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The Performance of Sesame (*Sesamum indicum* L.) of Genotypes under Agro-Ecological Conditions of Angónia District in Central Mozambique

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In Mozambique, Sesame (*Sesamum indicum* L.) is one of the main cash crops for small-scale farmers, but its low productivity is one of the greatest limitations to increasing the income of these families. Therefore, a field experiment was carried out at N'tengo-Umondzi Research Station (S14˚32.205' E034˚09.664') in Angónia district in two cropping seasons with the objective of evaluating the performance of four genotypes of sesame. The experiment was arranged in a randomized complete block design (RCBD) with four replications. The treatments were four genotypes of Sesame, namely Linde, Alua, Rama, and Nicaragua. Results revealed that the days to 50% flowering and days to beginning of capsules formation were significantly (p≤0.05) affected by treatments in both seasons. There were significant differences (p ≤ 0,05) between the treatments in relation to days to starting seed formations, height of the 1st capsule and day to beginning of maturity in both seasons. There were also significant differences (p≤0,05) between the treatments for varying number of capsules per plant, biomass yield, weight of 1000 seeds and seed yield. In both seasons, the variety Nicaragua observed a significant higher seed yield with 214,8 kg ha-1 and 241,4 kg ha-1, respectively. Significant relationships among some agronomic characteristics of sesame were also reported. The findings of this study confirm that there is potential for sesame cultivation under agro-ecological conditions of Angónia, Nicaragua being the variety that performed better in terms of yields than the other three tested varieties.

Keywords: Sesame, Genotype Performance, Angónia, Mozambique.

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INTRODUCTION

Sesame (*Sesamum indicum* L.) is one of the oldest known oilseeds, with its origin being Central Africa, where it concentrates most of the wild species of the genus *Sesamum* (Cattan and Schiling, 1991). In Mozambique, this is one of the most income oilseed crops, after groundnuts and being mostly practiced by small-scale farmers (INE, 2013). These farmers usually produce Sesame as sole crop in small separate areas or in intercropped field (IIAM, 2013). It has great economic potential in the domestic and international markets as a result of high quality oil, with application in the food and oil-chemistry, and a potential market capable of absorbing quantities exceeding the current supply. Sesame, deserves a great incentive to its production due to its wide adaptability to soil and climatic conditions of hot climates, good drought resistance level and represent an excellent option to agricultural for small-scale farmers, requiring simple farming practices and easy assimilation. It is a crop that fits both in traditional farming systems and in sustainable and organic agriculture (EMBRAPA, 2006).

However, low Sesame crop yields that are below 500 kg ha^{-1} have been major constraints for small-scale farmers, which have been resulting to lower income (IIAM, 2013). According to IIAM (2013), luck of use of improved varieties has been pointed out as one of the reasons why the yields have remained low within small-scale farms. Thus, IIAM and other International Research Institutions worldwide have been working on the development of improved genotypes that can adapt to different agro-ecological conditions (IIAM, 2013) and in Angónia district the information is scarce in regard to the performance of improved genotypes of Sesame under agro-ecological conditions of Angónia district.

MATERIALS AND METHODS

Study area

The experiment was carried out at N'tengo-Umondzi research station in Angónia district (Figure 1), Tete province of Central Mozambique, and occupies an area of 3,277 km^2 and population of 330,378 habitants. The experimental site lies within S14˚32.205' E034˚09.664' and at the altitude of 1655 m above the sea level. Table 1 shows the soil characteristics of the experimental site. The district is covered by humid temperate climate strongly influenced by altitude. It shows a wide variation of rainfall, 725 mm to 1149 mm, with most of the rainfall (about 90%) going from late November to early April. The standard temperature is conditioned by altitude, which ranges from 700 m to 1655 m, with an average temperature of 20.9°C. The topography is dominantly very undulating to dissected, and that occurs piecemeal being geographically located in the complex areas of Marávia-Angónia (Government of Mozambique, 2005). Rainfall and Temperature data for the two cropping seasons (2012/2013 and 2013/2014) in which the experiment was conducted are presented in Figure 2 and Figure 3.

Experimental design and management

Before planting, soil samples from the experimental sites were collected at 0 to 15 cm depth for analysis of organic carbon, total nitrogen using standard methods (Okalebo *et al.,* 2002), extractable P, Ca, Mg, K, Na using Mehlich-1 (M1) extraction method, where P and Mg^{2+} were determined colourimetrically in a spectrophotometer and Ca^{2+}, and K^+ were determined using flame photometer. The experiment was established at N'tengo-Umondzi Research Station (Angónia district) in a RCBD with four replications and plots measuring 9mx3.5m (31.5m^2) with four varieties corresponding to treatments, including Linde, Alua, Rama, and Nicaragua (Table 2). Before planting, the land was ploughed to a depth of 15 cm using manual hoe. The test crop was Sesame (*Sesamum indicum* L.), planted in a spacing of 50cmx10cm on January 2nd, 2013 and on January 4th, 2014, respectively. The experiment was fertilized with 200 kg ha^{-1} NPK 12:24:12.

Sesame harvest and yields

Sesame grain and stover was harvested at maturity from a net area of each treatment demarcated after leaving out two rows on each side of the plot and the first two and the last two plants on each row to minimize the edge effect. The yields and harvest index were calculated using the following formulas:

$$Adjusted\ yield = measured\ yield * \frac{(100 - sample\, moisture\, content)}{(100 - standard\, moisture\, content)} \quad (1)$$

$$Yield\ (t/ha) = 10 * \frac{Dry\, weight\ (kg/m^2)}{Net\ area\ (m^2)} \quad (2)$$

Data analysis

Data of Sesame yields and growth parameters were subjected to analysis of variance using SAS version 9.0 to test for significant differences between different treatments, the yields were subjected to *t-student* test at 95 percent of significance level ($p < 0.05$).

RESULTS AND DISCUSSION

Growth parameters

In both seasons, the plant height and the number of branches per plant were not significantly ($p≥0, 05$) influenced by the treatments. The height for the 1st branch was significantly affected by the treatments only on the second season (2013); and the variety Rama observed significantly the lowest height for 1st branch (14.9 cm; $p≤0.05$) than all other treatments. The days to 50% flowering and days to beginning of capsules formation were significantly ($p≤0.05$) affected the treatment in both seasons. For instance, the variety Rama had 50% of flowers significantly earlier in 2012 and in 2013, after 28 and 27 days, respectively, than all other treatments. In 2012, the variety Alua started the formation

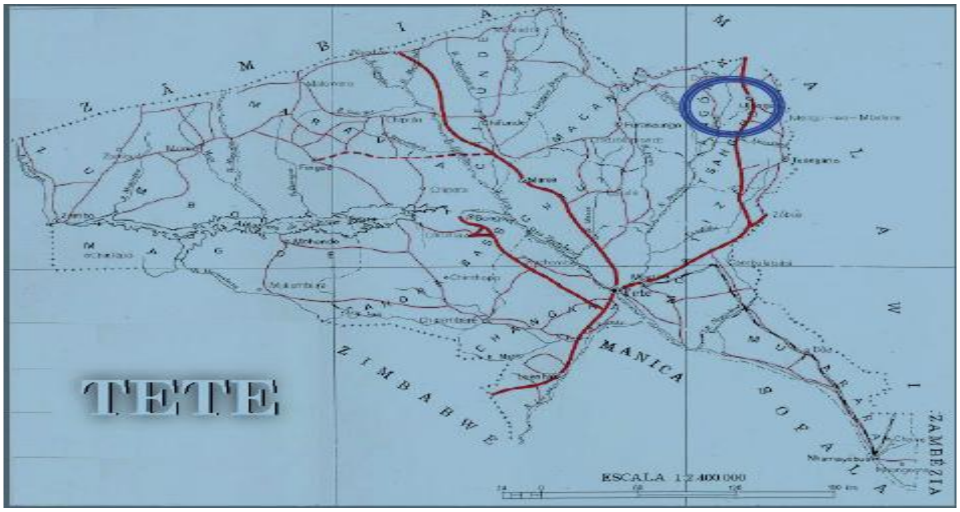

Figure 1: Map of the experimental site.

Table 1: Soil characteristics at experimental site

Soil parameter	Experimental site
pH in water (1:2,5)	5,78
pH in KCl	4,71
Available N (mg kg^{-1})	14,44
Available P (mg kg^{-1})	4,84
Exchangeable K (mg kg^{-1})	186,10
Exchangeable Ca (mg kg^{-1})	614,06
Exchangeable Mg (mg kg^{-1})	140,81
Exchangeable Na (mg kg^{-1})	8,41
Total soil organic Carbon (%)	1,12
Organic Matter (%)	1,93
Soil density (g/cm^3)	1,26

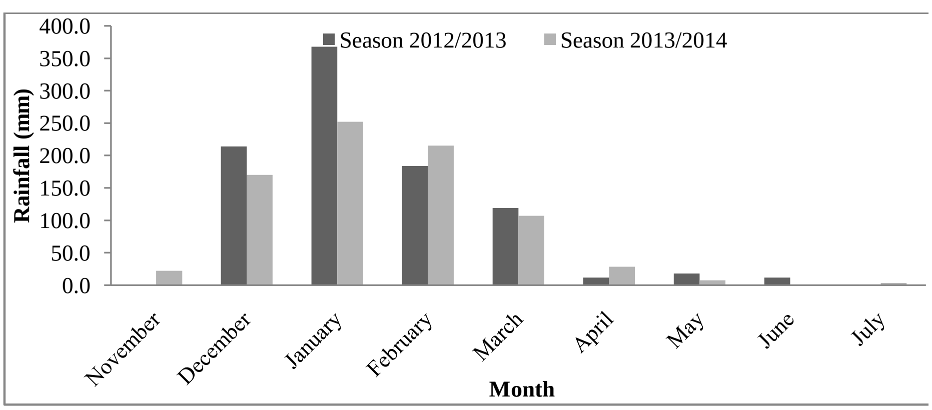

Figure 2: Rainfall amount in 2012/2013 and 2013/2014 at N'tengo-Umodzi site, Mozambique

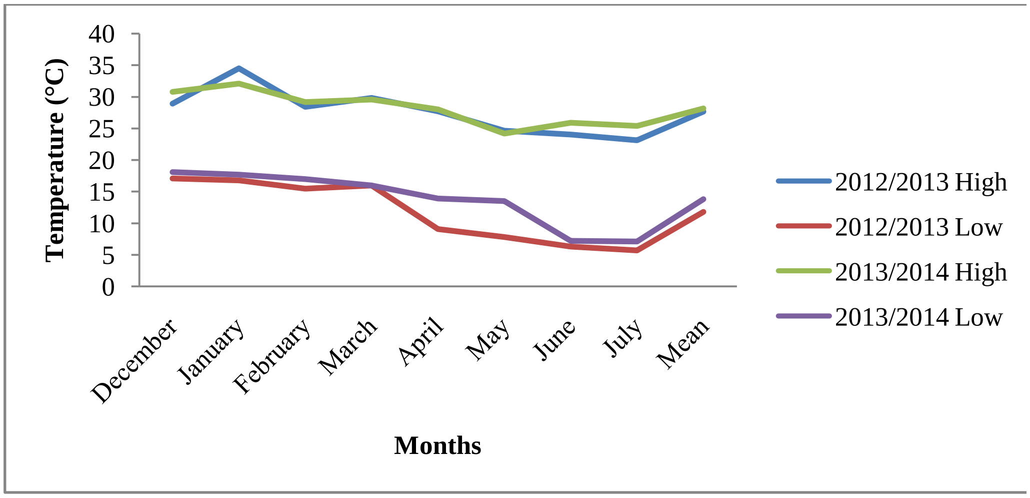

Figure 3: Temperature in 2012/13 and 2013/2014 at N'tengo-Umodzi site, Mozambique

Table 2: Mean values of plant height, height for 1st branch, and Nr of branches, days to 50% flowering, days to beginning of capsule formation.

Treatment	Plant height (cm)		Height for 1st branch (cm)		Nr of Branches		Days to 50% flowering		Days to beginning of capsules formation	
	2012	2013	2012	2013	2012	2013	2012	2013	2012	2013
Linde	91,8a	92,3a	24,5a	31,5a	2,6a	4,3a	29c	31a	45b	43a
Alua	86,2a	91,1a	21,9a	30,3a	2,3a	4,3a	32a	29b	42c	40b
Rama	88,5a	72,3a	19,8a	14,9b	2,1a	3,6a	28d	27d	45b	35d
Nicaragua	100,4a	98,7a	20,3a	30,3a	2,1a	4,8a	30b	28c	46a	36c
CV (%)	**13,3**	**4,7**	**23,4**	**6,9**	**15,9**	**23,5**	**5,1**	**5,2**	**6,2**	**8,9**

Means within a column followed by same letter in any season are not significantly different at p ≤ 0.05

of capsules significantly earlier (42 days; $p \leq 0.05$) than all other treatments; whereas, in 2013 was the variety Rama that started the formation of capsules significantly earlier at 36 days after planting than all other treatments (Table 2).

Similarly, Ahmed *et al.* (2012) did not find significant differences in plant height of three sesame varieties. Contrarily, Pham *et al.* (2010) reported significant differences on plant height and number of branches per plant when comparing the four genotypes of sesame. And, Queiroga *et al.* (2010) stated that the shorter the variety, in terms of height, the lower the probability of it lodging and the lesser the grain loss at harvest. Pham *et al.* (2010) also reported significant differences on the height for the 1st branch. Similarly to the results found in this study, Pham et al. (2010) also found significant differences in the varieties studied in regard to the varying number of days to flowering and capsule formation, although the observed values were relatively higher than those of the present study, indicating that they compared long cycle varieties. Differently from the findings on this study, Ahmed *et al*. (2010) did not find significant difference between the treatments on the time to 50% flowering.

Yield parameters

The Table 3 shows that there were significant differences ($p \leq 0,05$) between the treatments in relation to days to starting seed formations, height of the 1st capsule and day to beginning of maturity in both seasons. For instance, in 2012 cropping season the variety Linde started formation of seed significantly earlier (50 days after planting; $p \leq 0,05$) than all other treatments; whereas, in 2013 the same variety was significantly the latest (51 days after planting; $p \leq 0,05$) in seed formation of all the other treatments. This could be related to the fact that, in 2012, the cropping season registered more rainfall that resulted in longer vegetative period than in

Table 3: Mean values of seed formation days, height of 1st capsule, and beginning of maturity

Treatment	Days to beginning of seed formation		Height of 1st capsule		Days to beginning of maturity	
	2012	**2013**	**2012**	**2013**	**2012**	**2013**
Linde	50b	51a	45,9a	61,7a	87b	87a
Alua	51a	50b	38,9a	60,6a	87b	86b
Rama	51a	43c	29,8b	31,0b	86c	53d
Nicaragua	51a	43c	48,1a	57,9a	91a	57c
CV (%)	**1,5**	**4,5**	**6,8**	**8,9**	**1,9**	**7,8**

Means within a column followed by same letter in any season are not significantly different at $p \leq 0.05$

Table 4: Mean values of nr capsule per plant, biomass yield, weight 1000 seeds, seed yield

Treatment	Nr capsules per plant		Biomass yield ($t\ ha^{-1}$)		Weight 1000 seeds (grams)		Seed yield ($kg\ ha^{-1}$)	
	2012	**2013**	**2012**	**2013**	**2012**	**2013**	**2012**	**2013**
Linde	23,0a	50,9b	3,8a	3,4a	2,3b	3,7a	169,3ab	212,0ab
Alua	24,9a	54,5b	2,6a	2,2ab	3,3a	3,8a	157,0ab	218,3ab
Rama	20,1a	64,2a	2,4a	1,6b	3,5a	3,1b	108,6b	103,3b
Nicaragua	29,2a	71,6a	3,5a	3,0ab	3,3a	3,7a	214,8a	241,4a
CV (%)	**21,6**	**8,5**	**23,2**	**25,4**	**12,7**	**5,1**	**14,9**	**19,3**

Means within a column followed by same letter in any season are not significantly different at $p \leq 0.05$

2013 cropping season (Figure 2). Furthermore, Queiroga *at al.* (2010) stated that sesame can take longer time to start seed formation when cultivated under high rainfall conditions because of the longer vegetative period.

The variety Rama observed significantly shorter height of 1st capsule in both seasons (29,8 cm; $p \leq 0,05$ and 31,0 cm; $p \leq 0,05$, respectively) than all other treatments. The same treatment (Rama) started maturing significantly earlier in both seasons (86 days after planting; $p \leq 0,05$ and 53 days after planting; $p \leq 0,05$, respectively) than all other treatments (Table 3). Similarly, Pham *et al.* (2010), Ahmed *et al.* (2012), Ogbonna & Ukaan (2012) and Queiroga *et al.* (2010) also reported significant differences in the treatments regarding the variables days to beginning of seed formation, height of 1st capsule and days to beginning of maturity.

There were significant differences ($p \leq 0,05$) between the treatments for varying number of capsules per plant (only in 2013), biomass (only in 2013), weight of 1000 seeds and seed yield. In 2013, the variety Nicaragua observed significantly higher number of capsules per plant (71,6 capsules; $p \leq 0,05$) than Linde and Alua varieties; but it was statistically at par with Rama variety. Still in 2013, the variety Linde observed statistically higher biomass yield (3,4 $t\ ha^{-1}$) than Rama variety with 1,6 $t\ ha^{-1}$. In 2012, the variety Linde presented significantly the lowest weight of 1000 seeds with 2,3 grams of seeds, than all other treatments; whereas in 2013, the variety Rama observed statistically the lowest weight of 1000 seeds with 3,1 grams of seeds than all other varieties.

In both seasons, the variety Nicaragua observed a significant higher seed yield (214,8 $kg\ ha^{-1}$ and 241,4 $kg\ ha^{-1}$, respectively) than Rama treatment; but it was at par with the rest of the varieties (Table 4). These results were also reported by other researchers (Pham *et al.,* 2010; Ahmed *et al.,* 2012; Ogbama and Ukaan, 2012; Queiroga *et al*., 2010) when they were assessing the performance of sesame genotypes. However, the seed yield values observed in this study is lower than average seed yield for the crop in the country of 300 to 600 $kg\ ha^{-1}$. Sesame is generally a worm region crop and the temperatures recorded during this study were not suitable for the crop growth and development, particularly in critical months of May and June (flowering and seed formation). According to Cattan and Schilling (1991), temperature range of 25 to 27 °C encourages rapid germination, initial growth, flower and seed formation, whilst temperature below 18 °C inhibit germination and growth (Ramankutty, 2002).

Relationship between growth and yield parameters

Significant positive relationships between seed yield and days to 50% flowering were recorded in both seasons. The seed yield and height for 1st capsule significantly correlated with each other in 2012. Days to 50% flowering and days to beginning of capsule formation,

Table 5: Correlation coefficients among some agronomic characteristics of sesame in 2012 and 2013

Traits	**Days to 50% flowering**	**Days to beginning of capsule formation**	**Days to beginning of seed formation**	**Days to beginning of maturity**	**Height for 1st branch**	**Height for 1st capsule**	**Plant height**	**Biomass yield ton/ha**	**Weight 1000 seeds**	**Seed yield kg/ha**
Days to 50% flowering	—	(0.92***)	(0.89***)	(0.83***)						0.64** (0.61*)
Days to beginning of capsule formation		—	0.96*** (0.96***)	0.74*** (0.95***)	(0.64***)	(0.67***)			0.74**	
Days to beginning of seed formation			—	0.53* (0.99***)	(0.58**)	(0.62**)			0.78***	
Days to beginning of maturity				—	(0.64***)	(0.68***)				
Height for 1st branch					—	(0.97***)	(0.88***)		0.62**	
Height for 1st capsule						—	(0.86***)	0.56* (0.49*)		0.58*
Plant height							—	0.49*		
Biomass yield ton/ha								—		0.51*
Weight 1000 seeds									—	
Seed yield kg/ha										—

, ** and * significant at 5%, 1% and 0,1%, respectively. Values in parentheses correspond to 2013 and without 2012*

days to 50% flowering and days to beginning of seed formation, days to 50% flowering and days to beginning maturity significantly correlated with each other in 2013. Days to beginning of capsule formation and days to beginning of seed formation, days to beginning of capsule formation and days to beginning of maturity statistically correlated with each other in both years (Table 5).

Still according to the Table 5, significant positive relationships between days to beginning of capsule formation, height for 1st branch, and height for 1st capsule were recorded in 2013. Days to beginning of capsule formation and weight of 1000 seeds significantly correlated with each other in 2012. Days to beginning of seed formation and days to beginning of maturity significantly correlated in both years. Significant positive relationships between days to beginning of seed formation, height for 1st branch and height for 1st capsule were recorded in 2013. Days to beginning of seed formation and weight of 1000 seeds statistically correlated with each other in 2012. Other correlations were recorded and presented in the Table 5. Similarly, Ibrahim and Khidir (2012), and Olowe (2007) reported significant relationships among some agronomic characteristics of sesame.

CONCLUSIONS

The findings of these experiments confirm that there is potential for sesame cultivation under agro-ecological conditions of Angónia. However, Nicaragua variety performed better in terms of yields than the other three tested varieties.

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