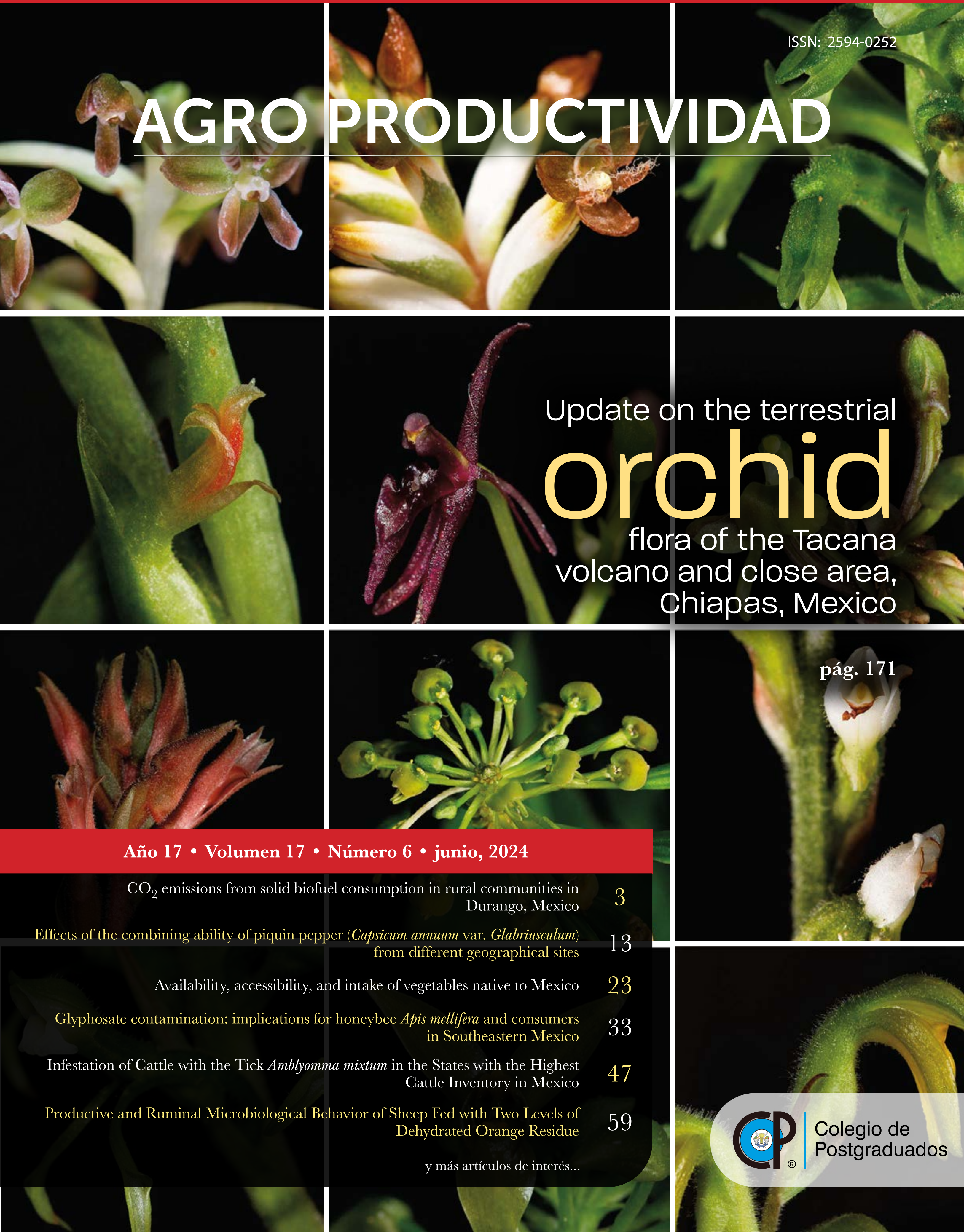
ISSN: 2594-0252

AGRO PRODUCTIVIDAD



Update on the terrestrial orchid flora of the Tacana volcano and close area, Chiapas, Mexico

pág. 171

Año 17 • Volumen 17 • Número 6 • junio, 2024

Colegio de Postgraduados

Colegio de Postgraduados

Profitability analysis of the use of a variable dosing system for the differentiated application of fertilizer in corn crops

Ayala-Garay, Alma V.[1*]; Audelo-Benítez, Marco A.[1]

[1] Campo Experimental Valle de México. Instituto Nacional de Investigaciones Forestales, Agrícolas y Pecuarias (INIFAP). Carretera Los Reyes-Lechería, km.18.5. Texcoco, Estado de México. México. 56230.

* Correspondence: ayala.alma@inifap.gob.mx

ABSTRACT

Objective: a profitability comparison was made between corn production with the use of a variable doser and a conventional fertilizer doser. The variable doser for the differentiated application of fertilizer was built at CENEMA of INIFAP.

An experimental plot was established, applying the recommendations established in the technological package for grain corn production, by INIFAP, in the State of Mexico.

With the variable doser, it was verified that the fertilizer needs of the soil required 11.5% less than that supplied by a constant application doser. The yield obtained was 5.6% higher than in the conventional one. The B/C benefit/cost ratio of corn production with the variable doser was 1.60, while with the conventional doser it was 1.44, for both cases the profitability is positive, with a difference of $0.16 cents.

The profitability with the use of the variable doser was higher than with the conventional doser.

Keywords: Precision agriculture, profitability, benefit-cost.

Citation: Ayala-Garay, A. V., & Audelo-Benítez, M.A. (2024). Profitability analysis of the use of a variable dosing system for the differentiated application of fertilizer in corn crops. *Agro Productividad*. https://doi.org/10.32854/agrop.v17i6.2787

Academic Editor: Jorge Cadena Iñiguez

Guest Editor: Daniel Alejandro Cadena Zamudio

Received: January 03, 2024.

Accepted: May 19, 2024.

Published on-line: July 09, 2024.

Agro Productividad, 17(6). June. 2024. pp: 125-130.

INTRODUCTION

The pursuit of maximizing agricultural production has led to the indiscriminate use of chemical fertilizers, which does not always translate into higher yields and leads to an increase in production costs (Audelo and Irizar, 2012). The adverse effects of excessive fertilizer use include nutrient losses in the environment, water pollution, and the eutrophication of freshwater systems and coastal areas [Food and Agriculture Organization (FAO, 2022)]. One of the current challenges is to continue maximizing production, and sustainably optimizing the use of resources (Martínez, 2008).

Agricultural mechanization in the agricultural production process constitutes a fundamental pathway for the further development of agriculture and the satisfaction of demands for agricultural products (Ávila *et al.*, 2019). Conventional agriculture considers soil conditions as homogeneous and applies the same amount of inputs, such as fertilizers.

Image by Andrew Martin at Pixabay

This increases costs and raises the risks of environmental contamination (Santillán and Rentería, 2018). Precision Agriculture (PA) is a set of techniques aimed at optimizing the use of agricultural inputs (seeds and agrochemicals) based on the quantification of spatial and temporal variability in agricultural production (Bongiovanni *et al.*, 2006; Santillán and Rentería, 2018). PA can reduce the use of agricultural inputs released into the environment by up to 90%. Its use depends on information technologies, where communication between devices is one of the most important tools (Santillán and Rentería, 2018). In Mexico, there is no fertilizer with a variable rate doser, that is, equipment that distributes fertilizer according to specific soil needs (Santillán and Rentería, 2018).

In the market, fertilizer spreaders with conventional dosers are distributed, which apply fertilizer homogeneously (Audelo and Ayala, 2023). The National Center for Agricultural Machinery Standardization (CENEMA) of the National Institute of Forestry, Agricultural, and Livestock Research (INIFAP) designed, built, and evaluated a variable rate doser for the differentiated application of fertilizer that adapts to a row crop planter. The evaluation included functional and economic aspects and was carried out considering corn cultivation, given its importance in Mexico. The objective of this research was to conduct a comparative study of profitability between corn production using a conventional doser and using a variable rate doser for differentiated fertilizer application, aiming to observe optimization of the costs with the use of this doser and to determine its profitability for the producer.

MATERIALS AND METHODS

Conventional and Variable Seeding Machine

For the profitability estimation, data obtained from the assessment of the functionality of a variable rate doser and those from a conventional doser were utilized. These assessments were conducted in an experimental corn plot at the Experimental Field of Valle de México, Texcoco, State of Mexico. In this evaluation, a 0L Magnus 400 seed planter from the Dobladense brand was employed, equipped with both a conventional doser and a variable rate doser. The variable rate doser includes a sensor capable of assessing the nutritional requirements of the surface before applying the fertilizer.

Figure 1. Installation of the variable doser in a seeding machine, 2023.

Experimental set up and profitability calculation

Establishment of the experiment and profitability calculation

The preparation of the land began in April, the sowing took place on May 12th and the harvest on November 16th and 17th, 2023. It was sown in rows of 55 m, with a distance of 0.8 m between them and 0.1 between plants.

Due to the configuration of the seeding machine, three rows were planted using the constant doser unit and three rows using the designed doser, making 5 repetitions of each of the sowings. Table 1 shows the amounts of fertilizer used by each doser. In the conventional one, the technical recommendations established in the technological package for the production of corn published by the INIFAP in the State of Mexico (INIFAP, 2021) were used and in the variable rate doser, the quantities were applied according to the information obtained by the sensor that was used.

To quantify the costs of cultivation, a record was kept. Prices inherent to the inputs were used: seed, agrochemical products such as fertilizers and insecticides, wages, and the rent of machinery used in land preparation, cultural labor, irrigation, and harvesting.

To determine profitability, algebraic expressions based on economic theory were used (Krugman and Wells, 2006; Samuelson and Nordhaus, 2009):

$$CT=P_x X$$

Where: CT=Total production cost, P_x=Price of input or activity, and X=Activity or input.

Total income per hectare is obtained by multiplying the crop yield by its market price. The algebraic expression is:

$$IT=P_y Y$$

Where: IT=Total income (\$ ha^{-1}), Py=Market price of crop Y (\$ Mg^{-1}) and Y=Crop yield (Mg ha^{-1}).

The market price that was used to calculate the income was the guarantee price reported by the Ministry of Agriculture and Rural Development (SADER, 2023).

A cost-benefit analysis (C/B) was conducted to evaluate profitability. According to the C/B analysis, the project will be profitable if the C/B ratio is greater than unity.

Table 1. Fertilizer used by doser.

Product	Quantity Used (kg ha^{-1})		
	Urea	Diammonium phosphate	Potassium chloride
Conventional Doser	361.0	217.66	160.30
Variable Rate Doser	323.77	172.48	180.09

RESULTS AND DISCUSSION

During the corn production cycle, it was verified that the variable rate doser applied up to 11.5% (Figure 2) less fertilizer than the conventional (constant) doser. This variation is based on soil fertilizer requirements since the variable doser used a georeferenced data sensor, which allows nutritional requirements to be evaluated. According to the Institute for Diversification and Energy Saving (IDAE, 2010), variable rate fertilizer distribution requires prior acquisition of data on soil fertility and/or crop status through the use of systems that are based on real-time sensors aboard mobile equipment that lead to immediate responses, measuring soil fertility. Similarly, Santillano *et al.* (2013) mention that the efficiency of fertilizer use could be improved, thus enhancing the sustainability of agricultural production, through the use of sensors.

The variable rate doser contributed to a 11.5% reduction in fertilizer usage. According to Carvajal and Mera (2010), indiscriminate use of chemical fertilizers does not guarantee increased yields in production; on the opposite, it has caused losses in soil productivity where incorrect agricultural practices are carried out, leading to degradation of the soil's biological, physical, and chemical properties. Santillano *et al.* (2013) mentions that through the use of sensor technology, it is possible to obtain substantial savings in fertilization costs, contribute to increasing profitability for producers and reduce environmental impacts by avoiding the application of unnecessary fertilizers. The negative effects of synthetic fertilizer use on the environment are indisputable. Chemicals found in fertilizers, such as nitrates and phosphates, contaminate aquifers and surface water bodies (Orozco and Valverde, 2012). Orozco *et al.* (2016) mention that low fertility of soils has been affected by the excessive use of chemical fertilizers, resulting in high pollution rates, increased compaction and salinity, decreased organic matter, and a decrease in soil microbiology, negatively impacting yield and quality.

One of the challenges faced in agricultural production is to continue maximizing production, while optimizing available resources, since not only the expenditure is excessive, but the contamination that it generates is greater. According to Pazos *et al.* (2016), nitrogen fertilizer added to crops causes physiological changes in plants, which affect the

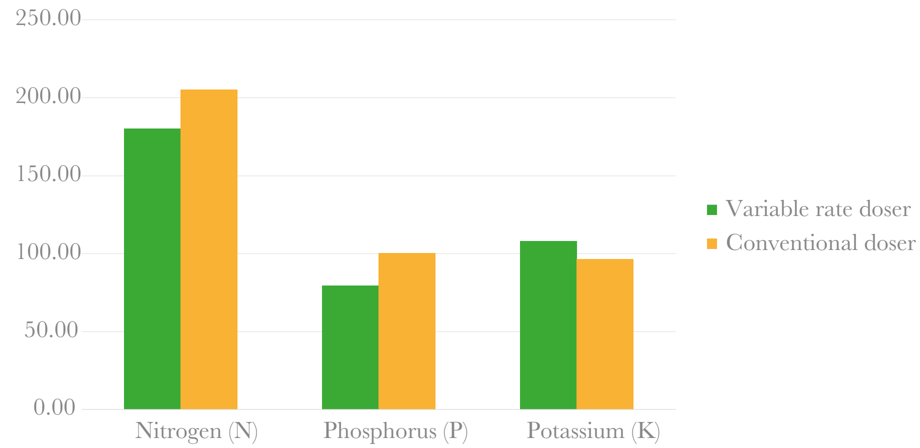


Figure 2. Fertilizer dosage used by each doser (kg/ha).

establishment of beneficial microorganisms. Therefore, the proper use of fertilizer becomes essential. Figure 3 shows the yields obtained with the use of the variable rate doser and the conventional doser. On average, this increased by 5.60%, that is, there was a higher yield where the variable rate doser was used.

Table 2 shows the costs and the benefit-cost relationship, as an indicator of the profitability of the crop. These data were obtained during the corn production cycle in both plots. It is observed that the cost-benefit ratio shows a difference of 0.16. This means that when the variable rate doser is used, \$0.60 MXN are earned for every peso invested, while with the conventional doser, \$0.44 MXN are earned. This indicates that it is 11.1% more profitable. This means that costs are saved, and the necessary nutrients are applied to the soil.

The results indicate that the use of the variable rate doser allows for cost savings. Costs were reduced by 10.4%, while yield increased by 5.6%. This difference in profitability

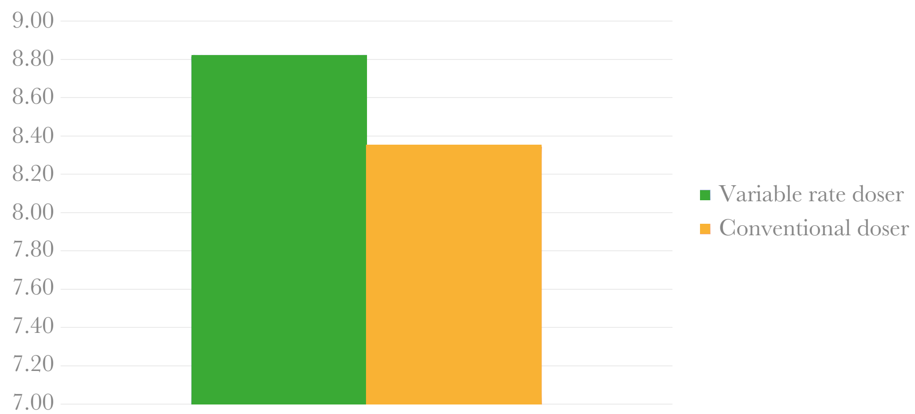


Figure 3. Yield obtained in both plots.

Table 2. Corn profitability, with variable rate doser, with prices.

Concept (\$)	Cultivation using Variable rate doser	Cultivation using Conventional doser
Land preparation	1,600.00	1,600.00
Sowing	800.00	800.00
Agricultural tasks	8,744.44	8,744.44
Inputs	21,683.66	23,394.90
Harvest	4,972.22	4,972.22
Total cost ha^{-1}	37,800.32	39,511.57
Yield (Mg ha^{-1})	8.82	8.35
Price (Mg^{-1})	6,805.00	6,805.00
Revenue ha^{-1}	60,020.10	56,821.75
Utility ha^{-1}	22,219.78	17,310.18
Cost Mg^{-1}	4,285.75	4,731.92
Utility Mg^{-1}	2,519.25	2,073.08
Cost-Benefit ratio	1.60	1.44

benefits those producers with small production areas and impacts the profitability of the crop.

CONCLUSIONS

A comparative study of profitability was conducted between corn production using a conventional doser and using a variable rate doser for differentiated fertilizer application. Corn production using the variable rate doser proves to be more profitable compared to the conventional method. Differentiated fertilization allowed reduced production costs without affecting yield, since it considers the specific nutritional conditions of the soil and applies the precise amount of fertilizer. The use of this type of doser represents progress in the application of Precision Agriculture, benefiting small-scale producers.

REFERENCES

Audelo, B. M. y Ayala, G. A. (2023). Dosificador Variable para la aplicación de Fertilizantes a los cultivos en México [Folleto técnico]. Instituto Nacional de Investigaciones Forestales, Agrícolas y Pecuarias. Folleto Técnico, N.m. 2. 52 p.

Audelo, B. M e Irizar, G. M. (2012). Diseño de un sistema para la desinfección de sustrato utilizado en la producción de micorrizas. *Revista Mexicana de Ciencias Agrícolas*. (4): 624-635.

Ávila, J. H., Rodríguez, F. M., Huerta, A. G. y Sáenz, H. C. B. (2019). Nivel de mecanización agrícola en el municipio de Zinacantepec, Estado de México. *Ciencia Ergo Sum, 27*(1): 75. https://doi.org/10.30878/ces.v27n1a7

Bongiovanni, R. G., Montovani, C. E., Best, S. S. y Roel, A. (2006) Agricultura de precisión: integrando conocimientos para una agricultura moderna y sustentable. https://hdl.handle.net/20.500.14001/68412

Carvajal, J. S. y Mera, A. C. (2010). Fertilización biológica: Técnicas de vanguardia para el desarrollo agrícola sostenible. *Producción + Limpia, 5* (2): 77-96.

Food Agricultural Organization (2022). Environmental and Health Impacts of Pesticides and Fertilizers and Ways to Minimize Them, United Nations Environment Programme, 2022.

Instituto Nacional de Investigaciones Forestales, Agrícolas y Pecuarias (2021). Paquete tecnológico del cultivo de maíz Estado de México.

Instituto para la Diversificación y Ahorro de la Energía (2010). Ahorro y Eficiencia Energética en la Agricultura de Precisión. Madrid, España. https://www.idae.es/uploads/documentos/documentos_10995_AEE_Agr_Precision_AGR16_A2010_69054ba0.pdf

Krugman, P. R. y Well, R. (2006). Introducción a la economía: Microeconomía. Reverté, Barcelona.

Martínez, R. (2008). Agricultura tradicional campesina: características ecológicas. *Tecnología en marcha, 21*(3): 3-13. https://revistas.tec.ac.cr/index.php/tec_marcha/article/view/179

Orozco, A., Valverde, M., Martínez, R., Chávez, C., Benavides, R. (2016) Propiedades físicas, químicas y biológicas de un suelo con biofertilización cultivado con manzano Terra Latinoamericana. *Sociedad Mexicana de la Ciencia del Suelo, A.C. 34*(4), 441-456

Orozco, A. y Valverde, M. (2012). Impacto ambiental del manejo del agua de riego con sondas de capacitancia sobre la contaminación de acuíferos por nitratos. *Tecnología y Ciencias del Agua*, 3: 23-35.

Pazos, L. A., Marín, V., Morales, Y. E., Baez, A., Villalobos, M. A., Pérez, M. y Muñoz, J. (2016). Uso de microorganismos benéficos para reducir los daños causados por la Revolución Verde. *Revista Iberoamericana de Ciencias*, 20: 72-85.

Secretaria de Agricultura y Desarrollo Rural. (2023). Todo lo que debes conocer sobre el programa precios de garantía.

Samuelson, P. A., Nodhaus, W. D. (2009). Economía con aplicaciones a Latinoamérica (19° ed.). Editorial MacGraw-Hill, Madrid.

Santillán, O., y Rentería, M. (2018). Agricultura de Precisión. Foro Consultivo, Científico y Tecnológico. https://www.foroconsultivo.org.mx/INCyTU/index.php/notas/76-15-agricultura-de-precision-n

Santillano, J., López, A., Ortiz, I. y Raun, W. R. (2013). Uso de sensores ópticos para la fertilización de trigo (*Triticum aestivum* L.). *Terra Latinoamericana, 31*(2), 95-103.