Revista Mexicana de Ciencias Agrícolas

DOI: https://doi.org/10.29312/remexca.v14i7.3293

Investigation note

Use of remote sensing for the determination of the Kc of the fig crop

Karla Janeth Martínez-Macias[1]
Selenne Yuridia Márquez-Guerrero[1,§]
Jorge Arnaldo Orozco-Vidal[1]
Arturo Reyes-González[2]

1 División de Estudios de Posgrado-Instituto Tecnológico de Torreón. Torreón, Coahuila, México. CP. 27170.

2 Campo Experimental La Laguna-INIFAP. Blvd. José Santos Valdez Núm. 1200 Pte. Col Centro, Matamoros, Coahuila, México.

Autor para correspondencia: selenne.marquez@hotmail.com.

Abstract

The fig crop has been introduced as a potential fruit alternative in our country. Nevertheless, there is little information regarding the efficient management of the fig crop, such as the crop coefficient, which is of great importance for the programming of efficient irrigation; through irrigation sheets that provide the crop with the water requirement for its production. Through satellite images, the normalized difference vegetation index, and the reference crop coefficient, an equation of the crop coefficient was determined for the fig crop with the power to provide technical information for irrigation programs.

Keywords:

Ficus carica L., crop coefficient (Kc), satellite images.

DOI: https://doi.org/10.29312/remexca.v14i7.3293

The complexity of current environmental problems, such as climate change, deforestation, soil degradation, water scarcity, among others, demands the use of geospatial techniques and tools such as geographic information systems (GIS) (Bautista *et al*., 2011), which are a set of software and hardware designed to read, edit, store, manage and analyze data, which are represented through maps, graphs, reports, etc. (Olaya, 2014).

GIS have become an important tool for researchers and professionals who require the management of databases related to various levels of spatial or territorial aggregation (IIRBAVH, 2006), such as the agricultural sector. Precision agriculture integrates various spatial information technologies by recognizing, locating, quantifying, and recording spatial and temporal variability of an agricultural unit, optimizing crop productivity, improving agronomic decisions of different crops for each specific site (Lizarazo-Salcedo and Alfonso-Carbajal, 2011).

The normalized difference vegetation index (NDVI) is a model universally used for the monitoring of vegetation in different environments, it uses a combination of reflectance values with high sensitivity in vegetation changes and low sensitivity to other types of information.

The NDVI is obtained from the ratio of red and near-infrared reflectance, reflected by the vegetation captured by the satellite sensor; values range from +1 to -1. Values of 0.1 correspond to rocky, sandy, or snowy areas, those from 0.2 to 0.3 correspond to areas with shrubs, meadows, or natural pastures, while values greater than 0.6 indicate temperate or tropical forests; that is, the highest values are for denser vegetation and with greater photosynthetic activity, while lower values for little vegetation, so it is considered an estimator of the amount of biomass and water needs of crops (Aguilar *et al*., 2010; Reyes-González *et al*., 2018; Rueda-Calier *et al*., 2019).

To estimate the water needs of a specific crop, the crop coefficient (Kc) and the reference evapotranspiration are used, which is why this method helps to plan and manage when and how much water should be used for irrigation prospectively, projectively, and in real-time (Zamora-Herrera *et al*., 2014; Herrera-Puebla *et al*., 2015). The fig tree is native to the Mediterranean region, is drought tolerant, supports high levels of salts, and adapts to infertile soils, offering advantages in its production in arid and semi-arid regions (Von Linneo, 1753; Peraza-Padilla *et al*., 2013).

The fig has a high nutritive, nutraceutical, and antioxidant capacity and can be consumed fresh, dehydrated, and minimally processed (INTAGRI, 2020). According to data from (FAOSTAT, 2020), in 2018, world fig production exceeded one million tons, where Turkey was the largest producer, with 270 000 t, while Mexico produced 7 000 t year^{-1}, in an area of 1 340 ha (Márquez-Guerrero *et al*., 2019), with Veracruz being the state with the highest yields per hectare (INTAGRI, 2020).

Due to its versatility, the fig crop has been introduced as a sustainable fruit alternative in arid and semi-arid areas, hence its importance in La Comarca Lagunera. However, there is no up-to-date information on the intensive management of the fig crop, such as Kc estimation, evapotranspiration (ET), and irrigation treatments. It is of interest to generate technical information that supports the sustainable management of the crop with the help of geographic information systems.

Experimentation site

The fieldwork was carried out in the ejido El Vergel, in Gómez Palacio, Durango (25° 39’ 16.679” north latitude, -103° 30’ 4.129”). With climate Bw (h’) hw (e), which corresponds to a hot desert dry climate with a rainfall regime in summer and extreme oscillation (Rosales-Serrano *et al*., 2015), with temperature ranges ranging from 4 °C to more than 30 °C and average annual precipitation of 250 mm concentrated from June to September (INEGI, 2017).

DOI: https://doi.org/10.29312/remexca.v14i7.3293

Satellite images

Images from the Sentinel-2 satellite with a processing level 1C were downloaded from the United States Department of Agriculture (USDA) website, from January 2020 to November 2021. The images were taken to a 2nd processing level, with an atmospheric correction DOS1, the QGIS 3.20 software.

NDVI Calculation

For the calculation of the NDVI, the formula described by Krtalic *et al*. (2019) was used:

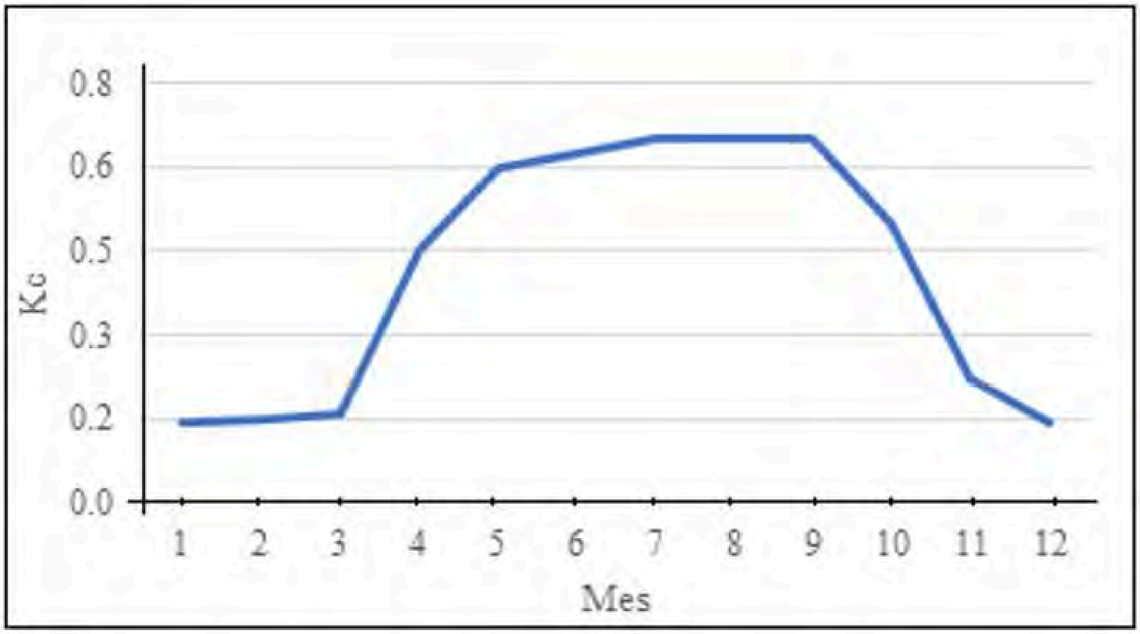
$$NDVI=\frac{NIR\text{-}RED}{NIR+RED}$$

Where: NIR= near infrared. RED= red. For the Sentinel-2 satellite, these represent the bands B8 for near-infrared and B4 for red.

Kc calculation

The calculation of Kc was carried out according to the methodology by Reyes-González *et al*. (2020), where the NDVI is plotted against the reference Kc of the crop, obtaining an equation that determines the real Kc of the crop based on the NDVI. The reference Kc (Figure 1) was taken from the article by Rodríguez and Valdez (1999), where they estimate the water needs of the fig tree during the years 1996, 1997, and 1998, obtaining the monthly Kc of the crop.

Figure 1. Kc reference of the fig crop.



The reference Kc agrees with the phenological stages of the fig crop reported by Márquez-Guerrero (2019), which are: November (11), December (12), January (1): latency stage. February (2): pruning. March (3), April (4): vegetative growth. May (5): fruit development and breba harvest. June (6): fruit ripening. July (7), August (8): high fruit harvest. September (9): medium fruit harvest. October (10): postharvest.

Revista Mexicana de Ciencias Agrícolas
REMEXCA
DOI: https://doi.org/10.29312/remexca.v14i7.3293

Analysis of information

With the ArcMap 10.3 software, the NDVI estimate was made for the years 2020 (Figure 2) and 2021 (Figure 3), considering two plots cultivated with fig, one plot A with 14 ha and drip irrigation, and one plot B with 25 ha and gravity irrigation.

Figure 2. Qualitative NDVI results for 2020 for plot A and plot B.

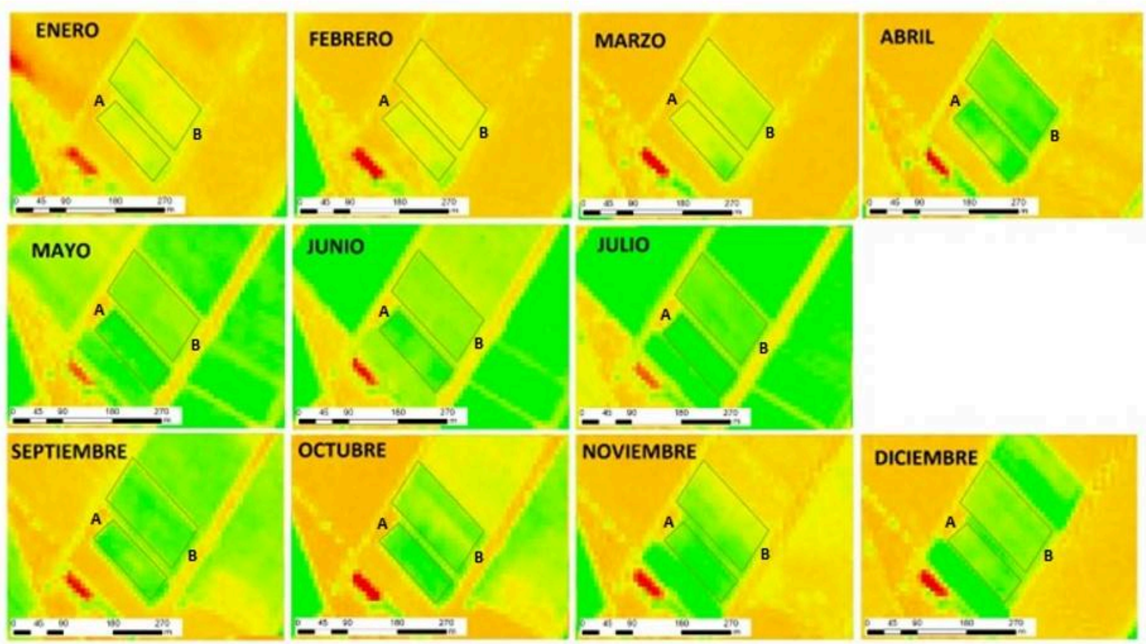
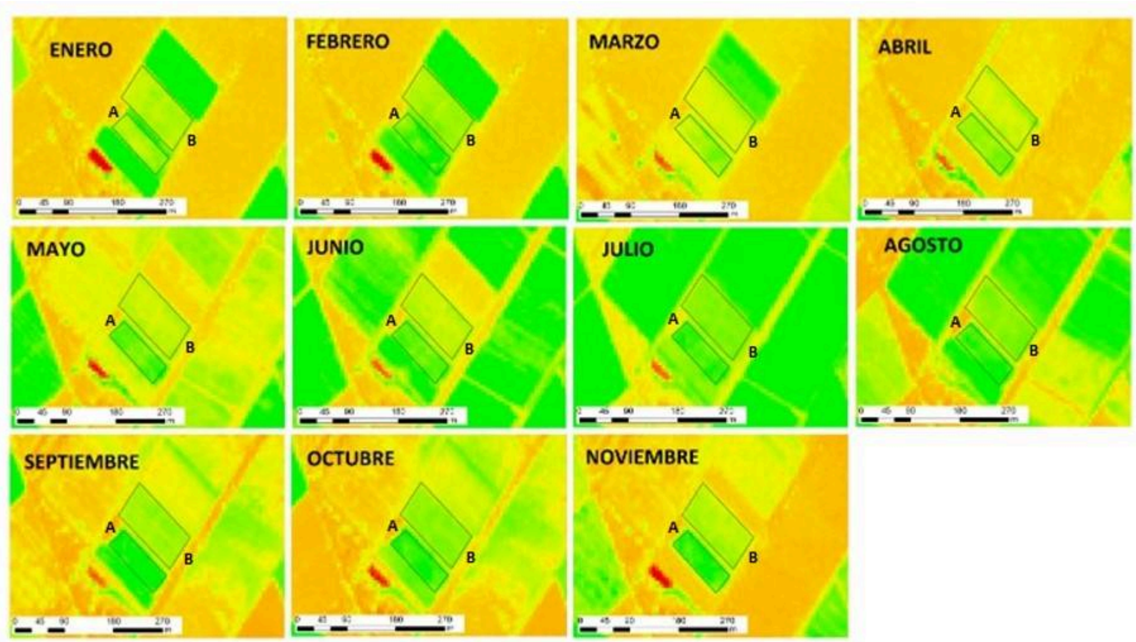


Figure 3. Qualitative NDVI results for 2021 for plot A and plot B.



DOI: https://doi.org/10.29312/remexca.v14i7.3293

Considering the uniformity of each plot, A and B, represented in Figures 2 and 3, 15 points were taken at random and averaged to obtain an NDVI value (Table 1 and 2) and plotted (Figures 4a-b, 5a-b) against the reference Kc as suggested by Reyes-González *et al*. (2020).

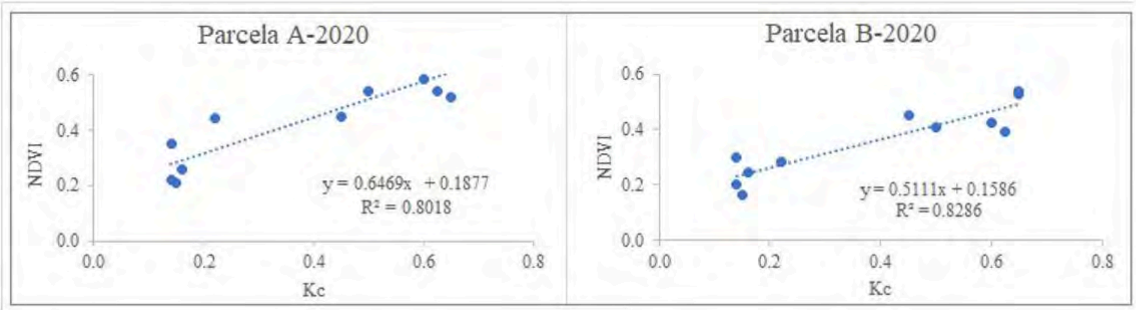
Table 1. Average NDVI for plots A and B of 2020.

Date	Julian day	Reference Kc	NDVI small plot	NDVI large plot
January 18	18	0.14	0.22	0.2
February 12	43	0.15	0.21	0.17
March 13	73	0.16	0.26	0.25
April 12	103	0.45	0.44	0.45
May 17	138	0.6	0.58	0.43
June 06	158	0.63	0.54	0.39
July 16	198	0.65	0.72	0.54
September 09	253	0.65	0.52	0.53
October 19	293	0.5	0.54	0.41
November 18	323	0.22	0.44	0.28
December 18	353	0.14	0.35	0.3

Table 2. Average NDVI for plots A and B of 2021.

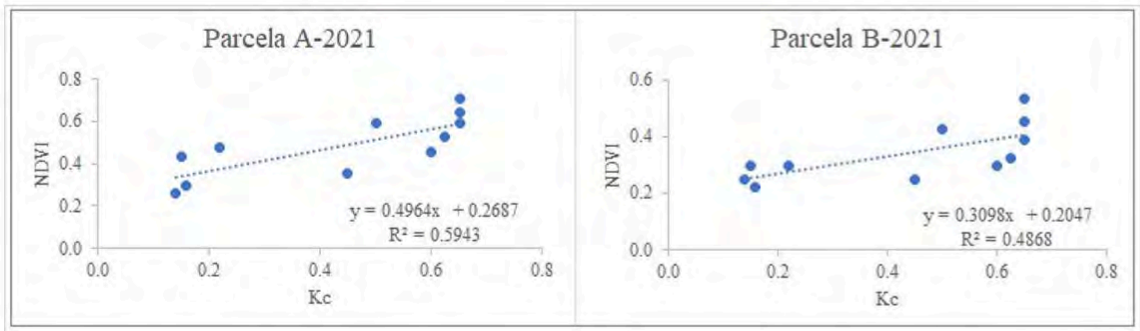
Date	Julian day	Reference Kc	NDVI small plot	NDVI large plot
January 18	18	0.14	0.26	0.25
February 12	43	0.15	0.44	0.29
March 13	73	0.16	0.29	0.22
April 12	103	0.45	0.35	0.25
May 17	138	0.6	0.46	0.3
June 06	158	0.63	0.52	0.33
July 16	198	0.65	0.59	0.45
August 10	222	0.65	0.71	0.53
September 19	262	0.65	0.64	0.39
October 14	287	0.5	0.59	0.43
November 13	317	0.22	0.48	0.3

Figure 4. Linear relationship between NDVI and Kc for plots A and B in 2020.



DOI: https://doi.org/10.29312/remexca.v14i7.3293

Figure 5. Linear relationship between NDVI and Kc for plots A and B in 2021.



In Figure 4, the most representative R^2 value was obtained in the large plot for 2020, so the proposed equation to determine the Kc of the fig crop would be K_C= 0.5111NDVI+0.1586. For the year 2021 (Figure 5), equations with low linear correlation were obtained, this due to the late agronomic management of the crop in the orchard, such as pruning at the wrong time, inadequate fertilization, poor pest control, caused by the Covid-19 health contingency.

Conclusions

The present study provides an alternative for calculating Kc remotely; nevertheless, it is recommended to continue monitoring to validate and improve the equation for the fig crop and analyze at least two production cycles.

Bibliography

1 Aguilar, N.; Galindo-Mendoza, G.; Fortanelli-Martínez, J. y Contreras-Servín, C. 2010. Índice normalizado de vegetación en caña de azúcar en la Huasteca Potosina. Av. Inv. Agrop. 14(2):49-65.

2 Bautista-Zúñiga, F.; Palacio-Prieto, J. L. y Delfín-González, H. 2011. Técnicas de muestreo para manejadores de recursos naturales. Centro de investigaciones en geografía ambiental. Universidad Nacional Autónoma de México (UNAM). 2da. Ed. 790 p.

3 Herrera-Puebla, J.; González-Robaina, F. y López-Seijas, T. 2015. Coeficientes de cultivo (Kc) para la determinación de la necesidad de agua en campos deportivos. Rev. Ing. Agríc. 5(2):3-9.

4 IIRBAVH. 2006. Instituto de Investigación de Recursos Biológicos Alexander von Humboldt. Los Sistemas de Información Geográfica (SIG). Geoenseñanza. 11(1):107-116.

5 INEGI. 2017. Instituto Nacional de Estadística y Geografía. Cuéntame. Información por entidad. Coahuila. México, DF. https://www.cuentame.inegi.org.mx/monografias/informacion/coah/territorio/clima.aspx?tema=me&e=05.

6 INTAGRI. 2020. Instituto para la Innovación Tecnológica en la Agricultura. Producción higo en México. Serie frutales. México, DF. 60(1):1-4. https://www.intagri.com/articulos/frutales/produccion-de-higo-en-mexico#.

7 Krtalic, A.; Prodan, A. and Racetin, I. 2019. Analysis of burned vegetation recovery by means of vegetation indices. International Multidisciplinary Scientific geoConference. https://doi.org/10.5593/sgem2019/2.2/S10.055.

8 Lizarazo-Salcedo, I. A. y Alfonso-Carbajal, O. A. 2011. Aplicaciones de la agricultura de precisión en palma de aceite '*Elaeis guineensis*' e hibrido O x G. Rev. Ing. 48(33):124-130.

DOI: https://doi.org/10.29312/remexca.v14i7.3293

9 Márquez-Guerrero, S. Y. 2019. Dinámica nutrimental del cultivo de higo (*Ficus carica* L.) bajo sistemas de producción intensiva. Tesis de doctorado. Universidad Autónoma de Chapingo (UACH). 77 p.

10 Olaya, V. F. 2014. Sistemas de Información Geográfica. http://volaya.es/writing. 854 p.

11 Peraza-Padilla, W.; Rosales-Flores, J.; Esquivel-Hernández, A.; Hilje-Rodríguez, I.; Molina-Bravo, R. y Castillo-Castillo, P. 2013. Identificación morfológica, morfométrica y molecular de *Meloidogyne incognita* en higuera (*Ficus carica* L.) en Costa Rica. Agron. Mesoam. 24(2):337-346.

12 Reyes-González, A.; Kjaersgaard, J.; Trooien, T.; Hay, C. and Ahiablame, L. 2018. Estimation of crop evapotranspiration using satellite remote sensing-based vegetation index. Adv. Meteorol. 1:1-12. DOI: 10.1155/2018/4525021.

13 Reyes-González, A.; Reta-Sánchez, D. G.; Sánchez-Duarte, J. I.; Rodríguez-Moreno, V. M.; Hernández-Leal, E. y Franco-Gaytán, I. 2020. Desarrollo del coeficiente de cultivo para cártamo forrajero basado en índices de vegetación. Tecnología y Ciencias del Agua. 11(6):39-80. Doi: https://doi.org/10.24850/j-tyca-2020-06-02

14 Rodríguez-Morán, J. M. y Valdez-Quiles, G. 1999. Riego de la higuera. Comunidad valenciana España. 33-38 pp.

15 Rosales-Serrano, L. A.; Segura-Castruita, M. Á.; González-Cervantes, G.; Potisek-Talavera, M. D.; Orozco-Vidal, J. A. y Preciado-Rangel, P. 2015. Influencia de los ácidos fúlvicos sobre la estabilidad de agregados y la raíz de melón en casa sombra. Interciencia. 40(5):317-323.

16 Rueda-Calier, F.; Peñaranda-Mallungo, L. A.; Velásquez-Vargas, W. L. y Díaz-Báez, S. A. 2019. Aplicación de una metodología de análisis de datos obtenidos por percepción remota orientados a la estimación de la productividad de caña para panela al cuantificar el NDVI (índice de vegetación de diferencia normalizada). Corpoica Ciencia y Tecnología Agropecuaria. 16(1):25-40.

17 Von-Lineo, C. 1753. *Ficus carica* L. Species Plantarum 2. 1 059 p.

18 Zamora-Herrera, E.; Duarte-Díaz, C.; Cun-González, R.; Pérez-Hernández, R. y León-Fundora, M. 2014. Coeficientes de cultivo (Kc) en cuba. Rev. Ingen. Agríc. 4(3):16-22.

Use of remote sensing for the determination of the Kc of the fig crop

Journal Information
Journal ID (publisher-id): remexca
Title: Revista mexicana de ciencias agrícolas
Abbreviated Title: Rev. Mex. Cienc. Agríc
ISSN (print): 2007-0934
Publisher: Instituto Nacional de Investigaciones Forestales, Agrícolas y Pecuarias

Article/Issue Information
Date received: 01 October 2023
Date accepted: 01 November 2023
Publication date: 10 November 2023
Publication date: October 2023
Volume: 14
Issue: 7
Electronic Location Identifier: e3293
DOI: 10.29312/remexca.v14i7.3293

Categories

Subject: Investigation note

Keywords:

Keywords:

Ficus carica L.

crop coefficient (Kc)

satellite images.

Counts

Figures: 5

Tables: 2

Equations: 1

References: 18

Pages: 0