

Agronomic performance of sesame lines cultivated under rainfed conditions in the rural region of Paraíba

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ABSTRACT

Sesame (*Sesamum indicum* L.) is one of the oldest cultivated oilseed crops in human history, and due to its widespread acceptance, both in the domestic and international markets, its cultivation has been expanding. Driven by genetic diversity and specific market demands, the research aims to achieve high productivity under various soil and climate conditions. In this regard, the sesame breeding program developed by Embrapa CNPA has been providing cultivars that meet the diverse demands of the market. This study aimed to evaluate the agronomic performance of sesame lines grown under rainfed conditions in the northeastern sub-region of Paraíba. Morpho-agronomic characteristics of the plants and physicochemical characteristics of the seeds were evaluated. It was found that five out of the ten studied lines showed significant differences compared to the BRS Morena cultivar, with the SHCNPA66 line standing out for its superior performance in all evaluated aspects, including grain production, highlighting its potential for future cultivar selection.

Keywords: oilseeds, genetic diversity, productivity, plant breeding.

INTRODUCTION

Sesame (*Sesamum indicum* L.) is a widely cultivated oilseed crop with its origins in the Indian and African continents, the latter being the largest reservoir of wild *Sesamum* species.^(1, 2) It is also one of the oldest cultivated oilseeds in the world.⁽³⁾ In Brazil, sesame has been cultivated since the 16th century, particularly in the semi-arid region, where it has recently shown significant economic potential due to its excellent acceptance in both national and international markets.⁽⁴⁾

Sesame characteristics are important across various economic sectors. Its seeds contain, on average, 50% high-quality nutritional oil, rich in antioxidant properties. Sesame also shows great adaptability to hot climates, drought tolerance, and represents an excellent agricultural option for small and medium-sized producers.⁽⁵⁾

Although Brazil is a small producer, it contributes approximately 16.000 tons, harvested from 25,000 hectare, with an average yield of around 640 pounds per hectare.⁽⁶⁾ Projections for the 2022/23 and 2023/24 harvests estimate a planted area of 391,200 hectare, maintaining an average yield of 482 kg per hectare and a total production of approximately 172,2 tons, highlighting the continuation of stable and significant production.⁽⁷⁾

According to Conab,⁽⁷⁾ sesame production in the Northeast region grew by 14.6% in output and 14.7% in area between the 2022/23 and 2023/24 harvests, highlighting its growth. At the national level, the 2023/24 harvest saw a significant increase of 61.4% in area and 62.0% in total production. These results represent a favorable scenario for sesame, driving initiatives such as Embrapa CNPA's genetic improvement program, which focuses on obtaining cultivars with drought tolerance, meaning they can be cultivated in rainfed conditions, with reduced input usage, and high production potential.

The genetic diversity present in this crop, combined with specific market demands, has been driving research efforts to achieve high productivities under various soil and climatic conditions in the country.^(8,9) This drive is motivated by its socioeconomic relevance, the need to increase production in the Semi-Arid region, its versatility of use, and advancements in crop genetic improvement.

There is potential to increase yield and invest in research with sesame, especially in semi-arid areas and locations with different soil and climatic conditions, as long as productivity is in line with ecosystem sustainability.⁽¹⁰⁾

The species is considered drought-tolerant, thriving well within an optimal range of 500 to 650 mm of evenly distributed annual rainfall.⁽¹¹⁾ Resilience and ease of cultivation compared to major crops are also attractive characteristics.⁽¹²⁾ Due to its good adaptability to the soil and climatic conditions of the Brazilian semi-arid region, this crop proves to be an excellent cultivation option for family farmers.

In addition to the mentioned characteristics, the oilseed presents an opportunity to improve the working and living conditions of rural producers. It is a viable option for rotation and intercropping with other crops, given that its inclusion on the property provides an alternative for a new, input-efficient cultivation source.⁽⁴⁾

Originating from small and medium-sized producers, sesame production often utilizes varieties unsuitable for certain growing conditions, resulting in low yields. To address this challenge, plant breeding research continues to be developed to propagate desirable alleles, increasing productivity and resistance to adverse factors. Within this context, Embrapa has been releasing cultivars suitable for the Northeast region since 1999, with high productivity characteristics even under rainfed conditions. Among them, the following stand out: CNPA G2 and CNPA G3 (1999), BRS 196 (2000), BRS Seda (2007), BRS Anahí (2015), BRS Morena (2018), and BRS Pérola Negra (2020).⁽¹³⁾

Based on the information provided, the objective of this study was to evaluate the agronomic performance of sesame lines grown under rainfed conditions in the northeastern sub-region of Paraíba.

MATERIAL AND METHODS

The experiment was conducted in the experimental area of Embrapa CNPA, located in the city of Alagoinha, Paraíba, within the physiographic region of the rural in Paraíba, at latitude 6°58'09,04" S and longitude 35°33'00,73" W. According to the Köppen climate classification, Alagoinha falls under the AS type, which includes the swamp, rural, a small strip of the sertão region, and the entire high semi-arid area.⁽¹⁴⁾ The soil in the area was classified as Abruptic Chromic Luvisol.⁽¹⁵⁾

The experimental setup was a randomized block design (RBD) with 11 lines and 4 replications. The treatments consisted of ten advanced sesame lines: SHCNPA25, SHCNPA56, SHCNPA57, SHCNPA66, SHCNPA67, SHCNPA68 c, selection BRAI, selection BRAII, AM3GBb, BRA32863G33, and one cultivar, BRS Morena. The

experimental plots consisted of 2 rows, each 5 meters long, spaced 0.70 meters apart between rows and 0.20 meters apart between plants.

The trial was conducted under rainfed conditions, and starting 70 days after planting, the following agronomic characteristics were evaluated: plant height (cm) (PH) and height of first fruit insertion (cm) (HFFI), and number of fruits per axil (NFA). At 100 days after planting, the evaluations included fruit dehiscence (D), number of fruits per plant (NFP), final stand (FS), production (P), 1000-seed weight (W1000) (g), seed color (SC), and seed oil content (OC) (%).

The analysis of variance was performed using Sisvar with mean comparison by Scott-Knott test at 5% significance level. The 1000-seed weight was determined in 44 samples by counting 1000 seeds using a seed and grain electronic counter (Model ESC2008) and weighing on a precision balance (0.001 g). The final stand (FS) was identified considering the total number of plants in the plot. Plant height (PH) was measured on five randomly selected plants from the plot, and measurements of height (in meters) from the ground to the apex of the plant were taken. The number of fruits per axil (NFA) was identified by counting the fruits in each leaf axil present on the plant. To identify the seed color (SC), ratings were assigned according to the color of the seed coat, as follows: 1- White, 2- Cream, 3- Brown, 4- Black, 5- Mixed. A rating of five indicates that the seeds have coat colors ranging from white to black. The total number of fruits per plant (TNFP) was also determined after the fruits began the maturation process, and collection was carried out on all plants in the plot. All fruits harvested from each plot were placed on polyethylene tarp and exposed to the sun to promote moisture loss and facilitate seed extraction. The production of each plant in the plot was determined by weighing the grains on a digital precision scale. The oil content was

obtained using a laboratory press, where 200-gram samples of seeds were used. The oil content (OC) result was expressed as a percentage, considering the ratio between the sample weight and the weight of the extracted oil.

RESULTS AND DISCUSSION

Sesame (*Sesamum indicum* L.) is an oilseed with wide utility across various production sectors, thanks to its seeds which promote agricultural diversification and present economic, agronomic, and social potential. It is rich in antioxidants such as sesamin, sesamolin, and tocopherol, which extend the shelf life of products, and also contains vitamins and oil with unsaturated fatty acids (40% oleic and 41% linoleic). This crop is widely cultivated and is a viable alternative for the semi-arid region of the Northeast.^(16,17)

Significant differences were found for the variables plant height (PH), number of fruits per plant (NFP), number of fruits per axil (NFA), production (PR), 1000-seed weight (W1000), and final stand (FS) (Table 1).

It was found that all 10 lines and the BRS Morena cultivar tested showed significant differences in morphoagronomic characteristics. The variables number of fruits per plant (NFP), number of fruits per axil (NFA), final stand (FS), and 1000-seed weight (W1000) showed differences at the 1% confidence level. For the characteristics of production (Pr) and final stand (FS), significance was observed at the 5% level.

The coefficient of variation (CV) is a parameter that provides an idea of the experiment's precision. According to Gomes,⁽¹⁸⁾ the percentage values of CV obtained in agricultural field experiments classify them into categories where lower values are associated with higher experimental precision. Thus, coefficients below 10% are considered low and desirable; between 10% and 20%, the CV is considered medium; CV between 20% and 30% is high; and very high when exceeding 30%.

Table 1. Summary of the analysis of variance for the variables: plant height (PH), number of fruits per plant (NFP), number of fruits per axil (NFA), 1000-seed weight (W1000), final stand (FS), and production (PR) for the 10 lines and the BRS Morena

SV	Mean Squares					
	PH	NFP	NFA	FS	PR	W1000
Treatment	305,21*	258,27**	0,13**	633,02**	23698,31*	0,38**
Block	219,67 ^{ns}	22,68 ^{ns}	0,01 ^{ns}	839,47 ^{ns}	2003,07 ^{ns}	0,05 ^{ns}
Residual	107,82	42,37	0,03	204,87	9428,59	0,04
CV (%)	9,41	20,90	15,32	18,70	26,83	6,69
Rate	110,38	31,13	1,14	72,52	361,88	3,25

** and * significant at 1% and 5% probability levels, respectively, by the F-test and ^{ns} (not significant), by the F-test.

It is noteworthy that the data for plant height (PH) and 1000-seed weight (W1000) show good experimental precision, as reflected by the coefficients of variation, 9.41% and 6.69%, respectively. However, a high CV was obtained for the variables number of fruits per plant (NFPP) and production (PR), and a medium CV for the number of fruits per axil (NFA) and final stand (FS) (Table 1). The classification by Gomes⁽¹⁸⁾ was proposed based on experiments with experimental designs and for agricultural attributes with relative stability, and therefore, should not be generalized. Schmildt *et al.*⁽¹⁹⁾ state that differences between the classification ranges of CV values obtained in experiments can be explained not only by environmental variability but also by numerous other factors, including the number of repetitions and data systematization.

Morphoagronomic characteristics are important variables when aiming for good crop yields. In the sesame breeding program, the goal is to find lines that exhibit qualities such as higher productivity, early maturation, easy management, and tolerance to pests, diseases, and drought.

Plant height (PH) is a variable that, according to results obtained by Vasconcelos *et al.*,⁽²⁰⁾ is positively related to the productivity of sesame lines. It was observed that the lines with the lowest average plant height were SHCNPA68c, BRAI, and BRAII. The other lines showed statistical equivalence, with heights ranging between 98.61 cm and 125.75 cm. However, it is important to note that taller plants do not always exhibit higher productivity, as identified in this study, where some of the tallest lines did not result in the best production yields. Considering that this study analyzed 10 different lines and the BRS Morena cultivar,

the variation in sesame plant growth can be attributed to the genetic diversity of each line, which may exhibit different branching patterns.⁽²¹⁾

The number of fruits per plant (NFPP) in sesame is a characteristic that can impact productivity. In this regard, the lines SHCNPA25, SHCNPA66, SHCNPA68c, BRAI, BRAII, and AM3GBb showed more promise for this characteristic, with 34.05 to 34.90 fruits per plant observed in these lines. It is worth noting that the lines SHCNPA67 and BRA 32863G33, although having lower NFPP averages compared to the previously mentioned lines, recorded high productivity averages, suggesting a high productive potential even with a lower number of fruits.

Regarding production, the lines SHCNPA66, SHCNPA67, SHCNPA68c, AM3GBb, and BRA32863G33 stood out, with averages ranging between 374.09 and 484.97 grams. Specifically, SHCNPA66 had the highest average production, representing a 38.72% increase compared to the cultivar BRS Morena (Table 2).

The number of fruits produced per plant (NFPP) in sesame is a characteristic that can have an impact on grain production and, consequently, on productivity. In this sense, the SHCNPA25, SHCNPA66, SHCNPA68c, BRAI, BRAII, and AM3GBb lines showed more promising results for this characteristic, as it was found to range from 34.05 to 34.90 fruits per plant in these lines. It is worth noting that the SHCNPA67 and BRA32863G33 lines, despite having lower averages for the NFPP variable compared to the aforementioned lines, recorded high productivity averages, suggesting high productive potential even with a smaller number of fruits.

Table 2. Mean values for the variables plant height (PH), number of fruits per plant (NFPP), number of fruits per axil (NFA), 1000 seed weight (W1000), final stand (FS), and production (PR), for the 10 lines and the BRS Morena cultivar

Treatment	PH	NFPP	NFA	FS	PR	W1000
SHCNPA25	125.75a	34,07a	1,30a	85,00a	299,23b	2,79c
SHCNPA56	115.68a	26,12b	1,0b	66,75b	273,49b	3,58a
SHCNPA57	111,55a	25,50b	1,0b	77,50a	280,95b	3,53a
SHCNPA66	107,95a	34,90a	1,35a	84,50a	484,97a	3,42a
SHCNPA67	114,42a	25,05b	1,0b	88,00a	397,04a	3,38a
SHCNPA68c	100,95b	34,25a	1,10b	92,75a	419,58a	3,36a
BRA I	98,60b	47,90a	1,20b	66,75b	326,55b	2,70c
BRA II	98,61b	41,37a	1,55a	49,50b	291,81b	2,98b
AM3G Bb	110,25a	34,05a	1,0b	73,00b	374,09a	3,10b
BRA32863G33	120,80a	14,50c	1,0b	71,75b	483,47a	3,57a
BRS Morena	109,70a	27,80b	1,05b	86,25a	349,55b	3,32a

Averages followed by the same letter in the rows do not differ statistically by the Scott Knott test at 5%.

Regarding grain production, the SHCNPA66, SHCNPA67, SHCNPA68c, AM3GBb, and BRA32863G33 lines stood out, with averages ranging from 374.09 to 484.97 grams. Considering that the grain production obtained in two rows of 5 meters each spaced 0.7 meters apart with the SHCNPA66 line was an average of 485 grams, under the same cultivation conditions, it can be inferred that the average productivity estimate would be 693 kg ha⁻¹. However, it is worth noting that this production could be increased with irrigated cultivation.

The Sesame Breeding Program at Embrapa CNPA has conducted numerous experiments to develop cultivars that meet the demands for low technological steps, plants tolerant to major diseases, and that demonstrate satisfactory productivity under rainfed conditions. In the aforementioned study, it was found that the SHCNPA66 line achieved a 38.72% higher productive performance compared to the grain production of the BRS Morena cultivar.

Productivity is considered one of the most important characteristics in various production systems, being the primary goal of producers. The aim is to achieve high levels of productivity to maximize profitability without increasing production costs or compromising efficiency. Additionally, factors such as resistance to pests and diseases, efficient use of nutrients, and tolerance to abiotic stresses play a crucial role in the genetic improvement program. These elements are essential to ensure the efficiency of the program and the quality of the final product, directly contributing to productivity and production.⁽²²⁾

In a study conducted by Oliveira et al.⁽²³⁾ with two sorghum varieties, it was observed that taller plants may exhibit a smaller proportion of the final product, that is, grains. Additionally, lodging of the plants may be associated with considerable heights, as a high ratio between insertion and plant stature can lower its center of gravity, increasing the likelihood of leaning or falling due to strong winds or excessive weight.⁽²⁴⁾ This can reduce harvest efficiency and, consequently, productivity.

The SHCNPA56, SHCNPA57, SHCNPA66, SHCNPA67, SHCNPA68c, BRA32863G33, and BRS Morena lines showed the highest means of 1000 seed weight (W1000), reflecting a greater average weight for every 1000 seeds.

The sesame seed yield is primarily determined by the number of fruits per area, which is directly influenced by the number of seeds per fruit and the weight of 1000 seeds. Although these factors can compensate for each other, higher grain productivity is achieved when the highest possible number of grains per unit area is obtained. In summary, to maximize production, it is crucial to ensure a high grain density in the cultivation area.⁽⁵⁾

The evaluated lines stood out compared to the BRS Morena cultivar in several characteristics of the experiment, including plant height, number of fruits per plant, final stand, production, and thousand-seed weight. Specifically, the SHCNPA67 and SHCNPA68c lines showed superior performance in various areas, such as final stand, production, and 1000-seed weight. The genotype SHCNPA66 deserves special mention, as it exhibited the best statistical averages in all evaluated characteristics.

Considered a valuable strategy to increase productivity sustainably and in a balanced way, genetic improvement plays a fundamental role in ensuring food security for the population. Over the past 50 years, it is estimated that half of the increase in productivity of agronomic plant species has been achieved through genetic improvement. This process has incorporated new techniques and concepts from sustainable agriculture, enhancing selection methods developed over the last 120 years. These advances have significantly contributed to refuting Malthus' catastrophic theories, ensuring an adequate food supply for the world's population.⁽²⁵⁾

Ferreira et al.⁽²⁶⁾ emphasize the importance of reassessing plant breeding strategies to promote genetic diversity rather than compromising it. This approach is essential for addressing the complexity of climate change and meeting the growing food demand while ensuring food security and human health.

Selecting genotypes based solely on yield would be an inadequate approach as crop yield is influenced by various genetic and environmental factors. Therefore, it is crucial to consider other characteristics that also impact yield, taking into account both biotic and abiotic factors. Understanding how different genetic traits are associated with seed yield expression helps define more effective selection criteria. This way, it is possible to choose genotypes that exhibit more desirable characteristics in terms of productivity and adaptability, promoting consistent and sustainable results over time.⁽²⁷⁾

CONCLUSIONS

The evaluated sesame lines showed significant morpho-agronomic differences compared to the BRS Morena cultivar, especially regarding the most commercially interesting characteristic for producers: grain production. A standout was observed in the SHCNPA66 genotype, which exhibited the best statistical average in all evaluated aspects, particularly in production, exceeding that of the BRS Morena cultivar by 38.72%, highlighting its potential as a candidate for future cultivar selection.

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DATA AVAILABILITY STATEMENT

All datasets supporting the findings of this study have been deposited in SciELO Data and are available at 10.48331/SCIELODATA.I71N9Y

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