v. 3, n. 9, 2023

Journal of Agricultural Sciences Research

TECHNICAL-ECONOMIC INDICATORS OF TOMATO CROP UNDER PROTECTED AGRICULTURE IN THE LAGUNERA REGION, MEXICO

Ignacio Orona Castillo
Universidad Juárez del Estado de Durango, Facultad de Agricultura y Zootecnia, Gómez Palacio, Durango, México.

Cirilo Vázquez Vázquez
Universidad Juárez del Estado de Durango, Facultad de Agricultura y Zootecnia, Gómez Palacio, Durango, México.

Florencio Jiménez Dìaz
Universidad Juárez del Estado de Durango, Facultad de Agricultura y Zootecnia, Gómez Palacio, Durango, México.

Apolinar González Mancilla
Universidad Juárez del Estado de Durango, Facultad de Agricultura y Zootecnia, Gómez Palacio, Durango, México.

Juan Estrada Àvalos
CENID RASPA - INIFAP. Km. 6.5 margen derecha Canal Sacramento, Gómez Palacio, Durango.

Abstract: Tomato cultivation is very important due to its high consumption as a culinary ingredient and its wide adaptation to climatic and soil factors. Mexico is in tenth place worldwide and this product is one of the most exported vegetables, mainly to the United States of America. In 2020, the Comarca Lagunera allocated an area of 984 ha under shade mesh with a production of 138,036 tons. Due to the economic and social importance in the region, the objective was to determine the productivity indicators of water, soil, labor and capital, which will support the producer to make better decisions. To carry out the study, five production units under shade mesh that occupied 50 % of the total planted area were selected through systematic sampling and the necessary information was obtained through a survey, finding that the average value of the indicators was 11.9 kg. tomato per square meter; 54.3 kg of tomato per cubic meter of water, and 61.9 and 99.7 pesos the net income obtained per square meter of surface and cubic meter of water, respectively. The highest values were registered by the largest production units, concluding that this behavior is due to the greater economy of scale and greater care with which the crop is managed.
Keywords: *Solanum Lycopersicum*, shade mesh, Comarca Lagunera, productivity.

INTRODUCTION

In Mexico, tomato production grew at an average annual rate of 4.8% between 2006 and 2016, reaching a record high of 3.3 million tons. During this period, the total area devoted to this crop decreased at an average annual rate of 2.5 %. On the contrary, the area established with protected agriculture (PA), shade mesh and greenhouse, grew at an average annual rate of 30.1 %. Thus, the volume of tomato obtained with the use of these technologies went from 6.5 % in 2006 to 32.2 % in 2010, and 60.7 % of the total volume in 2016. (FIRA, 2017). Tomato cultivation in AP represents 70 % of the cultivated area (INEGI, 2018).

Worldwide, Mexico is in position number 10 with a participation of 87,918 hectares harvested of tomato and with a production of 4,271,914 tons (FAOSTAT, 2021). According to SIAP (2020) tomato is the main vegetable that is exported. For the year 2020 in La Comarca Lagunera, 984 ha were harvested with a production of 138,036 tons of which the predominant system was agriculture protected with shade mesh (SIAP, 2020).

Levitan and Werneke (1984) mention that technology and education allow generating differences in productivity over time and that the technological characterization of tomato production will allow understanding the dynamics and operation of the crop in the context of its development, evolution and change in order to achieve plans and programs for groups with similar characteristics (Valerio et al., 2004).

Protected agriculture is a production system developed with the aim of providing plants with the ideal conditions for their development, and thereby expressing the maximum productive potential (Vargas-Canales et al., 2018). Similarly, it is possible to manage environmental conditions (temperature, relative humidity, nutrition, water, light, etc.) and some other risks (pests and diseases) for the best development of crops (Marjorie et al., 2017; INIFAP, 2012). Protected Agriculture (PA) is the term used to describe a series of cultivation techniques that fully or partially control the microclimate surrounding the plant body according to the needs of the species during its growth period. The PA in Mexico has been developed as a strategy to reduce polluting emissions that contribute to global warming; strategy that conforms to FAO recommendations on the sustainable intensification of agricultural

production (Pratt and Ortega, 2019).

The objective of this production system is focused on increasing and maintaining productivity in quantity, quality and commercial opportunity (Castañeda et al., 2007; Moreno et al., 2011).

Productivity is considered as the way of using the factors of production in the generation of goods and services to obtain benefits and is summarized as the quotient between the products generated and the productive inputs used, and productivity in shade mesh can increase through the incorporation of better technologies (Fontalvo-Herrera et al., 2017; Valbuena et al., 2018).

For Mexico it is very important to evaluate these indicators since it is the main tomato exporter worldwide; in 2016 it contributed 25.11% of the value of world exports, covering 90.67% of imports from the United States of North America and 65.31% from Canada (SAGARPA, 2017).

Due to all of the above, the objectives of this work were: a) to evaluate the productivity of the water, soil and capital resources used in tomato production under shade mesh at different surface sizes in the Comarca Lagunera, establishing as a hypothesis that the larger the surface established with shade mesh, higher levels of productivity of water and soil resources and profitability are obtained due to the economy of scale at which the crop is practiced; b) determine the destination and price of tomato production grown in the Comarca Lagunera.

MATERIALS AND METHODS

The study area was the Comarca Lagunera, located in north-central Mexico, considered an agricultural and industrial area located between the meridians 102º 50' and 103º 40' West longitude, and the parallels 25º 25' and 26º 30' latitude. North; in the states of Durango and Coahuila.

The climate of this area, according to the Köppen classification modified by Enriqueta García (Cháirez and Palerm, 2013), corresponds to BWhw" (e´), which is characterized by being very dry or desert-like, semi-warm with cool winters, with a average annual temperature between 18 and 22 ºC, and of the coldest month less than 18 ºC, with an average precipitation of 250 mm and a potential evaporation of the order of 2,500 mm per year.

To carry out this study, the register of tomato producers was obtained at the offices of the Tomato Product System, made up of nine producers with shade mesh. Based on this pattern, five production units were chosen by systematic sampling where all the production units with differentiated surface sizes are represented where (i) = N/n = 9/5 = 1.8, that is, a producer was selected from each two producers, located in four municipalities, two from the state of Coahuila (Matamoros and Francisco I. Madero) and two from the state of Durango (Gómez Palacio and Tlahualilo), whose surface represented 50 % of the 984 ha planted with tomato this year (SADER, 2022). The data was obtained from a questionnaire made up of 27 questions answered by those in charge of the shade mesh production units and their technicians; the first part collected the informant's identification data; the second, technical aspects of the crop, density and planting date, varieties, yields, surface area, inputs and amounts used in planting and crop development, including products for phytosanitary control and crop nutrition; and the third, labor used; production costs; sale prices, destination of production, technical assistance and level of certification of your agricultural unit.

This stage ran from July to September 2020. Once the information from the questionnaires was reviewed, it was captured, using the Microsoft Excel Program, where frequencies,

averages, volumes, total costs, net income, production percentages destined for internal and external consumption, etc., determining for each agricultural unit and the average of the indicators of efficiency in the use of soil, water, capital resources (profitability), having made the corresponding comparative analysis between them. The average productivity of the soil and water were calculated taking into account the yields obtained divided between the surface occupied by the shade mesh and the volume of water used during the crop cycle and the profitability of the use of said resources and the labor resource. (wage used) was estimated by dividing the total net benefits achieved by the sale of tomatoes from the production unit, between the area, the volume of water and the wages used per unit area.

RESULTS AND DISCUSSION

TECHNICAL ASPECTS

Production unit size: The minimum and maximum value recorded for the size of the area planted with shade mesh of the crop ranged between six and 230 ha respectively, finding an average size of 98.9 ha. The situation found in the area differs from that prevailing at the national level, where 86 % of tomato production units are less than 0.5 hectares; 11.5%, from 0.51 to 5, and 2.5% have more than 5 hectares, which limits their access to technology, training and technical assistance, as well as a greater penetration in the most demanding markets (Ponce, 2013), therefore; Having larger production units, as is the case in the study area at hand, allows for the introduction of efficient technologies in the use of water, better use of nutrients applied through the irrigation system, greater protection against pests and climatic events. like hailstones, and better product quality. However, the cost of production under shade mesh is very high, which requires more investment, labor training, and assistance for the management of the production process.

Yield per hectare: The average yield reached was 120.8 t ha-1; the highest value was registered by the largest agricultural unit with 170 t ha-1 and the lowest by the smallest unit, with 90 t ha-1. These values are above the one registered at the national level for the crop in general, which are 48.6 t ha-1, which shows the benefits of the production system under shade mesh. Cih-Dzul et al. (2011), reported for the state of Jalisco 210 t ha-1 for greenhouse and shade mesh production systems.

Plant density per unit area: This variable oscillated between 23 and 33 thousand tomato plants per hectare, that is, 2.3 to 3.3 plants per square meter, registering an average value of 27,400 plants; the smallest agricultural unit (6 ha) was the one that used the lowest density of all and the one that used the highest density of plants was the largest agricultural unit. In this regard, Alvarado (2014) indicates that the planting density under shade mesh ranges from 20 to 30 thousand plants per hectare and Jasso et al., (2012) indicate that it can vary depending on the hybrid or variety, but can reach up to 31 250 plants.

Tomato production per square meter of surface: The kilograms obtained per square meter ranged between 7.5 and 17 kilograms; the lowest value corresponded to the smallest agricultural unit and the highest to the largest. The average value found for this element was 11.9 kg per square meter. It is pertinent to clarify that said value changes according to the established variety. The value reported by Alvarado et al. (2014) for the northeast of Mexico ranged between 9.8 and 19.6 kg.

Irrigation water productivity: Considering the different yields obtained by the agricultural units under study, it was found that for each cubic meter of water it is possible to obtain an average production of 19.45 kg; however, it is observed that the agricultural unit with the

largest area achieves a value of 23.37 and the smallest 14.49 kg (Figure 1).

The average volume of water required to produce a kilogram of tomato in the Comarca Lagunera was estimated at 54.3 liters, while the one reported by Henao (2016) at the national level is 99 and for the United States 40, who concludes that this value varies according to to the technological level used. Cabrera de la Fuente (2017), stated that to produce a kilo of tomato sowing the crop in the open field, 215 liters are required and that only 36 are required under a greenhouse (Figure 2).

Main pests of tomato cultivation: The largest agricultural units were those that registered the lowest number of pests: Whitefly (Bremicia tabaci) leafminer (Liriomyza bryoniae) and the smallest ones those that registered the highest number. Figure 3 shows the pests reported in the different production units.

As in the study carried out for the state of Jalisco (Cih-Dzul et al., 2011), it was found that the white fly is the main pest in the study area.

Main diseases in the crop: These were numerous and different in each agricultural unit and were controlled with the application of different chemical products (Figure 4).

ECONOMIC ASPECTS

Destination and price of production: Of the five agricultural units studied, three export an average of 74% of their production to the United States market; however, those that export 79 and 85% are those with a size of 230 and 72 ha. Only the smallest one allocates all its production to the national market (Figure 5). In this regard, Estrategia Aduanera (2021) reported that by the year 2020, approximately 80% of the tomatoes that use protected agricultural systems are exported and the United States Department of Agriculture (USDA) projects a growth in exports of 2% for the 2021-2022 cycle.

Of the total production destined for the national market, two thirds sell it as a top quality product; a quarter as a second-grade tomato and the rest as a third. Average rural prices were 7.6, 6.4 and 5.33 pesos per kilogram for first, second and third quality tomatoes, respectively.

The export price of first and second quality tomatoes registered for the study year, according to the information provided by the producers, was 10 and 8 pesos, respectively. The total income from the foreign market is six times greater than that of the domestic market.

FIRA (2017) points out that red tomato prices in the national market differ according to the type of product (grown in the open field or in a greenhouse, organic, etc.) and the variety (saladette, bola and cherry), mainly.

Production costs per kg of tomato: According to the information provided, it is noted that the average production cost to produce a kilogram of tomato amounts to 4.02 pesos; however, the trend line indicates that the greater the established area, this value decreases (Figure 6).

Economic indicators: In Table 1, it can be seen that the net income obtained per square meter of land is higher in the U.A. larger area, as well as the net income derived from the cubic meter of water used. However, the average value of both indicators is 61.9 and 99.7, respectively. The average net income per wage employed was 896 pesos.

Suppliers of inputs, technical assistance and production certification. The agricultural companies that supply inputs for production such as seeds, fertilizers, pesticides and chemical products for disease control were: Agricenter Zevilla, S.A. de C.V.; Greenhow, S.A. de C.V.; versa; Proagro, VMV, S.A. de C.V., and Gaia, S.A. de C.V.

All tomato producers under shade mesh have technical assistance in a particular way;

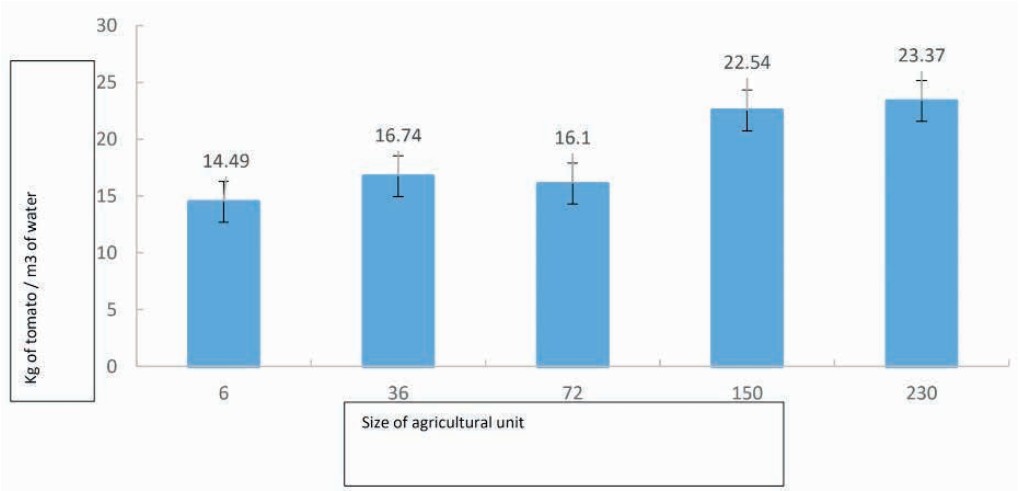

Figure 1. Productivity of the cubic meter of water in kilograms of tomato under shade mesh in agricultural units with different surfaces in the Comarca Lagunera.

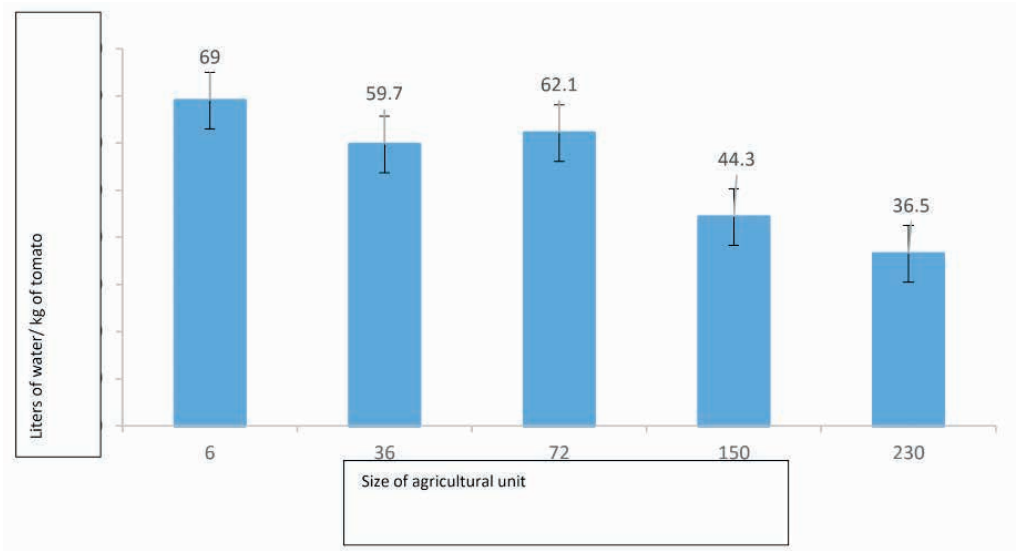

Figure 2. Liters of water necessary to produce one kilogram of tomato under shade mesh in agricultural units with different surfaces in the Comarca Lagunera.

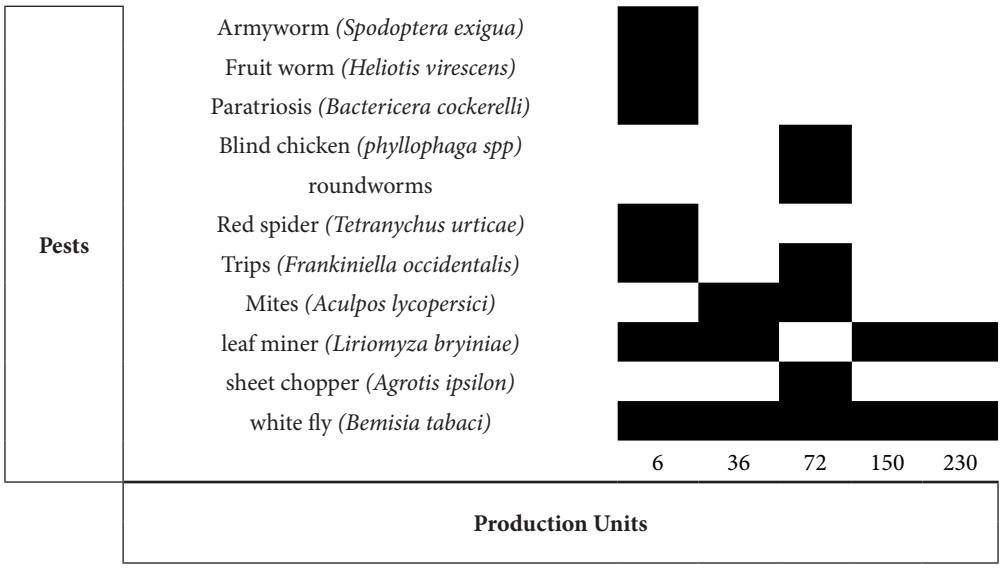

Figure 3. Production units affected by pests reported in the Comarca Lagunera.

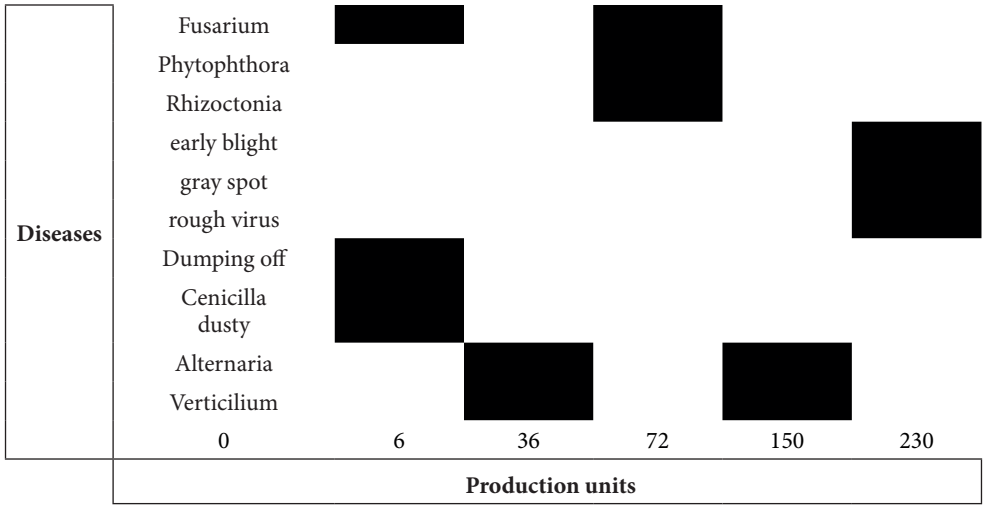

Figure 4. Diseases reported in tomato cultivation by different production units in the Comarca Lagunera.

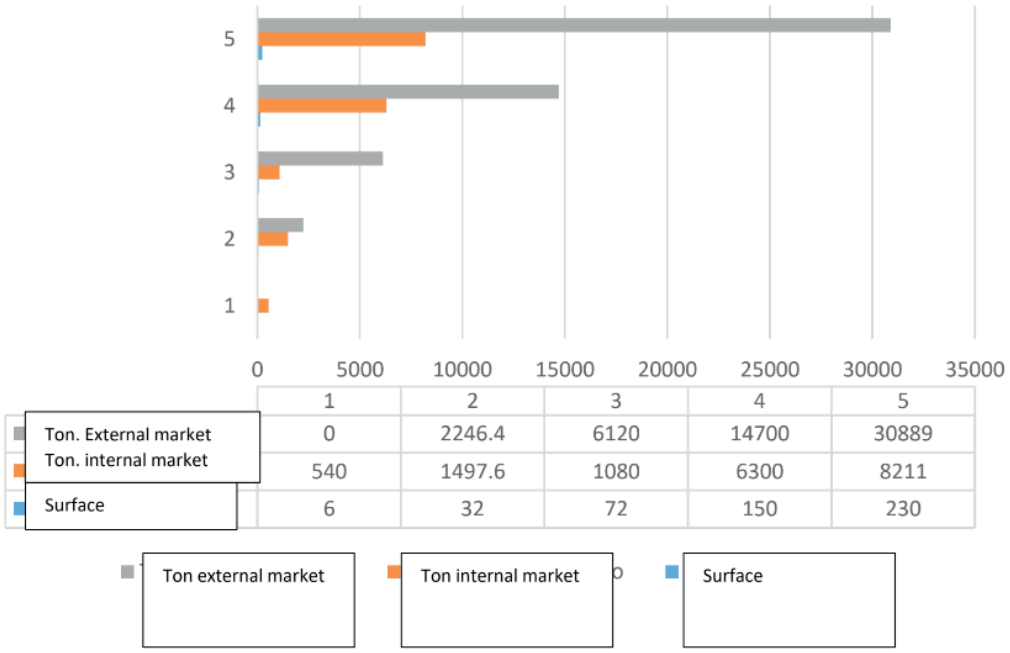

Figure 5. Volume of tomato production obtained under shade mesh destined for the internal and external market by the different agricultural production units.

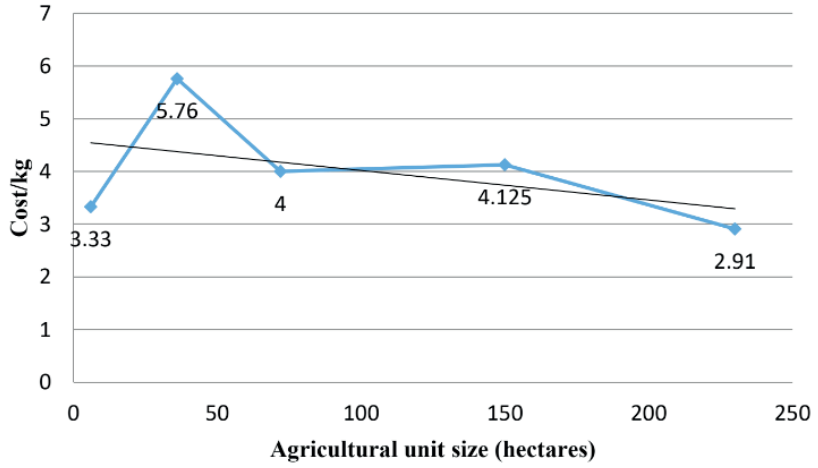

Figure 6. Production cost per kilogram of tomato reported by the different production units.

Size (ha)	$ /m² of soil	$/m³ of water	$/employee wage
6	61.40	98.87	1 116.30
36	11.40	18.49	259.10
72	56.90	91.62	517.30
150	75.10	120.93	682.70
230	104.83	168.82	1 906.10

Table 1. Economic-social indicators of tomato cultivation under shade mesh in the Comarca Lagunera.

even some with international advisors. In the areas that receive technical assistance are: pest control, diseases and crop nutrition. All the agricultural units have the certification of their good agricultural practices in their production; The certifying companies are: Senasica; Primus lab; C-TPAT; SMETA; DEALTI and GLOBAL GAP, T. This situation explains why they can send their production to the foreign market.

CONCLUSIONS

The productivity achieved by the cultivation of tomatoes under shade mesh that is practiced in the Comarca Lagunera is higher in the production units with the largest established area; that is, the hypothesis that the greater the size of the agricultural unit established with tomatoes under shade mesh, higher levels of productivity of water, soil and capital are reached, was verified, which suggests that the greater the producer's investment, the higher the level of productivity. demanding in terms of technology management under shade mesh. The destination of the tomato production produced in this region is mainly for export (80%) to the US market, thereby achieving a higher price per kilogram sold. The main reason for this situation is due to the fact that all the tomato farming units are certified and that they carry out the good agricultural practices (GAP), established by the National Health, Safety and Quality Service (SENASICA).

REFERENCES

Alvarado, C.M., Díaz, F.A. y Hernández, M.R. 2014. Tecnología para producir tomates en casa malla para el norte de Tamaulipas. Instituto Nacional de Investigaciones Forestales, Agrícolas y Pecuarias. Folleto para productores No. MX-0-310301-49-0313-10-60. ISBN; 978-607-37-330-7. Río Bravo Tamaulipas. 31 p.

Cabrera de la Fuente, M. 2017. https://www.iagua.es/noticias/mexico/conacyt/17/09/04/como-obtener-mas-tomates-utilizando-menos-agua.

Castañeda-Miranda, R., Ventura-Ramos, E., Peniche-Vera, R. del R., & Herrera-Ruiz G. (2007). Análisis y simulación del modelo físico de un invernadero bajo condiciones climáticas de la región central de México. Agrociencia, 41(3), 317–335.

Cháirez, A. C. y Palerm, V. J. 2013. Organizaciones autogestivas en los distritos de riego: el caso del módulo III San Jacinto en el Distrito de Riego 017, Durango, México. En: Tecnología y Ciencias del Agua, vol IV, núm 4., septiembre-octubre, 2013, pp. 19-46.

Cih-Dzul, I.R.; Jaramillo V., J.L.; Tornero C., M.A.y Schwentesius R. R. 2011. Caracterización de los sistemas de producción de tomate (*Lycopersicum esculentum* Mill) en el estado de Jalisco, México. Revista Tropical and Subtropical Agroecosystems, Vol. 14 pp 501 – 512.

Díaz, R. C.; Pérez de la Cruz, J. M. y Ramos-Herrera. 2018. Nuevas y competitividad: implicaciones en una unión monetaria. Rev. Econ. Mundial. 49:39-56.

Estrategia Aduanera. Revista Mexicana de Comercio Exterior. 2021. https://www.estrategiaaduanera.mx/marcan-records-exportaciones-de-tomate-de-mexico-a-estados-unidos/

FAOSTAT. 2021. https://www.fao.org/faostat/es/#data

FIRA, 2017. Panorama agroalimentario (Tomate Rojo 2017). Dirección de Investigación y Evaluación Económica y Sectorial. 25 p.

Fontalvo-Herrera, T.; De La Hoz-Granadillo, E. y Morelos-Gómez, J. 2017. La productividad y sus factores: incidencia en el mejoramiento organizacional. Dimensión empresarial. 15(2):47-60. Doi: http://dx.doi.org/10.15665/rde.v15i2.1375. http://www.scielo.org.co/ pdf/ diem/ v16n1/1692-8563-diem-16-01-00047.pdf.

Henao, O. F. 2016. https://www.iagua.es/blogs/ferley-henao/tomate-y-huella-agua

INEGI. 2018. Instituto Nacional de Estadística y Geografía. Encuesta Nacional Agropecuaria 2017. https://www.inegi.org.mx/programas/ena/2017/.

INIFAP. 2012. Guía para cultivar jitomate en condiciones de malla sombra en San Luis Potosí. San Luis Potosí. Obtenido de http://www.inifapcirne.gob.mx/Biblioteca/Publicaciones/905.pdf

Jasso, Ch. C., Martínez, G. M.A., Chávez V. J.R., Ramírez, T. J.A. y Garza, U. E. 2012. Guía para cultivar jitomate en condiciones de malla sombra en San Luis Potosí. Folleto Técnico No. MX-0-310305-49-03-17-09-44 ISBN: 978-607-425-821-9. Instituto Nacional de Investigaciones Forestales, Agrícolas y Pecuarias. Campo Experimental San Luis Potosí, S.L.P. 54 p.

Levitan, S. A. and Werneke, D. 1984. Productivity: problems, prospects, and policies. The Johns Hopkins University Press No. 40. 200 p.

Marjorie, A.C., Salinas, P.L., Rodríguez A.F., Olivares, P.N., Riquelme, S.J., Antúnez, B. A., Martínez, C. JP., Corradini, S.F., Sepúlveda, S.P., Abarca, R. P., Guzmán, L.A., y Felmer, E.S. 2017. Manual de cultivo del tomate bajo invernadero, Boletín INIA No. 12. Editora: Torres, P.A. Instituto de Investigaciones Agropecuarias. Manual del cultivo del tomate bajo invernadero. Boletín INIA, No. 12, ISSN: 0717-4829. 111 p.

Moreno, R. A., Aguilar, D. J., & Luévano, G. A. (2011). Características de la agricultura protegida y su entorno en México. Revista Mexicana de Agronegocios, 15(29), 763–774.

Muguira A. 2022. Question Pro. https://www.questionpro.com/blog/es/muestreo-sistematico/amp/

Ortiz-Jiménez, B.; Jiménez-Sánchez, L.; Morales-Guerra, M.; Quispe-Limaylla, A.; Turrent Fernández, A.; Rendón-Sánchez, G. y Rendón-Medel, R. 2013. Nivel de adopción de tecnologías para la producción de jitomate en productores de pequeña escala en el estado de Oaxaca. Rev. Mex. Cienc. Agríc. 4(3):447-460.

Ponce, C.P. 2013. Producción de tomates en invernadero en México. (https://www.hortalizas.com/horticultura-protegida/produccion-de-tomates-en-invernadero-en-mexico/).

Pratt, P. y Ortega, J.M. 2019. Elaboración de la metodología para el primer bono verde certificado. En: Agricultura Protegida en México, Nieto, E. y Braly C. I. Editores. Banco Interamericano de Desarrollo Nota Técnica No. IDB-TM-1668.

Secretaría de Agricultura, Ganadería, Desarrollo Rural, Pesca y Alimentación (SAGARPA). 2017. Planeación Agrícola Nacional 2017-2030. México: Author. Retrieved from https://www.gob.mx/cms/uploads/ attachment/f i le/255627/Planeaci_n_Agr_cola_Nacional_2017-2030-_parte_uno.pdf

SIAP. 2020. Sistema de Información Agroalimentaria y Pesquera. Agricultura protegida. https://www.gob.mx/siap/documentos/siacon-ng-161430.

Vargas, C. J. M., Palacios-Rangel, M. I., Aguilar-Ávila, J., Ocampo-Ledesma, J., & Medina-Cuellar, S. E. (2018). Efficiency of small enterprises of protected agriculture in the adoption of innovations in Mexico. Estudios Gerenciales, 34(146), 52–62. https://doi.org/10.18046/j. estger.2018.146.2811

Valbuena-Díaz, N.; Leal-Guerra, M. y Urdaneta-Montiel, A. 2018. ADN organizacional y productividad en las empresas familiares. Desarrollo Gerencial. 10(1):105-122.

Valerio, C. D.; García, M. A.; Acero, de la C. R.; Castaldo, A.; Perea, J. M. y Martos, P. J. 2004. Metodología para la caracterización y tipificación de sistemas ganaderos. Departamento de producción animal Universidad de Córdoba. Producción animal y gestión. 9 p.