{a}
73A-97	60^{cd}	73^{ab}	59^{d}	78^{a}	76^{ab}	69^{a}
C-K-2	67^{bc}	72^{ab}	79^{a}	69^{b}	75^{b}	72^{a}
530-3	63^{c}	62^{cd}	42^{e}	55^{e}	80^{a}	71^{a}
Pbtil No1	68^{bc}	68^{bc}	67^{c}	68^{b}	78^{a}	58^{c}
Mean	62	70	68	68	78	66
CV (%)	7.55	6.3	5.70	6.0	5.50	6.50

Means in the same column followed by the same letter are not significantly different from one another at $p<0.05$, S1: 2001 cropping season, S2: 2002 cropping season

73A-94 (44%) and Domu (49%) were among the genotypes with lower seed longevity potential. During 2002 season, out of 33,333 plants ha^{-1}, two genotypes 93A-57 (76%) and Domu (78%) recorded distinct higher seed longevity whereas Goza (57%), 530-6-1 (59%) was among genotypes with low seed longevity potential. At 166,667 plant ha^{-1}, only genotypes Yandev 55 (81%), 73A-94 (79%), 73A-11 (79%) and C-K-2 (79%) were identified with remarkable and significantly higher seed longevity in 2001 while Type A (44%) and 530-3 (42%) had low seed longevity in the same season. However, in 2002, genotypes 73A-97 (78%), followed by Yandev 55 (76%), 73A-11 (75%), 73A-94 (73%) and Domu (73%) had significantly higher seed longevity potential whereas 530-3 and 93A-57 with 55% values recorded significantly low seed longevity. Increasing the population to 266,667 plants ha^{-1}, the variations in seed longevity among the genotypes were not significant in 2001, in 2002. Five genotypes, Yandev 55 (70%), 93A-57 (72%), C-K-2 (71%), Domu (70%), 69B-88Z (70%), 530-3 (71%), 73A-97(69%) and E8 (67%) had significant higher seed longevity potential whereas Type A (56%) were among genotypes with significantly lower seed longevity. A cursory look of the population density means showed that 2001 season at 266,667 plants ha^{-1} had higher seed longevity which may be attributed to a better growth environment characterised greater solar radiation, good temperature, regular and adequate rainfall and favourable soil conditions.

Mean seed longevity of 14 sesame genotypes across two cropping seasons across three plants densities are presented in Table 3. Significant differences occurred among the genotypes within the cropping season. In 2001 cropping season, genotypes 73A-11 (80%), 93A-57 (78%), followed by E8 (74%), C-K-2 (73%) recorded significantly greater seed longevity whereas Type A with 58% was identified with low seed longevity potential. Similarly, in 2002 cropping season, genotypes, Yandev 55 (73%), 73A-11 (73%), Domu (73%), 73A-97 (74%) had significant higher seed longevity, closely followed by E8 (70%), C-K-2 (71%),) and 73A-94 (69%) while 530-6-1 (59%) recorded lowest seed longevity. From this Table 3, genotypes 73A-11, E8 and C-K-2 were identified with

Table 3: Mean potential seed longevity of 14 sesame genotypes under two cropping seasons across three plant population environment

Genotype	S1	S2
Yandev 55	69[d]	73[a]
93A-57	78[a]	68[b]
Goza	73[bc]	64[bc]
Type A	58[c]	66[bc]
73A-11	80[a]	73[a]
530-6-1	67[d]	59[d]
73A-94	68[d]	69[ab]
69B-88Z	63[e]	65[bc]
E8	74[b]	70[ab]
Domu	66[d]	73[a]
73a-97	65[de]	74[a]
C-K-2	73[b]	71[ab]
530-3	62[e]	63[c]
Pbtil No1	71[bcd]	65[bc]
Mean	69	68
CV (%)	2.05	2.45

Means in the same column followed by the same letter are not significantly different from at $p<0.05$, S1: 2001 cropping season, S2: 2002 cropping season

Table 4: Analysis of variance of Finlay-Wilkinson regression of potential seed longevity of 14 sesame genotypes in six environments

Source of variation	df	SS	Mean square	F_{cal}
Replication	12	125.40	10.45 ns	0.76
Genotype (Gen)	13	4539.08	349.16**	25.37
Environment (Env) (Linear)	5	5871.20	1174.24**	85.34
Gen X Env. Linear	65	12217.40	187.96**	13.66
Pooled Error	156	2146.56	13.76	

*, **Significant at 0.05 and 0.01 levels of probability, respectively, ns: Not significant

consistent superior seed longevity potential in each of the seasons. These genotypes deserve a better place in future seed improvement strategies. Hassanpanah (2010) also showed that Agria and Caesar cultivars had high tuber yield in all sites and for the four different irrigation regimes for two years in an experiment conducted to determine the yield performance and stability of three potato cultivars and four irrigation regimes in six environments.

The joint regression analysis revealed that the G×E (Linear) effect due to environment showed significant differences between regression coefficients pertaining to the regression of genotype seed longevity on environmental seed longevity. The result showed that there were differences among slopes of regression lines and the regression model was adequate in describing the stability of the sesame genotypes Table 4. Similar findings were earlier reported by Osman (1991) and Adebisi (2010) for seed yield of rain-fed sesame and seed quality (germination and field emergence) of sesame. Also, Tiawari *et al.* (2011) reported similar result in Genotype×Environment interaction and stability analysis in elite clones of sugarcane.

Mean seed longevity and estimates of stability parameters in 14 sesame genotypes at six environments are shown in Table 4. Since the environment sum of squares contributed to the regression sum of squares, Adebisi and Ajala (2008) reported that linear regression accounted for 84-99, 7-82 and 0-89% of the variations in seed yields, seed germination and field emergence of sesame, respectively.

Table 5: Mean potential seed longevity and estimates of stability parameters in 14 sesame genotypes at six environments

Genotype	Mean seed longevity	R^2	Fwb	S^2d	T
Yandev 55	71^b	0.37	1.15 ns	0.75 ns	1.53
93A-57	73^b	0.01	0.16 ns	0.85 ns	0.19
Goza	68^c	0.30	0.79 ns	0.60 ns	1.32
Type A	62^d	0.53	1.80 ns	0.87 ns	2.13
73A-11	77^a	0.06	0.05 ns	0.37 ns	0.12
530-6-1	63^d	0.72	1.55*	0.49**	3.18
73A-94	68^c	0.63	2.06*	0.78**	2.63
69B-88Z	64^d	0.70	1.33*	0.44**	3.05
E8	72^a	0.26	0.37 ns	0.31 ns	1.19
Domu	70^{bc}	0.71	1.73*	0.55 ns	3.16
73A-97	69^c	0.40	1.0 ns	0.61 ns	1.64
C-K-2	72^a	0.25	0.41 ns	0.35 ns	1.16
530-3	62^d	0.21	1.10 ns	1.08 ns	1.02
Pbtil No1	68^{bc}	0.45	0.80 ns	0.45 ns	1.79
Mean	69		1.00		

Means in the same column followed by the same letter are not significantly different from one another at $p<0.05$. *, **significant at 0.05 and 0.01 levels of probability, ns: Not significant. R^2: Coefficient of determination, S^2d: Mean square deviation from regression, T: 't' test value, Fwb: Finlay-Wilkinson regression coefficient

According to Eberhart and Russell (1966), a genotype considered stable should meet the criteria of high mean seed longevity with b equal to unit and S^2d approaching zero. Using these criteria, one genotype 73A-97 with regression coefficient of 1.00, S^2d approaching zero and with relatively high mean seed longevity (Table 5) could be considered widely adapted and stable and with ability to express longevity potential in an array of environmental conditions. This supports earlier findings by Osmanzai and Sharma (2008) for high yielding stable wheat genotypes for diverse environments in Afghanistan.

A desirable genotype is one with high mean, at least average performance in all environments and an undesirable genotype or below average performance in some environments. Following Choo *et al.* (1984) criteria and defining high mean seed longevity performance as at least 5% above the grand mean, only genotypes 73A-11, 93A-57, E8 and C-K-2 showed themselves to be desirable in all cropping seasons and plant density environments (Table 5). In 2003, Min and Saleh (2003) also reported Suwan 1 as the best performer for 100-grain weight among the 14 grain maize genotypes selected for stability performance in four different locations thus revealing average stability of the genotype.

Similarly, performance at individual plant density (Table 6) revealed that 73A-11, E8, 73A-97 and C-K-2 recorded above average longevity in each of the three plant densities examined in this study. Among these genotypes, only 73A-11, E8 and C-K-2 as indicated previously appeared to be the most desirable. It may thus be concluded that the regression analysis effectively identified 73A-97, 73A-11, E8 and C-K-2 as desirable genotypes that will give high seed longevity across an array of environments encountered in the south-west of Nigeria and similar rain-fed ecologies. However, when applied to individual plant density environment, the method used pointed out 93A-57, 73A-11, E8, 73A-97, C-K-2 and Pbtil as being most appropriate for cultivation in 133, 333 plants ha^{-1} and all the genotypes except 93A-57, Type A, 530-61 and 69B-88Z in 166,667 plants ha^{-1} and all the genotypes except Type A and 530-6-1 would be most suitable for cultivation in 266,667 plants ha^{-1} environments.

Table 6: Mean potential seed longevity under three plant population environments across two cropping seasons

Genotype	133, 333 plants ha^{-1}	166, 667 plants ha^{-1}	266, 667 plants ha^{-1}
Yandev 55	63^{e}	79^{a}	72^{bc}
93A-57	78^{a}	67^{cde}	74^{abc}
Goza	61^{ef}	71^{cde}	73^{abc}
Type A	63^{e}	56h	67^{ef}
73A-11	78^{a}	77^{ab}	76^{a}
530-6-1	57^{g}	66^{f}	66^{f}
73A-94	58^{fg}	76^{ab}	71^{cd}
69b-88Z	58^{fg}	62^{g}	73^{abc}
E8	74^{b}	71^{cde}	72^{bc}
Domu	64^{de}	71^{cde}	75^{ab}
73A-97	67^{cd}	69^{def}	73^{abc}
C-K-2	69^{c}	74^{bc}	74^{abc}
530-3	63^{e}	69^{def}	75^{ab}
Pbtil No1	68^{c}	68^{ef}	68^{def}
Mean	66	68	72
LSD (0.05)	3.85	3.90	4.05

CONCLUSION

The test genotypes showed considerable variations in potential seed longevity and were sensitive to factors limiting seed quality; hence their wider adaptability, stability and general performance to the fluctuations in the growing conditions within and across cropping seasons and plant density environments were considerably lowered. The stability analysis provides meaningful stability and consistency of performance of rain-fed sesame genotypes across different environments.

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