Stability Analysis of Seed Germination and Field Emergence Performance of Tropical Rain-fed Sesame Genotypes

Adebisi, Moruf Ayodele
Department of Plant Breeding and Seed Technology,
University of Agriculture, P. M. B. 2240, Abeokuta, Ogun State, Nigeria.
Tel.:+2348035842319. Email: mayoadebisi@yahoo.co.uk

ABSTRACT

The work was carried out to determine the stability of two seed quality traits (seed germination and field emergence) in 14 sesame genotypes that were grown in three plant population environments in Abeokuta, southwest Nigeria in each of two seasons. Seeds harvested from each environment were tested for these quality traits. Data obtained were subjected to analysis of variance of Finlay-Wilkinson regressions and stability analysis. Each genotype was defined by three stability parameters: (1) mean seed germination and field emergence over all environments, (2) the linear regression (b values) of genotype mean seed germination and field emergence in each environment, (3) the mean square deviation from the regression for each genotype (S^2d value). The genotypes varied considerably in the two seed quality traits and genotype x environment (GxE) interactions were significant. Regression coefficients ranged from 0.19 to 1.70 for seed germination and 0.14 to 3.01 for field emergence. Genotype 530-6-1 with a regression coefficient close to unit (b=1.03), smaller S^2d value and a relatively high seed germination of 79% had general adaptability and somehow averagely stable. The highest field emerging genotypes proved less stable and selection solely for high emergence could result in discarding many genotypes that were relatively better adapted to environmental changes. Genotypes 530-6-1, 73A-11 and C-K-2 were identified as desirable for seed production in all the three plant population environments. Genotypes 69B-88Z, Domu and 73A-97 were identified as desirable genotypes for cultivation in 133,333 plants ha $^{-1}$ environment, C-K-2 in 166,667 plants ha $^{-1}$ environment and 93A-97, 73A-11, 69B-88Z and C-K-2 in 266,667 plants ha $^{-1}$ environment to obtain seed of high and stable germination and emergence. These genotypes were superior in seed quality and therefore deserve a place in commercial seed production and future seed improvement strategies. [Report and Opinion. 2009;1(5):1-8). (ISSN: 1553-9873].

Keywords: environment, interaction, plant population, seed quality,

Introduction

Seed quality is defined as a standard of excellence in certain characters or attributes that will determine the performance of the seed when sown or stored (Hampton, 2002). It relates to the characteristics of seeds which result in the high field performance and eventually high seed/grain yield. Seed germination and field emergence have been identified as good indicators of seed quality in different crops.

Most of the quality characteristics are polygenically inherited, and will therefore be influenced by the environment to a large extent (Labuschangne *et al*., 2002). Studies have shown that seed quality can be largely influenced by a wide range of environmental factors during seed production, harvesting, processing, storage and treatments such as seed priming (Tektrony *et al*., 1980; McDonald, 2000; Adebisi and Ojo, 2001; Tesnier, 2002; Adebisi and Ajala, 2007). Those factors of the production environment which dictate the quality of seeds produced include temperature, available moisture during seed development and maturation, incidence of diseases and pests in the field and at storage, management practices, harvest and post-harvest seed handling (Tekrony *et al*., 1980; Adeyemo *et al*., 1998; Adebisi and Ojo, 2001).

Different attempts have been made to solve the problems created by genotype x environment interactions (Hanson *et al*., 1956; Comstock and Moll, 1963). Most of the estimates, however, only provide information on their existence and magnitude, but give no measurements of the individual genotype. Selection of stable genotype that performs consistently across environments can reduce the magnitude of these interactions. Besides, stability of sesame performance is of special importance under rain-fed conditions in developing countries where environmental conditions varied considerably and the technologies of modifying the environments are far from adequate (Adebisi, 2004). Interest has been focused on the regression analysis, an approach originally proposed by Yates and Cochram (1938) and later modified by Finlay and Wilkinson (1963) and Eberhart and Russel (1966). Regression analysis has been widely used in comparing and measuring genotypic performances of common bean (Beaver *et al.*, 1985), Soybean (Ojo, 2002 and Ojo *et al*., 2002), cashew (Adebola and Esan, 2002), navy bean (Gebeyehu and Assefa, 2003) and sesame (Adebisi, 2004)

Most of the sesame (*Sesamum indicum* L.) genotypes grown in the South-west Nigeria were selected based only on their desirable seed weight or yield per hectare with little or no reference to stability of seed quality performance. This has resulted in poor yield and quality of seed obtainable. Although sesame is grown in diverse plant population environments in Nigeria, there is currently no information on the seed quality stability and response of different tropical sesame genotypes under these environments. There is the need to identify outstanding genotypes with stable, desirable and superior seed quality for the farmers.

A genotype is stable if, at a given location or plant population it exhibits very little fluctuation in seed quality from year to year. An ideal sesame selection (genotype) is therefore one that combines high seed quality and stable performance in most of the ecological environments where it is cultivated. Therefore, the present work was conducted to determine the stability of seed germination and field emergence performance in some tropical rain-fed sesame genotypes grown in south-west Nigeria under three plant population environments and identify genotypes that performed well under such environments.

Materials and Methods

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 ($7^o15'N$, $3^o25'E$). Seeds of the 14 sesame genotypes were grown under three plant populations during the rainy seasons of 2001 and 2002. The treatments formed experimental environments as follows: Environment 1 = 50 cm x 15 cm (133,333 plants ha^{-1}), Environment 2 = 60 cm by 10cm (166,667 plants ha^{-1} and Environment 3 = 75 cm x 5 cm (266,667 plants ha^{-1}). The plant populations and seasons, therefore, constituted six environments.

The experimental fields were well-drained sandy-loamy soil with a pH range of 6.81 to 7.80, nitrogen status between 0.07% and 0.14%, organic matter between 1.42% and 2.86% and carbon status between 0.82% and 1.66 %. The average rainfall for the two seasons ranged from 500 mm annum $^{-1}$ in 2001 to about 800 mm annum^{-1} 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 four-row-plots of 3 m long and spaced 50 cm x 15 cm, 60 cm x 10 cm and 75 cm x 5 cm. Seeds were mixed with sand and hand drilled while seedlings were thinned at 3 weeks after sowing to about 15 cm, 10 cm 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 60kgN, 30kg P_20_5 and 50kg K_20 ha^{-1}. Weeding was carried out twice before and after fertilizer application.

Seeds harvested from each of the environments were evaluated in the seed laboratory for seed germination and field emergence thus:

Seed germination: The test was performed according to ISTA (1995). Three 100-seed replicates of each genotype were germinated in 11cm diameter petri dishes inside a moistened paper towels with 5ml of distilled water. The petri dishes were arranged inside an incubator at 30^0C temperature in a completely randomized design. After seven days of germination, the proportion of germinated seed (visibly emerged normal radicle) was expressed as normal germination percentage.

Field emergence: Four sub samples of 50 seeds for each genotype under each environment were hand-sown in furrows of 2.0m, 0.30m apart and 0.05m deep in the field. Soil medium was kept sufficiently wet for emergence. The number of emerged seedlings was counted at 14 days after sowing and expressed as percentage of seed sown.

Data Analysis

Data generated were firstly transformed using angular transformation (arcsine). and then subjected to analysis of variance of Finlay-Wilkinson regressions using GENSTAT (2001) 10.0 statistical package.

Stability parameters for each genotype were determined using the regression procedure of Eberhart and Russel (1966). Each genotype was defined by three values: (1) mean seed germination and field emergence over all environments, (2) the linear regression (b values) of genotype mean seed germination and field emergence in each environment, (3) the mean square deviation from the regression for each genotype (S^2d value). Significance of regression co-efficient (b-values) was tested by the student's t-test (Steel *et al*., 1997). For the regression analysis of variance, the residuals from the combined analysis of variance were used as a polled 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-efficients of determination (r^2 values) were computed from individual linear regression analysis (Pinthus, 1973).

Stimulation of current experiment by varying the number of plant density was used to determine the most efficient plant density for sesame seed quality testing under rain fed tropical conditions.

Results

Results of analysis of variance of Finlay-Wilkinson regressions for seed germination and field emergence are presented in Table 1. There were high significant mean squares for environment and genotype x environment interaction for seed germination and field emergence. Genotype effects were highly significant for seed germination and field emergence.

Stability parameters of seed germination of 14 sesame genotypes evaluated in six environments are presented in Table 2. Regression co-efficients ranged from 0.19 (for genotype 73A-97) to 1.70 (for genotype Type A). Six genotypes (Goza, Type-A, E8, Domu, C-K-2 and 530-3) had regression co-efficients greater than 1.0. One of these genotypes (C-K-2) had higher seed germination than the mean of all the genotypes. However, seven genotypes (73A-97, Pbtil No1, 69B-88Z, 73A-94, 73A-11, 93A-97 and Yandev 55) had regression co-efficients less than 1.0. Genotype 530-6-1 had regression co-efficient close to unit (b = 1.03).

Results in Table 3 show the stability parameters of field emergence of 14 sesame genotypes evaluated across six plant population environments. Regression co-efficients for field emergence trait ranged from 0.14 (for Pbtil No1) to 3.01 (for 73A-94). Eight genotypes (93A-97, 93A-11, Type-A, 530-6-1, 73A-94, Domu, 73A-97 and 530-3) had regression co-efficients higher than 1.0. Four of these genotypes (73A-11, 530-6-1, 73A-94 and 73A-97) had higher field emergence than the mean of all the genotypes. Regression co-efficients of Goza, 69B-88Z, Yandev 55, E8, C-K-2 and Pbtil No1 were less than 1.0 with field emergence below the mean of all the genotypes except for Yandev 55, 69B-88Z and C-K-2 which had higher mean than mean of all the genotypes.

As shown in Table 4, seed germination of the sesame genotypes showed significant differences in each of the three plant population environments. Genotypes 69B-88Z (78%), 530-6-1 (77%) and Domu (77%) as well as 73A-97 (76%) had higher seed germination at 133,333 plants ha^{-1}. Similarly, C-K-2 (80%), 73A-11 (78%), 93A-97 (78%), 530-6-1 (77%) and 73A-94 (77%) recorded remarkably higher seed germination at 166,667 plant ha^{-1} while 73A-97, Yandev 55, C-K-2, 73A-11 and 530-6-1 with seed germination above 80% were among genotypes with significant higher seed germination at 266,667 plant ha^{-1}.

In Table 5, 73A-97, 73A-94, Yandev 55, 73A-11, 69B-88Z and 530-6-1 were among genotypes that had significant greater field emergence at 133,333 plants ha^{-1} while Pbtill No1 (85%) followed by C-K-2 (75%) and E8 (71%) recorded significant higher emergence at 166,667 plants ha^{-1}. At 266,667 plants ha^{-1}, 73A-97, 5306-1, C-K-2and 93A-97 and 73A-11had significant higher emergence of 73, 71, 70, 69 and 69%, respectively.

Table 1: Analysis of variance of Finlay-Wilkinson regressions for seed germination and field emergence over 14 sesame genotypes in six environments.

Source of variation	DF	Mean Square Values	
		Seed germination	Field emergence
Replication	12	6.69	34.37
Genotype (Gen.)	13	195.61**	267.12**
Environment (Env) (Linear)	5	1069.90**	266.86**
Gen.xEnv.(Linear)		154.68**	147.49**
Pooled Error	156	11.33	18.08

** Significant at 0.01 level of probability ns = not significant

Table 2. Mean seed germination and estimates of stability parameters in 14 sesame genotypes evaluated over six environments

Genotype	+ Mean seed germination (%)	R^2	FWb	S^2d	T
Yandev 55	77^{a}	0.22	0.69^{ns}	0.64^{ns}	1.07
93A-97	76^{a}	0.23	0.57^{ns}	0.52^{ns}	1.09
Goza	68^{d}	0.44	1.47^{ns}	0.83^{ns}	1.78
Type-A	70^{cd}	0.68	1.70*	0.59^{ns}	2.88
73A-11	77^{a}	0.56	0.79^{ns}	0.35^{ns}	2.25
530-6-1	79^{a}	0.82	1.03**	0.24^{ns}	4.27
73A-94	73^{bc}	0.53	0.84^{ns}	0.40^{ns}	0.17
69B-88Z	76^{ab}	0.60	0.98^{ns}	0.40^{ns}	2.43
E8	71^{c}	0.91	2.31**	0.37^{ns}	6.22
Domu	72^{c}	0.41	1.58**	0.94^{ns}	1.68
73A-97	78^{a}	0.21	0.19^{ns}	0.52^{ns}	0.36
C-K-2	77^{a}	0.38	1.12^{ns}	0.71^{ns}	1.56
530-3	72^{c}	0.53	1.67^{ns}	0.08^{ns}	2.11
Pbtil No1	71^{cd}	0.07	0.21^{ns}	0.38^{ns}	0.56
Mean	74		1.00		

Mean values within a column with a letter superscript in common are not significantly different at $P < 0.05$
*, ** FWb value significantly different at 5% and 1% levels of probability respectively
FWb: Finlay-Wilkinson regression co-efficient,
R^2 = coefficient of determination
S^2d = Mean square deviation from the regression
t = 't' test value
+ Mean standard germination after angular transformation

Table 3. Mean field emergence and estimates of stability parameters in 14 sesame genotypes evaluated over six plant population environments

Genotype	+ Mean Field emergence (%)	R^2	FWb	S^2d	T
Yandev 55	67^{ab}	0.11	0.90^{ns}	1.27^{ns}	0.71
93A-97	62^{bc}	0.38	2.09^{ns}	1.33^{ns}	1.58
Goza	58^{c}	0.01	0.21^{ns}	0.94^{ns}	0.22
Type-A	59^{bc}	0.36	2.17^{ns}	1.44^{ns}	1.50
73A-11	68^{ab}	0.89	1.40**	0.23^{ns}	5.98
530-6-1	66^{b}	0.68	2.29*	0.79^{ns}	2.91
73A-94	66^{b}	0.73	3.01*	0.93^{ns}	3.25
69B-88Z	66^{b}	0.01	0.17^{ns}	0.90^{ns}	0.18
E8	63^{bc}	0.01	0.39^{ns}	1.78^{ns}	0.22
Domu	64^{bc}	0.78	2.29**	0.60^{ns}	3.77
73A-97	69^{a}	0.72	2.37*	0.74^{ns}	3.21
C-K-2	71^{a}	0.02	0.35*	1.32^{ns}	0.26
530-3	63^{bc}	0.66	2.80*	1.02^{ns}	2.76
Pbtil No1	61^{c}	0.00	0.14^{ns}	1.34^{ns}	0.10
Mean	65		1.00		

Mean values within a column with a letter superscript in common are not significantly different at $P < 0.05$
*, ** FWb value significantly different at 5% and 1% levels of probability respectively
FWb: Finlay-Wilkinson regression co-efficient,
R^2 = coefficient of determination
S^2d = Mean square deviation from the regression
t = 't' test value
+ Mean field emergence after angular transformation

Table 4. Performance of seed germination under three plant population environments over two cropping seasons.

	Seed germination (%)		
Genotype	133,333 plants ha-[1]	166,667 plants ha-[1]	266,667 plants ha-[1]
Yandev 55	72	74	84
93A-97	72	78	78
Goza	70	71	54
Type A	70	75	85
73 A-11	73	78	80
530-6-1	77	77	82
73A-94	69	77	74
69B-88Z	78	73	75
E8	71	73	68
Domu	77	75	65
73A-97	76	76	84
C-K-Z	74	80	80
530-3	70	76	71
Pbtil No1	71	70	74
Mean	73	75	75
Lsd(0.05)	5.19	5.52	5.45

Data presented according to method of Choo *et al.* (1984) of determination of stability of performance

Table 5: Performance of field emergence under three plant population environments over two cropping seasons.

	Field emergence (%)		
Genotype	133,333 plants ha-[1]	166,667 plants ha-[1]	266,667 plants ha-[1]
Yandev 55	69	68	64
93A-97	61	55	69
Goza	60	61	56
Type A	51	63	63
73 A-11	68	68	69
530-6-1	67	67	71
73A-94	71	61	65
69B-88Z	68	62	68
E8	53	71	54
Domu	65	63	63
73A-97	71	63	73
C-K-Z	66	75	70
530-3	59	62	66
Pbtil No1	60	85	65
Mean	64	66	65
Lsd(0.05)	4.41	5.02	5.19

Data presented according to method of Choo *et al.* (1984) of determination of stability of performance

Discussion

The results of joint regression analysis revealed that the GXE (linear) effect due to environment showed significant differences between regression co-efficients pertaining to the regression of genotype seed germination and field emergence on environmental seed germination and field emergence. The result revealed differences among slopes of regression lines and the regression model was adequate in explaining stability of the 14 sesame genotypes in respect of their seed quality (seed germination and field emergence). These observations are in agreement with that reported by Adebisi and Ajala (2006) for sesame seed yield in south- west Nigeria.

In this study, the coefficients of determination (R^2) ranged from 0..07 to 0.91 Since the environmental sum of squares contributed to the regression sum of squares, Moll *et al*., 1978 and Osman (1991) showed serious concern in the interpretation of R^2 values. Osman (1991) reported that linear regressions accounted for 76-99% of the variation in sesame seed yield. Similarly, Adebisi and Ajala (2006) observed that linear regression accounted for 0.65-1.25 of the variation in seed yield of Nigerian sesame genotypes. In this study, linear regressions contributed as much as between 07 and 91% of the variation in seed germination and between 01 and 89% in field emergence. The significant differences in b values suggested that all the 14 sesame genotypes responded differently to the different plant population environments. Variability in environments was an important factor and largely determined the usefulness of b values (Pfahler and Linskens, 1979).

The stability result of seed germination indicated that Goza, Type-A, 530-6-1, E8, Domu, C-K-2 and 530-3 had regression coefficients greater than 1.0, they were, therefore, sensitive to environmental changes in respect of seed germination. However, one of these genotypes (C-K-2) with higher seed germination than the overall genotype mean suggests that it could be recommended for cultivation under productive environments for higher seed germination. Genotypes 73A-97, Pbtil No1, 69B-88Z, 73A-94, 73A-11, 73A-97 and Yandev 55 had regression co-efficients less than 1.0. These genotypes were relatively better adapted to poor environment and were insensitive to environmental changes in respect of seed germination. Such genotypes could be recommended only for cultivation in unfavourable conditions. Also genotype 530-6-1 with regression co-efficient close to unit (b = 1.03) had general adaptability and somehow averagely stable.

For field emergence performance, genotypes 73A-11, Type-A, 530-6-1, 73A-94, Domu, 73A-97 and 530-3 had regression co-efficients above 1.0, and they were therefore sensitive to environmental changes for field emergence. Four of these genotypes (73A-11, 530-6-1, 73A-94 and 73A-97) recorded higher field emergence than the genotype mean, and hence, could be recommended for production under productive environments. Conversely, field emergence of six genotypes (Goza, 69B-88Z, Yander 55, E8, C-K-2 and Pbtil No1) had regression co-efficient values less than 1.0, with mean emergence of either below or above genotype mean, hence, they were relatively better adapted to environmental changes and could be suggested for cultivation in unfavourable conditions, without any adverse effect on field emergence.

According to Eberhart and Russel (1966), a genotype considered as stable should meet criteria of high mean performance, with b equal to unity and S^2d approaching zero. Using these criteria, seed germination of genotype 530-6-1 with regression coefficients of 1.03, S^2d approaching zero and with relatively high seed germination of 78.50% could be considered widely adapted and stable. It has the ability to express its germination potential when produced in a range of environmental conditions. The highest field emerging genotypes proved less stable and selection solely for high emergence could result in discarding many genotypes that were relatively better adapted to environmental changes.

In a similar vein, Choo *et al*. (1984) described a desirable genotype as one with high mean, at least average performance, in all environments and an undesirable genotype as having either a low mean performance or below-average performance in some environments. Following Choo *et al.* (1984) criteria and defining high mean seed germination as at least 5% above the grand mean (Table 4), only 530-6-1 showed itself to be desirable in each of the plant population environments. However, for field emergence (Table 5), the performance at individual plant population environment indicated that 73A-11 and C-K-2 maintained above average emergence in each of the three plant population environments evaluated.

The method of Choo *et al*. (1984) coupled with the regression analysis have jointly pointed out genotypes 530-6-1, and 73A-11 and C-K-2 as desirable genotypes that will give good germination and field emergence, respectively over an array of environments encountered in the south-west of Nigeria and similar ecologies. Moreover, when applied to individual plant population environment, the method of Choo *et al*. (1984) pointed out 69B-88Z, Domu and 73A-97 as being most suitable for seed production in 133,333 plants ha^{-1} environment and genotypes 73A-11 and C-K-2 in 166,667 plants ha^{-1} environment. However, genotypes 93A-97, 73A-11, 73A-97, 69B-88Z and C-K-2 would be appropriate in 266,667 plants ha^{-1} environment to obtain stable and high seed germination and emergence.

Conclusion

The investigation of stability of sesame genotypes clearly showed that most of the test genotypes were sensitive to production environments. Hence, their wider adaptability, stability and general performance to the fluctuating growing conditions within and across plant population environments were considerably lowered. The stability analysis provides meaningful information regarding stability and consistency of seed quality performance of sesame genotypes across different environments. These genotypes can be obtained from the University of Agriculture, Abeokuta, Nigeria and National

Cereal Research Institute (NCRI), Badeggi, Nigeria. The identified genotypes may be used as parents in future sesame crop improvement programmes. Sesame seed must be tested for germination and vigour in different environments to determine the favourable conditions for sesame seed production, as discussed by Heydecker (1972); Dickson (1980); Odiemah (1991) and Adebisi (2004).

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Correspondence to:
Adebisi, Moruf Ayodele *PhD*
Department of Plant Breeding and Seed Technology,
University of Agriculture, P. M. B. 2240, Abeokuta,
Ogun State, Nigeria.
Email: mayoadebisi@yahoo.co..uk

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