Research Article
Open Access
CrossMark

Mineral and agroecological fertilization in six sesame (*Sesamum indicum L.*) genotypes, Iguala, Guerrero, Mexico

Summary

This study evalutated the effects of mineral and agroecological fertilization on the growth and yield traits of six sesame (*Sesamum indicum* L.) genotypes in Iguala, Guerrero, Mexico. The experimental design used a split-plot design with the large plots or blocks representing the type of mineral and organic input and the small plots representing the six sesame genotypes Criolla Mezón, Negro Paraguay, Vara Verde, Tres Huesillos, Calentana and Canasta. The plots were randomly assigned within each block; the evaluation was conducted with four replications. The experimental units consisted of three 4 m long furrows, with the useful area being 2 m from the central furrow, excluding 1 m from both ends and the bank furrows. The distance between rows was 0.75 m and plants were spaced 0.1 m apart. Ten plants were evaluated from the central furrow per genotype. The study measured the following variables: number of branches, number of capsules, seed weight and 100-seed weight. Analysis of variance (ANOVA) was conducted using SAS, Version 9.0 and the separation of means with Tukey's test ($P \leq 0.05$). The results showed non-significant statistical differences for the effect of mineral or agroecological fertilization. However, the averages in number of branches, number of capsules, seed weight and 100-seed weight were statistically different, with R^2 of 78%, 72%, 65% and 59%, respectively. The variability observed in the genotypes is attributed to the contribution of mycorrhizae, which may have influenced the total number of branches, capsules, seed weight and 100-seed weight.

Keywords: sesame, chemical fertilization, organic fertilizers, iguala, guerrero, Mexico

Volume 9 Issue 2 - 2025

Arredondo-Gallardo E,[1] R González-Mateos,[1] SV González-Zavaleta,[1] DH Noriega-Cantú,[2] J Pereyda-Hernández,[1] C Martínez-Alonso,[1] T Brito Guadarrama[1]

[1]UAGro. Facultad de Ciencias Agropecuarias y Ambientales. Periférico Pte. S/N, Col. Villa de Guadalupe, Iguala, Guerrero, México

[2]INIFAP. Campo Experimental Iguala. Carretera Iguala-Tuxpan, México

Correspondence: Ricardo González-Mateos, UAGro. Facultad de Ciencias Agropecuarias y Ambientales. Periférico Pte. S/N, Col. Villa de Guadalupe, Iguala, Guerrero, México; C.P. 40010 y Centro de Innovación de Competitividad y Sustentabilidad, Maestría en Competitividad y Sustentabilidad, Calle Pino s/n Col. El Roble, Acapulco, Gro

Received: March 29, 2025 | **Published:** April 7, 2025

Introduction

Sesame (*Sesamum indicum* L.) is native to India and Africa.[1] It was introduced in the Americas through the slave trade, where slaves used the seeds as a condiment. Sesame seeds are known for their high oil content, accounting for between 50 and 60% of their weight[2] and are rich in calcium, phosphorus, iron, and vitamins such as thiamine, riboflavin, and niacin.[3]

Sesame seed-producing countries include India, China, and Mexico. In Mexico, a total of 62,466 hectares are dedicated to sesame production, with an average yield of 0.74 t ha^{-1}. The states with the largest area and yields are Sinaloa, Guerrero, and Michoacán, with 25,252, 15,484, and 9,846 ha respectively, and yields of 0.74, 0.84, and 0.58 t ha^{-1}, respectively.[4] Guerrero ranks second in cultivated area and first in yield compared to Sinaloa and Michoacán. Within Guerrero, the districts with outstanding sesame yields are Las Vigas and Altamirano, with 0.84 t ha^{-1} and 0.93 t ha^{-1},[5] respectively. This suggests that the Tierra Caliente and Costa Chica agroecosystems have favorable soils and climates for the development and production of sesame. However, in recent years, drought has become the most limiting factor due to erratic rainfall patterns that are increasingly frequent and prolonged,[6] as along with atypical rainfall evens. While sesame crops are resistant to dry periods, water stress during the flowering and pollination phases can damage pollen, negatively affecting seed yield and quality.

In sesame production systems productivity refers to the output per unit of surface area; profitability is determined by the difference between the value of the product and the cost of production Sustainability on the other hand, pretains to the long-term impact on the resources involved.

Agroecosystems have depleted their nutrients reserves due to various processes, including erosive processes and nutrient extraction by plants.[7] Chemical fertilizers are rapidly assimilated and induce fast growth in plants; however, there have several disadvantages, include high production costs, non-renewable natural resources, and pollution of the soil, water bodies, and atmosphere.[8]

The management of fertilizer sources, application rates, timing, and placement is often deficient, resulting in nitrogen losses through multiple environmental processes influenced by precipitation and temperature, as well as soil-related factors such as physical, chemical, and biological properties. Additionally, crop residues from previous harvests[9] such as, the incorporation maize stubble, which is rich in carbon and low in nitrogen (high C:N ratio), can immobilize nitrogen during decomposition. Moreover, agroecosystems are degraded, which contributes to the proliferation of pests and diseases. To combat these, large quantities of pesticides are used, many of which are highly toxic.[10]

Therefore, given the negative impacts of conventional agriculture that altered agroecosystems, we are moving towards agroecological production, which is more environmentally friendly. Its benefits include "organic agriculture combines tradition, innovation and science to benefit the common environment and promotes fair relationships and a good quality of life for all those involved".[11] Biological sources such as biofertilizers are sought. They are low-cost, use renewable natural resources, easy to transport, produce negligible pollution. improve soil organic matter content, contribute to the production of plant biomass to obtain "clean energy". Currently, there is a global trend in the production of free agrochemicals.[1] With the use and management of organic fertilizers, manures, green manures, leachates, biofertilizers and biostimulants, among others, which replaces chemical fertilizers to gradually transiting to hybrid agriculture. Various biostimulants and other beneficial molecules for crops have been evaluated in different areas.[8] The artisanal products evaluated in sesame (*S. indicum*) in growth and yield were two bioles and chemical fertilization that produced significant yields and surpassed the bioles and control,[1] in other crops such as poblano pepper, doses 120N - 60P_2O_5 - 120K_2O, 80N -40P_2O_5 - 80K_2O and 40N - 20P_2O_5 - 40K_2O were evaluated mixed with commercial organic fertilizers including sheep and cattle manure with levels of 5, 10 and 15 t ha-1, it was determined that the best response was with the mixture of 15 t ha^{-1} and 80-40-80 with a yield of 35.5 t ha-1 of green fruit. It was concluded that a high level of sheep manure and chemical fertilizer media provided better yields,[12] in corn (*Zea Mays*) it was compared the response of chemical fertilizers and organic fertilizers such as Yara, ecological, organic, chemical and control, Yara provided greater leaf cover, photosynthetic capacity and therefore, better yields.[13]

Materials and Methods

The experiment was established on an agricultural plot in the community of Zacacoyuca, in the municipality of Iguala de la Independencia, Guerrero, with geographic coordinates between 18° 15'34" N and 99° 35'19" W, at 902 meters above sea level. The climate is a dry tropical climate,[14] with summer rainfall of 939 mm, high evaporation of 2,393 mm, and an average annual temperature of 25.9 °C.[15] Data from the Tepecuacuilco meteorological station in Guerrero indicate a temperature of 25.32 °C and precipitation of 659.51 mm in 2021, indicating low precipitation and intra-summer drought. The parent material is sedimentary; it is a hilly area associated with undulations and small intermittent streams. The soil is reported to be eutric Regosol, with a loamy-clay texture, pH ~8.0, and moderate organic matter content. The vegetation consists of annual crops such as corn and sorghum, as well as weeds.

The experimental design was in split-plots with a factorial arrangement (Figure 1). The large plot consisted of factor A: mineral (A1) and organic (A2) input; factor B (six sesame genotypes) or subplots, randomly distributed within each large plot or block. The experiment consisted of four replications. Each subplot had three rows of 4 m in length, with a distance between rows of 0.75 m and a distance between plants of 0.10 m. The genotypes evaluated were: Criollo Mesón, Negro Paraguay, Vara Verde, Tres Huesillos, Calentana, and Canasta. Sowing was done manually, and the seed was distributed in a stream at a depth of 0.02 m. When the plant reached 0.10 m in height, thinning was performed, leaving one plant at a distance of 0.10 m. The population density was 133,333 plants per hectare. The useful plot was the 2-m-long central furrow, 1 m was removed on both sides and the edge furrows. The useful plot consisted of 21 plants, from which 10 plants were pre-tagged and monitored for the study variables.

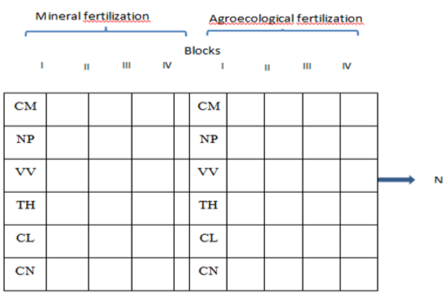

Figure 1 Spatial distribution of the genotypes according to the experimental design, Tepecoacuilco de Trujano, Guerrero, Mexico.

CM, criollo mesón; NP, negra paraguay; VV, vara verde; tres huesillo; CL, calentana; y CN, canasta

Mineral input: The dose was 65-40-00 NPK, the nitrogen source was from $(NH_4)_2SO_4$, divided into two parts: the first was applied 15 days and the second 30 days after germination. The first application was 0.49 g/plant, and the experimental unit received 58.50 g. The phosphorus source was calcium superphosphate (Ca (H_2PO_4), with 0.30 g/plant of P_2O_5 and 36.0 g of phosphorus applied per experimental plot. In addition, foliage was sprayed with cytokinins as a growth and biosynthesis regulator at a rate of 1 mL L^{-1} in water, applied once a week.

The agrochemical fertilizer was previously prepared with cruciferous residues and organic kitchen waste. It was mineralized until humified, then sieved to obtain humus, which was applied in a stream at a rate of 0.150 kg per linear furrow. Therefore, in 4 m, the amount was 0.600 kg per experimental plot, equivalent to 5 t ha^{-1} of humus. Bioestymux® was also applied via foliar application. This organic biostimulant enhances plant genetics. The product's percentage composition is as follows: free amino acids (10%), proteins, peptides, polypeptides, glucosamine and chitosan (15%), and a carrier formula (75%). It was applied at a rate of 1 mL L^{-1} in water and is ideal for controlling water stress in rainfed crops. Amioextym Xtra, with the following composition: free amino acids (20%), N (17.70%), Fe (1.26%), Mn (0.76%), Zn (0.62%), and OM (38.90%), is a source of micronutrients.

The variables examined in the study by genotype include the number of branches, number of capsules, seed weight, and weight of 100 seeds. From each genotype, 10 plants were harvested per replicate, from which the seeds were obtained. They were cleaned with a 0.2 mm diameter sieve. Healthy seeds were collected, free of external physical defects and pest damage. They were then weighed on a digital scale with two decimal places (Ohaus Analitycal Plus 0.1 mg®).

Statistical analysis of the study variables was performed using SAS (Statistical Analysis Software version 9.0) for variance and comparison of means using the Tukey test between chemical and organic fertilization by genotype and the interaction between genotypes.

Results

The variables analyzed were number of branches, number of capsules, seed weight, and 100-seed weight of sesame, as described below.

Table 1 reports the analysis of variance. The statistical differences in number of branches and capsules were highly significant, with R^2 of 78% and 72%, respectively, while the differences in 100-seed weight and seed weight were significant, at 59% and 65%, respectively. Therefore, the variability of the genotypes is a function of chemical and agroecological fertilization (Table 1), indicating that at least one genotype is different (Table 2).

Table 1 Analysis of variance of chemical and organic fertilization in six sesame genotypes (*Sesamun indicum*, L.), Iguala de la Independencia, Guerrero, Mexico. 2023.

Variables	R^2	CV	Genotypes (Pr > F)
Number of branches	0.785	27.29	<0.0001**
Number of capsules per plant	0.725	27.23	<0.0001**
Weight of 100 seeds	0.589	13.74	0.0126*
Seed yield	0.653	36.36	<0.0020*

*significant and ** highly significant

Table 2 Effect on response variables to chemical and organic fertilization (Tukey α 05) in six genotypes of sesame (*S. indicum*), Iguala de la Independencia, Guerrero, Mexico. 2023.

Genotypes	Honest Significant Difference (HSD)			
	Branches	Capsules Seed	weight	Weight of 100 seeds
	(No.)	(No.)	(g)	(g)
Criollo Mesón	1.00 b	28.63 ab	0.36 ab	4.63 ab
Negra Paraguay	3.13 a	22.25 bc	0.34 ab	2.75 cb
Vara Verde	3.25 a	23.75 bc	0.30 ab	4.25 ab
Tres Huesillo	1.50 b	16.88 c	0.29 b	1.88 c
Calentana	2.00 b	38.50 a	0.38 a	6.25 a
Canasta	1.75 b	25.63 ab	0.38 a	4.25 ab

In Table 2, the Tukey test α=0.05 is reported, where it is shown that the number of branches of Vara Verde and Negra Paraguay showed the highest number of branches with statistically significant differences (α = 0.05) of 3.25 and 3.13, respectively, compared to the Criolla Mesón without branches (1.0). In capsules per plant, Calentana stood out with statistically significant differences (α = 0.05) of 38.5, followed by Criolla Mesón with 28.63 and Tres Huesillos with 16.88. Negra Paraguay, on average, contributed 3.13 branches per plant, similar to the data recorded in the southern region of Paraguay at a planting density of 50,000 plants ha^{-1},[16] but with more than 100,000 plants per hectare, the plant does not branch. The same source reports an average of 53.04 capsules per plant in that region, while under the conditions of Iguala, Guerrero, the average was 22.25 capsules per plant, equivalent to 58.1% fewer capsules than in its country of origin (and In weight of 100 seeds, Calentana stood out with 6.25 g, followed by Criollo Mesón with 4.63 g, and the one that registered the lowest weight was Tres Huesillo with 1.88 g. In seed weight, Calentana and Canasta registered 0.38 g, respectively, and Tres Huesillos with 0.29 g.

Discussion

Conventional food production requires large amounts of chemical fertilizers[17] with environmental impacts including greenhouse gas emissions, eutrophication, and biodiversity loss.[18] Synthetic fertilizers can solve crop nutrition problems, increasing per unit yields, although they led to high economic, environmental, and social costs.[8,19] They remain preferred by farmers for food production.[9] More than 70% of agricultural land devoted to corn is subject to nitrogen fertilizers, and Guerrero is no exception, with nitrogen fertilizers being used throughout the state. In February 2025, the federal government will support producers with 150 kg of urea and 150 kg of diammonium phosphate. However, due to poor management of these agrochemicals, they are frequently lost through volatilization and erosion,[7] with consequent contamination of the environment[9] and water bodies.

Boza,[11] discusses that among the advantages of biofertilizers are their low cost, use of renewable natural resources, the small quantities required for seed inoculation, easy transport, and the fact that they do not pollute the soil.[1] It is important to mention that bio-stimulants, bioles, and organic fertilizers promote metabolic and nutritional processes, being efficient in stimulating growth and development as well as inducing tolerance to abiotic and biotic stress.[20] In this regard, Zarate, Olviedo, and González[21] reported that humic substances contributed to an increase in the number of capsules per plant and sesame yield, however, they require evaluations to demonstrate consistent results.[8]

Mexico has positioned itself globally as a promoter of agroecological transition agriculture in the agricultural sector, to produce food free from synthetic chemical inputs. For this purpose, manures are used that improve the physical, chemical, and biological properties of the soil. González-Betancourt et al.,[22] evaluated the effect of solarization of bovine manure, which contributed to soil sustainability. Núñez-Vázquez, Delgado-Acosta, and López-Padrón,[23] reported that bioinputs improve soil and plant quality, making them valuable allies in the agroecological transition, particularly through the reduction in the use of synthetic fertilizers. For their part, chemical fertilizers have high costs and volatile prices, while bioinputs are low cost and, above all, reduce greenhouse gas emissions, water and soil pollution, increase biodiversity and resistance of agricultural systems to climate change.

Biostimulants are an alternative because they are beneficial to plants, providing nutrients and substances such as proteins, amino acids, humic and fulvic acids, growth regulators.[24] Héctor-Ardisan et al.[8] evaluated artisanal biofertilizer, obtaining a 78.67% yield with NPK, higher than that recorded in untreated soil (22.48%). Its use is possible as an environmentally friendly alternative, but they suggest evaluating other doses of this product. The application of biostimulants based on *Spirulina* and vinasse stimulated the productivity of common bean (*Phaseolus vulgaris*), with more prominent results observed when combined with Quitomax® and Azofert®.[23] This procedure may represent an efficient alternative to increase the yield of this crop.

Tlelo-Cuautle et al.[12] reported that chili yield was highest when sheep manure was applied at a rate of 15 t ha^{-1} in combination with chemical fertilizer at a rate of 80N–40P–80K, resulting in a green fruit yield (35.5 t ha^{-1}), plant height (74 cm), nomber of fruits per plant (22 fruits), and a fresh fruit weight (86.52 g). In contrast, the use of the commercial organic fertilizer Solep® at 5 t ha^{-1} combined with the 80N–40P–80K formula resulted in lower performance (14 t ha^{-1} of fresh fruit), plant height (50 cm), nomber of fruits per plant (9 fruits), and a lower fruit weight (65.13 g). In sesame cultivars, an agroecological alternative is seed inoculation with *Glomus spp.* and *Azospirillum* at 20 to 25 mL or 40 to 60 g per kg of seed.[25] Mineral fertilization with an NPK ratio of 65–40–00 resulted in the number of branches, capsules per plant, 100-seed weight, and seed yield with R^2 values of 0.785**, 0.725**, 0.589*, and 0.653*, respectively, all statistically significant or highly significant. This is consistent with the findings of Díaz-Mederos,[26] who reported that in sesame-producing regions, low doses of NPK increased yield, while high levels of nitrogen (100 kg) and phosphorus (80 kg) resulted in mutual inhibition between N and P.

Conclusion

This research on sesame cultivation (*Sesamum indicum* L.) concludes that both mineral and agroecological fertilization yielded similar results in soils classified as Calcisols according to the IUSS-WRB[27] and under Awo climate conditions. The Negra Paraguay and Vara Verde seed genotypes produced a higher number of branches, while Criollo Meson, Vara Verde, Calentana, and Canasta showed no significant differences compared to the other varieties. However, the Calentana variety had the highest number of capsules and seed yield, outperforming all other genotypes. Therefore, mineral fertilization should be replaced by agroecological practices due to their social, economic, and environmental benefits; consequently, in a transitional agroecological production, synthetic fertilizers will gradually replace organic fertilizers and biostimulants in sesame cultivars.

Acknowledgments

None

Conflicts of interest

The authors declare no conflict of interest exists.

References

1. Montoya BL, Héctor A, Torres G, et al. Crecimiento y rendimiento del ajonjolí (*Sesamum indicum* L.) bajo la acción de dos bioles. *La Técnica: Revista de las Agrociencias*. 2019;22:01-10.
2. Pham TD, Thi-Nguyen TD, Carlsson AS, et al. Morphological evaluation of sesame (*Sesamum indicum* L.) varieties from different origins. *Aust J Crop Sci*. 2010;4(7):498-504.
3. Ismaila A, Usman A. Genetic variability for yield and yield components in sesame (*Sesamum indicum* L.). *Int J Sci Res (IJSR)*. 2012;3:358-361.
4. Servicio de Información Agroalimentaria y Pesquera (SIAP). Gob.mx. 2021.
5. Servicio de Información Agroalimentaria y Pesquera (SIAP). Gob.mx. 2022.
6. González-Mateos R, Noriega-Cantú DH, Volke-Haller VH, et al. Maize yield (*Zea mays* L.) and response to sources and doses of fertilizers and biofertilizers in Guerrero, Mexico. *Agroproductividad*. 2018;11(1):22-31.
7. Bruulsema TW, Witt C, García F, et al. A global framework for fertilizer BMPs. *Better Crops with Plant Food*. 2008;92(2):13-15.
8. Héctor-Ardisana E, Torres-García A, Fosado-Téllez O, et al. Influencia de bioestimulantes sobre el crecimiento y el rendimiento de cultivos de ciclo corto en Manabí, Ecuador. *Cultivos Tropicales*. 2020;41(4):e02.
9. Ferraris GN, Couretot LA, Toribio M. Pérdida de nitrógeno por volatilización e implicaciones en el rendimiento de maíz. *Informaciones Agronómicas – International Plant Nutrition Institute*. 2009;(75).
10. De la Isla de Bauer M. *Agricultura: deterioro y preservación ambiental*. Primera edición. México: Mundi-Prensa; 2009.
11. Boza M. Desafío del desarrollo: la agricultura orgánica como parte de una estrategia de mitigación de la pobreza rural en México. *Nóesis. Revista de Ciencias Sociales y Humanidades*. 2010;19(37):92-11.
12. Tlelo-Cuautle AM, Taboada-Gaytán OR, Cruz-Hernández J, et al. Effect of organic and chemical fertilization on fruit yield of Poblano pepper. *Rev Fitotec Mex*. 2020;43(3):283-289.
13. García CM, Castro P CA, Moreno MG. Estudio de la fertilización química y orgánica y su efecto en el cultivo de maíz (Zea mays), en una comuna. *Revista de Investigación en Ciencias Agronómicas y Veterinarias*. 2021;5(14):145-152.
14. García E. Changes to system Köppen climate classification: Mexico city, national autonomous University of Mexico, Institute of Geography. 2004.
15. Servicio Metrológico Nacional (SMN): periodo 1981 – 2010. Published June 12, 2022.
16. Villalba-Algarín CA, Ramítez-Paniagua IR, Sanabria-Franco MF, et al. Comportamiento agronómico bajo diferentes densidades de siembra del sésamo negro (*Sesamum indicum* L.) en la región sur de Paraguay. *Invest Agrar*. 2024;26(1):22-28.
17. González-Salas U, Gallegos-Robles MA, Preciado-Rangel P, et al. Efecto de fuentes de nutrición orgánicas e inorgánicas mezcladas con biofertilizantes en la producción y calidad de frutos de melón. *Terra Latinoamericana*. 2021;39:1-10. e904.
18. Roig Vila D. Hacia una alimentación sostenible: un esfuerzo multidisciplinario. *Nutr Hosp*. 2020;37(Extra 2):43-46.
19. Chávez-Díaz IF, Zelaya M LX, Cruz C I, et al. Consideraciones sobre el uso de biofertilizantes como alternativa agro-biotecnológica sostenible para la seguridad alimentaria en México. *Rev Mex Cienc Agríc.* 2020;11(6):1423-1436.
20. Moreno FLP. Respuesta de las plantas al estrés por déficit hídrico. *Agronomía Colombiana*. 2009;27(2):179-191.
21. Zárate CL, Oviedo de CRM, González ED. Rendimiento del cultivo de sésamo (*Sesamum indicum* L.), variedad Mbarete, en diferentes épocas de siembra y poblaciones de plantas. *Investig Agrar*. 2011;13(2):67-74.
22. González-Betancourt ML, Gallegos-Robles MA, Sánchez-Chávez E, et al. Estiércol bovino solarizado en la producción de tomate bajo condiciones de malla sombra. *Revista Mexicana de Ciencias Agrícolas*. 2020;11(2):253-262.
23. Núñez-Vázquez MC, Delgado-Acosta C, López-Padrón I, et al. Nuevo bioestimulante y su influencia en la producción del frijol común. *Cultivos Tropicales*. 2020;41(4):e08.
24. Anastacio-Angel G, González-Fuentes JA, Zermeño-González A, et al. Effect of bioestimulants on raspberry (Rubus idaeus L.) growth, physiology and biochemical quality subjected to water stress. *Terra Latinoamericana*. 2024;42.
25. Toledo-Aguilar R, Vázquez-Ortiz R, Grajales-Solís M, et al. Manejo agronómico del cultivo de ajonjolí en Guerrero. *Folleto Técnico Num. 28*. Iguala de la Independencia, Guerrero: INIFAP; 2024.
26. Díaz-Mederos P. Respuesta del ajonjolí (*Sesamum indicum* L.) a cinco factores de la producción, bajo condiciones de temporal, en la región de Tierra Caliente, Gro. Tesis Prof. Ing. Agrónomo. Universidad de Guadalajara; 1981:77.
27. IUSS-WRB. *International Soil Classification System for naming soils and creating legends for soil maps Update 2015*. World Soil Resources Reports 106. FAO; 2015.

Citation: Arredondo-Gallardo E, González-Mateos R, González-Zavaleta SV, et al. Mineral and agroecological fertilization in six sesame (*Sesamum indicum L.*) genotypes, Iguala, Guerrero, Mexico. *Horticult Int J.* 2025;9(2):63–66. DOI: 10.15406/hij.2025.09.00324