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Assessment of the production and profitability of squash mayera with the use of biofertilizers and a commercial chemical fertilizer



Evaluación de la producción y rentabilidad de la calabaza mayera con el uso de biofertilizantes y un fertilizante químico comercial



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ABSTRACT

Pumpkin (*Cucurbita pepo*) is a food rich in vitamins and minerals, and its fruit is mainly consumed fresh. However, production levels are low, and the excessive use of chemical fertilizers increases costs and negatively impacts ecosystems. The aim of this study was to assess the production and profitability of Mayera squash using biofertilizers and a commercial chemical fertilizer. The crop was established under open-field conditions in Pilar de Zaragoza, Durango, Mexico. Yield (kg and ton ha⁻¹), fruit traits, and economic profitability were evaluated. The treatments tested were: BioKomplet® (10 L ha⁻¹), biofertilizer (5 L ha⁻¹), chemical fertilizer urea (25 kg ha⁻¹), and a control (irrigation water only). Results showed significant increases ($p \leq 0.01$) in fruit number (6.5 fruits plant⁻¹) and fruit length (17.01 cm) with biofertilizer application. The chemical fertilizer stabilized yields (101 kg ha⁻¹ on average), while BioKomplet® achieved the highest production (884 kg ha⁻¹) and the best profitability, with a return of \$2.02 per peso invested. In conclusion, the application of BioKomplet® in Mayera squash reduced the need for chemical fertilizers, increased yield, and improved economic profitability.

Keywords: *Cucurbita pepo*, yield, economic profitability.

RESUMEN

La calabaza (*Cucurbita pepo*) es un alimento con alto contenido de vitaminas y minerales, cuyo fruto se consume principalmente en fresco. Sin embargo, su producción es baja y los costos derivados del uso de fertilizantes químicos resultan excesivos, además de generar impactos negativos en los ecosistemas. El objetivo de este estudio fue evaluar la producción y rentabilidad de la calabaza mayera mediante la aplicación de biofertilizantes y un fertilizante químico comercial. El cultivo se estableció en campo abierto en el poblado Pilar de Zaragoza, Durango, México. Se evaluaron el rendimiento (kg y ton ha⁻¹),



características de fruto y rentabilidad económica. Los tratamientos aplicados fueron: BioKomplet® (10 L ha⁻¹), biofertilizante (5 L ha⁻¹), fertilizante químico urea (25 kg ha⁻¹) y testigo (solo riego). Los resultados mostraron incrementos significativos ($p \leq 0.01$) en el número (6.5 frutos planta⁻¹) y longitud de frutos (17.01 cm) con la aplicación de biofertilizantes. El fertilizante químico estabilizó el rendimiento (101 kg ha⁻¹ en promedio), mientras que BioKomplet® alcanzó la mayor producción (884 kg ha⁻¹) y una ganancia por peso invertido de \$2.02. En conclusión, la aplicación de BioKomplet® en calabaza mayera permite reducir el uso de fertilizantes químicos, incrementar el rendimiento y mejorar la rentabilidad económica.

Palabras clave: *Cucurbita pepo*, rendimiento, rentabilidad económica.

INTRODUCTION

The application of microorganisms in crops represents a sustainable alternative to the excessive use of chemical fertilizers, as it enhances nutrient uptake and contributes to the control of pests and diseases (Morocho-Mariuxi & Leiva-Mora, 2019). Biofertilizers, formulated from beneficial microbial communities, are a cost-effective strategy within agroecology. They promote the restoration of soil structure, increase organic matter content, and strengthen crop development (Cruz-Cárdenas *et al.*, 2021). Historically, plant domestication involved modifications in soil-associated microbial communities, leading to monoculture systems that reduce plant diversity and negatively affect soil fertility (Bellon *et al.*, 2018; Mastretta-Yanes *et al.*, 2019). In this context, agricultural soil degradation has become a major concern. Beneficial microorganisms, such as bacteria, cyanobacteria, microalgae, protozoa, yeasts, and filamentous fungi, can naturally associate with plant roots, improving their nutritional profile, photosynthetic capacity, and overall growth (FAO, s/f).

In particular, microorganisms influence the transformation and availability of nutrients such as phosphorus and nitrogen in the soil (Jansson & Hofmockel, 2018). Furthermore, chemical fertilizers are costly and may deteriorate soil quality. Therefore, the use of biofertilizers constitutes a viable alternative for improving crop productivity, reducing environmental pollution, and ensuring sustainability (Rosabal-Ayan *et al.*, 2021, González-Breijo *et al.* 2023). Based on the above, the objective of this study was to evaluate the production and profitability of Mayan squash (*Cucurbita moschata*) under the application of biofertilizers and a commercial chemical fertilizer under open-field conditions in the state of Durango, Mexico.



MATERIAL AND METHODS

The research was conducted in the community of Pilar de Zaragoza, Durango, Mexico, located at the geographic coordinates 23.9251-104.6028, at an altitude of 1,876 meters above mean sea level. The experiment was established on a 500 m² open-field plot, where two biofertilizers based on nitrogen-fixing bacteria and fungi were evaluated and compared with a chemical fertilizer (urea).

Plant Material and Treatments

The Mayera squash variety (*Cucurbita pepo*) was used in this study and was purchased from Agribest®. Sowing was carried out directly in soil previously moistened to 80% of field capacity. Forty days after planting, the seedlings were subjected to the following treatments:

1. Control: irrigation water only.
2. BioKomplet®: 10 L ha⁻¹.
3. Biofertilizer: 5 L ha⁻¹ (prepared from cattle manure and other organic materials).
4. Urea: 25 kg ha⁻¹ (chemical fertilizer).

Additionally, cattle manure was applied across the entire experimental area at a rate of 1 t ha⁻¹.

Evaluated Variables

At 71 days after sowing, the fruits were harvested, washed with distilled water, and the following variables were measured:

- Number of fruits per plant (NF).
- Average fruit weight (AFW, g).
- Fruit length (FL, cm).
- Fruit diameter (FD, cm).
- Yield (kg ha⁻¹).

Economic Analyses

Profitability was calculated using the equation of [Volke, \(1982\)](#).

$$IN = YPy - (\sum XiPi + CF)$$

where: *NI* = net income; *Y* = yield (kg ha⁻¹); *Py* = price per kilogram (\$10.00 MXN); *XiPi* = variable costs (fertilizers, labor, and transportation); and *FC* = fixed costs (land preparation, seed, and crop management).



Experimental Design

The data obtained were subjected to analysis of variance (ANOVA) and supported by a mean comparison test among treatments (Tukey, $p \leq 0.05$). Both analyses were performed using the Statistical Analysis System (SAS)

RESULTS AND DISCUSION

Fresh Fruit Yield and Yield Components

Biofertilizer treatments produced significant changes ($p \leq 0.01$) in the number of fruits per plant and fruit length (Table 1). The BioKomplet® treatment resulted in the highest number of fruits (6.66 fruits plant⁻¹) and the greatest fruit length (17.01 cm). In contrast, the chemical fertilizer treatment exhibited the lowest number of fruits (4.06 fruits plant⁻¹).

Table 1. Mean comparison test for number of fruits per plant (NF), average fruit weight (AFW), fruit length (FL), and fruit diameter (FD) of squash as affected by biofertilizers and chemical fertilizer

Treatment	NF (No. plant ⁻¹)	AFW (g)	FL (cm)	FD (cm)
Control	5.85 ab [†]	101.02 b	12.02 b	5.22 a
BioKomplet®	6.66 a	230.03 a	17.01 a	5.42 a
Biofertilizer	6.53 a	220.02 a	16.18 ab	5.44 a
Chemical	4.06 b	191.11 ab	16.20 ab	5.76 a
General means	4.42	201.07	15.22	5.04
Probability F	**	**	**	Ns
DMSH _{0.05}	1.1	98.04	2.33	0.89
Coefficient of variation (%)	13.39	18.88	5.20	7.022

= means with equal letters within of each column no different (Tukey, $p \leq 0.05$). *, ** $p \leq 0.01$ y 0.05 , respectively; Ns = no significant ($p \geq 0.05$); DMSH_{0.05} = honest minimal significant difference.

In terms of yield, BioKomplet® achieved the highest fresh fruit production (884 kg ha⁻¹), followed by the biofertilizer treatment (220 g average fruit weight). The chemical fertilizer treatment maintained a lower yield, averaging 101 kg ha⁻¹. These results are consistent with those reported by Singh *et al.*, (2015); and Maldonado-Montalvo *et al.* (2017), who highlighted those vigorous plants contribute to increased yield and long-term profitability. The values obtained are similar to those reported in studies on organic fertilization with zeolite (Soca-Núñez & Villarreal-Núñez, 2016), and the use of biofertilizers in vegetable crops (Raya-Montaño *et al.* (2018).



Figure 1 presents the average yield values expressed in $t\ ha^{-1}$. Treatment 2 (BioKomplet®) showed the best performance, recording the highest production ($884\ kg\ ha^{-1}$). In addition, healthy and vigorous plants were observed, likely due to the application of microorganisms that enhanced nutrient uptake by the plants.

The values obtained are similar to those reported in studies on organic fertilization using zeolite and the application of biofertilizers in vegetable crops.

Economic Profitability Analysis

The economic analysis revealed clear differences among treatments (Table 2). The chemical fertilizer treatment had the highest total production cost ($\$78,366\ MXN\ ha^{-1}$), whereas the biofertilizer treatments significantly reduced production costs.

The best economic performance was observed with BioKomplet®, which generated a return per peso invested (RPI) of $\$2.02$, while the biofertilizer treatment achieved an RPI of $\$2.30$. Although the chemical fertilizer treatment was productive, it proved less profitable due to its high input costs.

These results are consistent with those described by [Apáez-Barrios et al. \(2019\)](#), who reported lower production costs and competitive yields when combining chemical fertilizers with organic amendments.

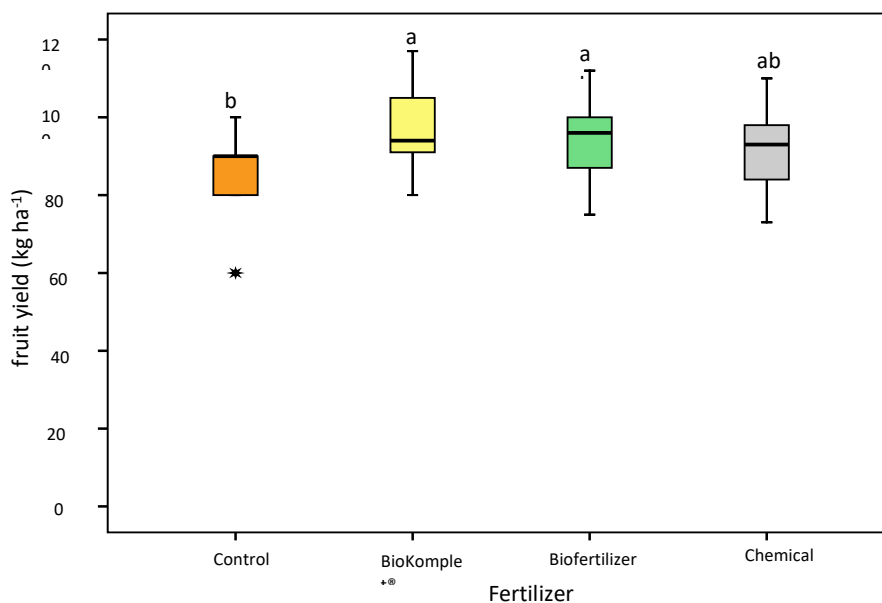


Figure 1. Zucchini yield as a function of two organic fertilizers and chemical fertilizer



Table 2. Production costs and profitability of zucchini cultivation based on the use of biofertilizers and chemical fertilizers

Treatments	Yield (kg ha ⁻¹)	TR (\$ MXN)	FC (\$ MXN)	VC (\$ MXN)	TC (\$ MXN)	NR (\$ MXN)	PPI (\$ MXN)
Control	09 123	91230	37 404	20 128	57 532	33 698	2.70
BioKomplet®	11 728	117 280	37 404	22 088	59 474	57 806	2.02
Biofertilizer	10 507	105 070	37 404	22 070	59 474	45 596	2.30
Chemical	10 304	103 040	37 404	40 962	78 366	24 674	4.17

Total Revenue (TR) = yield * price per kg (\$10.00). Fixed Costs (FC) = includes costs of land preparation, irrigation system installation, water, seed, and labor for crop management. Variable Costs (VC) = includes the cost of fertilizer, labor for fertilizer application, harvesting, and freight. Total Cost (TC) = fixed costs + variable costs. Net Revenue (NR) = total revenue - total costs. Profit Per Investment (PPI) = profit per dollar invested.

CONCLUSIONS

Mayera squash is a viable alternative for local and national producers due to its high market demand and its adaptability to the climatic conditions of Durango. The application of biofertilizers significantly improved yield and reduced production costs compared with chemical fertilization. Biofertilizers represent a sustainable and cost-effective strategy because they reduce dependence on synthetic inputs while contributing to soil conservation and environmental balance. Therefore, their use should be promoted in agricultural systems to strengthen the productivity and profitability of horticultural crops.

Given the high local and national consumption of Mayera squash, this crop represents an excellent option for producers. Furthermore, the climatic conditions of the region are suitable for its growth and development. The use of biofertilizers in squash production offers an important opportunity, as it improved harvested yields while demonstrating lower production costs. These findings highlight the potential of biofertilizers as an environmentally friendly and economically attractive alternative for sustainable crop production.

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