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Crop Cover Fraction Estimation Based On Digital Images from 2014-2016: A Case Study of Kadirli in Osmaniye Province

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RGB to HSI
Digital Camera
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ABSTRACT

Crop cover fraction is commonly used to define ecosystem change and vegetation quality. In 2014, 2015 and 2016, color images were taken in approximately 90 sample fields at intervals of one to two weeks. Images were gathered in April, May, June and July. These 4 months means the growth period from planting until the harvesting. In this way, plant phenology was studied closely. Two approaches were used to estimate crop cover fraction in two crop types in this study. In first method, the images were transformed from the RGB color space to the HSI color space. Object-based classification was used to separate the images as the green vegetation and the non-green part. In the second method, The Green Crop Tracker software is used. The Green Crop Tracker is an applicable alternative to ground-based methods. In this approach, both the loss of time and the loss of labor is less than object-based classification. Results from the green Crop Tracker software and object based classification were compared during the growing seasons in 2014, 2015 and 2016 high correlation was obtained between these two methods (for 2014 R^2=0.89, for 2015 R^2=0.87, for 2016 R^2=0.90).

2014-2016 Dijital Görüntülerinden Bitki Örtü Kesitinin Tahmini: Osmaniye İli Kadirli Örneği

Anahtar Kelimeler
Bitki Örtü Kesiti
Green Crop Tracker
RGB'den HSI'ya
Sayısal Kamera
Nesne Tabanlı Sınıflandırma

ÖZ

Bitki örtü kesiti, genellikle ekosistem değişikliği ve bitki örtüsü kalitesini tanımlamak için kullanılır. 2014, 2015 ve 2016 yıllarında bir ila iki hafta aralıklarla sahada yaklaşık 90 renkli görüntü alınmıştır. Görüntüler Nisan, Mayıs, Haziran ve Temmuz aylarında elde edilmiştir. Bu 4 ay, ekimden hasada kadar olan büyüme dönemini içermektedir. Bu şekilde bitki fenolojisi yakından incelenmiştir. Bu çalışmada iki ürün türünde bitki örtü kesitini tahmin etmek için iki yaklaşım kullanılmıştır. İlk yöntemde, görüntüler RGB renk uzayından HSI renk uzayına dönüştürülmüştür. Nesne tabanlı sınıflandırma, görüntüleri yeşil bitki örtüsü ve yeşil olmayan kısım olarak ayırmak için kullanılmıştır. İkinci yöntemde Green Crop Tracker yazılımı kullanılmıştır. Green Crop Tracker, arazi tabanlı yöntemlere uygulanabilir bir alternatiftir. Bu yaklaşımda hem zaman kaybı hem de iş gücü kaybı, nesne tabanlı sınıflandırmaya göre daha azdır. Green Crop Tracker yazılımından ve nesne tabanlı sınıflandırmadan elde edilen sonuçlar, 2014, 2015 ve 2016 yıllarındaki büyüme sezonlarında karşılaştırılmış, bu iki yöntem arasında yüksek korelasyon elde edilmiştir (2014 için R^2 = 0.89, 2015 için R^2 = 0.87, 2016 için R^2 = 0.90).

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Research Article

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1. INTRODUCTION

Fractional vegetation cover (FVC) is the ratio of vertically projected area of vegetation to the total ground surface (Song et al, 2017). This green vegetation has including leaves, stems, and branches (Purevdorj et al., 1998; Gitelson et al., 2002; Godinez-Alvarez et al., 2009; Xiao et al., 2017).

Crop cover fraction is a controlling factor terrestrial processes and climate models. Photosynthesis, transpiration, global climate changes are these terrestrial processes (Gutman and Ignatov, 1998; Barlage and Zeng, 2004; Jiapaer et al., 2011; Ameth, 2015; Song et al., 2017). In addition to this, crop cover fraction can be used as direct input to crop models. Also crop cover fraction is as a predictor of crop yield, above-ground biomass and plant nutritional status (Coy et al., 2016).

Ground based methods are a common tool for estimating crop cover fraction but are time consuming and labor intensive (Richardson et al., 2001). Due to the development of computer technology and digital image analysis, the use of digital images in the estimating FVC has gradually increased (Zhang et. al, 2018).

Digital color images are analyses of changes in the spatial pattern of vegetation and an appropriate for vegetation classification (Bestelmeyer et al., 2006). Digital color imaging is also an active tool for detecting many soil and ecological processes, including wind erosion (Okin et al., 2006).

The green pixel percentage of the total number of pixels with the image processing software can be taken to obtain the information of crop cover fraction. The methods of threshold method (Lukina et al., 1999; Liu and Pattey, 2010), green to red band (Adamsen et al., 1999), spectral-contextual classifier (Zhou and Robson, 2001), Green Crop Tracker (Liu and Pattey, 2010), spectral mixture analysis method (Elmore et al., 2000), by counting the green pixels in the image (Purevdorj et al., 1998) have been used to estimating crop cover fraction from digital color images.

Digital color image analysis traditionally was performed using pixel based classification. In this method, each pixel's digital number is used individually. Another commonly used method is object-based classification. In this method, pixels are combined in a first step into objects that are homogeneous with consider to spatial or spectral characteristics (Ryher and Woodcoock, 1996). Homogeneity in this case refers to smaller within-object than between-object variance. In a second step, those objects rather than single pixels are classified. HSI transformation can be applied to digital color images and then has been used to estimating crop cover fraction from these images (Ewing and Horton, 1999; Tang et al., 2000; Hemming and Rath, 2001; Laliberte et al., 2007).

In recent years, research into object-based classification of digital image photography has increased. Most studies using object-based classification only estimate total vegetation cover of the plot (Fiala et al., 2006; Laliberte et al., 2007; Lee and Lee, 2011), estimation LAI (Liu and Pattey,2010), vegetation monitoring (Sakamoto et al.,2012), crop identification (Meyer et al.,1999), weed detection (Perez et al.,2000; Sui et al.,2008). Crop cover fraction can be obtained faster, easier and more accurately with the help of digital cameras.

Some authors such as Hemming and Rath, 2001; Ewing and Horton, 1999; Karcher and Richardson, 2003 have reported increased accuracy in vegetation analysis using digital color images with HSI transformations rather than the original RGB bands. Green and other plant materials are intermixed constantly. In particular, it is difficult to distinguish between digital images that lack a near infrared band and consist of only red, green, blue bands.

Band inter-correlation is high in the RGB space rather than HSI space. Band inter-correlation is reduced, when images are transformed to the intensity-hue-saturation (HSI) space. RGB color representation of a cube, HSI is also based on the color sphere (Jensen, 2005). Intensity associates with brightness. Intensity is represented as the vertical axis of the sphere. Hue is the dominant wavelength of the color. Hue is represented as the circumference on the sphere. Saturation is expressed as the relative purity of the color. Saturation is represented as the sphere's radius. The HSI model splits up the intensity part from the color information. Hue and saturation parts relate to how humans perceive color (Jensen, 2005).

The Green Crop Tracker automatically takes estimates of crop cover fraction from digital color images of growing sunflower and corn crops. The software uses a histogram-based threshold technique applied to the RGB values of the images. This is done to estimates crop cover fraction by segmenting green canopy from soil and the other materials (Coy et al., 2016).

The aim of this study was to estimate crop cover fraction with digital camera images from approximately 1 to 1.5 m from the ground. Other aim is to compare the two methods used in the determination of crop cover.

2. METHOD

2.1. Study area and in situ data measurements

Content should be written in 2 columns with Cam The study area is located in Eastern Mediterranean region, Kadirli, Osmaniye, Turkey. It is located in between 36º and 37º north latitude and 35º and 36º east longitudes. The elevation from sea level of Kadirli is 95m. Area of Kadirli is 1071.3-kilometer squares.

The mean annual temperature is 18℃. The average minimum temperature is 6℃, the average maximum temperature is 42.8℃. The precipitation is higher in winter and autumn than in the other months. The mean annual precipitation is 827.5 mm.

The highest average temperature is 36°C in August and the coldest temperature is 3°C in January. The annual average amount of rain is 890/m^2.

This area was chosen as a study area because it has very fertile soil. The florae of the area are very rich in species. Lowlands are used for agriculture. Also, there are a lot of forest lands. The town has %39 green area and the forests, which is much more than world's average and Turkey's average standards.

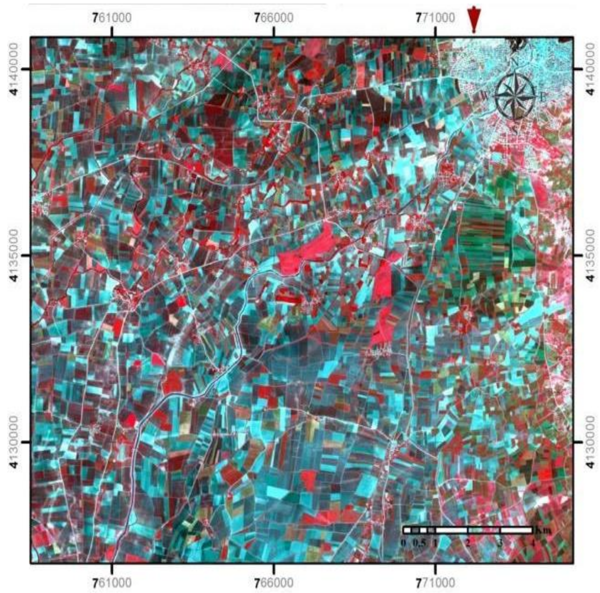

Figure 1. Study area

The experimental site, Kadirli, is located at the northeast of Çukurova and in the south of Orta Toros mountains. Çukurova region in the south of Turkey is one of the most agriculturally fertile lands in the world.

Kadirli, the biggest town of Osmaniye, is surrounded by Feke and Saimbeyli in the north, Andırın and Düziçi in the east, Osmaniye and Ceyhan in the south, Sumbas and Kozan in the west, as is shown in Figure 1 (Karakus ve ark.,2017). 2/3 of Kadirli land consists of lowlands and 1/3 consists of mountains.

Subtropical Mediterranean climate prevails in Kadirli. In summers it is hot and arid; in winter it is warm and rainy.

2.2. Vegetation cover measurement

The Sony DSC-s930, a digital camera, was used to determine the crop fraction. Vertical digital color images were taken over each of the 30 sample fields every year (total 90 sample fields) at 1-2-week intervals, as is shown in Figure 2. Digital images were taken from about 1-1.5 m height.

Digital color images were taken to determine the crop cover fraction estimates of crop cover fraction were made by classification of digital color photos with object-based classification and were used by Green Crop Tracker software. Digital color images for corn and sunflowers were collected during 3 years, including the 2014-2016 crop cycle, in several sample fields in the Kadirli of Osmaniye. The images were imported into Ecognition Developer and converted from RGB to HSI space.

Figure 2. Sony DSC-S930 digital camera (URL-1)

2.3. RGB to HSI

From RGB to HIS image transformation was an useful phase for image classification. Each pixel of a digital color photo consists of three digital numbers. These are light intensity quantized in the red, green and blue bands (Liu and Pattey, 2010). RGB values can be converted directly to hue-saturation-intensity (HSI) values for ease of interpretation. The RGB color presentation is based on a cube, although HSI color presentation is based on a color sphere (Jensen, 2005). Hue of a color refers to which spectral wavelength it most closely matches and is expressed as an angle in HSI color space. Arbitrarily, 240° is blue, 120° is green and a hue of 0° is red. And Purple colors between 240 ° and 360 ° (Pan et al., 2007).

Converting from RGB to HSI format can be done as follows (Castleman, 1996):

$$H = \left[\frac{(R-G)+(R-B)}{2\sqrt{(R-G)^2+(R-B)(G-B)}}\right]$$

$$S = 1 - \frac{3 * min(R,G,B)}{R+G+B}$$

$$I = \tfrac{1}{3}(R+G+B) \qquad (1)$$

where R= Red
G=Green
B=Blue

represent the intensity levels recorded by the red, green and blue channels of the digital camera.

2.4. Image segmentation and analysis

eCognition Developer Software was used in the processing of digital images. Firstly, there was conversion from RGB to HSI for digital color images. An image is divided into homogeneous areas according to three parameters: scale, shape, and color in this method. Color and shape parameters can be weighted from zero to one. The scale parameter is unitless. These parameter controls the relative size of image objects, with a larger scale parameter resulting in larger image objects (Definiens, 2016). We classified green canopy and the other materials. The number of green pixels in each image is divided into the total number of pixels in the image to determine the vegetation cover in the image. The k-nearest neighbors classifier is one of the most widely used methods of classification, because of it is simple and easy to implement. The k-nearest neighbors algorithm is a non-parametric method used for classification. Analysis in eCognition can be conducted using either a nearest-neighbor classification based on selected samples or with membership functions, representing a rule-base classification. Nearest neighbor classification is more appropriate when classes are more difficult to separate from each other. Because this approach is more appropriate to evaluate the relationship between object properties and to define a multidimensional feature space (Definiens, 2003). Suitable samples have to be selected for each class for a nearest neighbor classification.

2.5. Green crop tracker software

Green crop Tracker (GCT) is a histogram-based threshold method. Green crop Tracker is used to process digital color photographs taken on agricultural products. The Green Crop Tracker software can be used to process digital color images at a 57.5 ° tilting angle or portrait orientation, up and down (Liu and Pattey, 2010; Liu and Pattey, 2013).

3. RESULTS

3.1. Comparison of green crop tracker and object-based classification

Crop cover fraction values were obtained by using two methods. In the first method, the color images were converted from RGB to HSI with the eCognition software, as is shown in Figure 3-4.

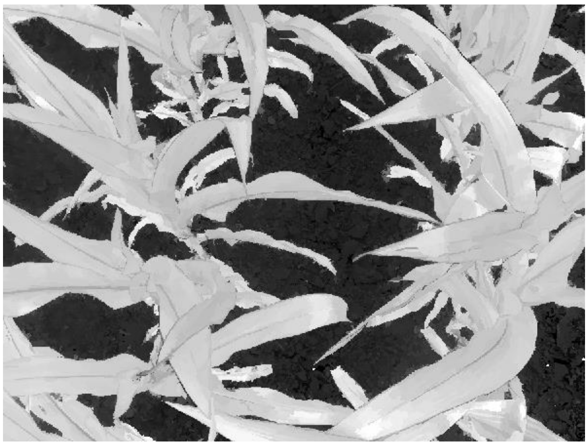

Figure 3. An example for digital camera images of 2014-4, corn plant images transformed RGB to HIS on 05.05.2014.

Figure 4. An example for digital camera images of 2014-3, sunflower plant images transformed RGB to HIS on 05.05.2014.

In the second part of the first method, samples are selected. An image is segmented into homogeneous areas based on three parameters: scale, shape, and color with multi resolution segmentation (Figure 5). Scale and shape parameters were selected as 0.1 and 60 in the phenological period of the crops, as is shown in Figure 6.

Then images classified green pixel and other materials, as is shown in Figure 7-8. Unclassified objects and wrongly assign objects are assigned to the correct classes. This period should be repeated if needed to correct classification results. Then to determine the vegetation cover in the image, the green crop pixels in each image were divided by the total pixel number of images.

In the second method, the crop cover fraction was determined by Green crop tracker software. Focal length, camera looking direction, camera looking angle, sensor horizontal size /mm, range of angle parameters are needed for estimation of crop cover fraction. From these parameters, the camera looking direction is selected down, looking angle is selected vertical, sensor horizontal size is taken 6,17 mm, range of angle is taken 3,4375 and focal length is taken 6,3 mm, as is shown in Figure 9.

Crop cover fraction values were determined by using Green Crop Tracker software by changing the required parameters, as is shown in Figure 9.

R^2 was used to establish the relationship between the two methods used in determining the crop cover fraction.

There is a high correlation between these two methods, as is shown in Figure 10-Figure 15.

4. DISCUSSION AND CONCLUSIONS

In this study, a reliable, fast and cost-effective method was used to determine the crop cover fraction from digital color images. As others have found, HSI transformation can be very useful for estimating crop cover fraction.

The object-based classification was also useful because it eliminated the 'salt and pepper effect' common in pixel based classification. The' salt and pepper effect ' originates from high local spatial heterogeneity, among neighboring pixels. The object-based classification can decrease many of these problems.

Object based classification from low altitude digital color image was an effective technique for estimating crop cover fraction and soil and for separating green and senescent vegetation. An additional advantage is the installation of permanent digital color images that can be used to detect vegetation changes over time.

According to the object-based classification with the Green Crop Tracker (GCT) software. Moreover, from fig10 to fig 15 it is always used as GCT, fractional crop cover was obtained in a shorter time. When R^2 values were examined, it was observed that the two methods estimated very close results.

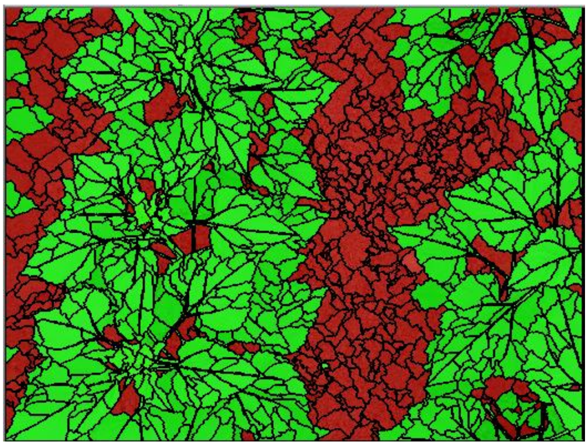

Figure 5. An example for digital camera images of 2014-3, sunflower plant images were segmented on 05.05.2014

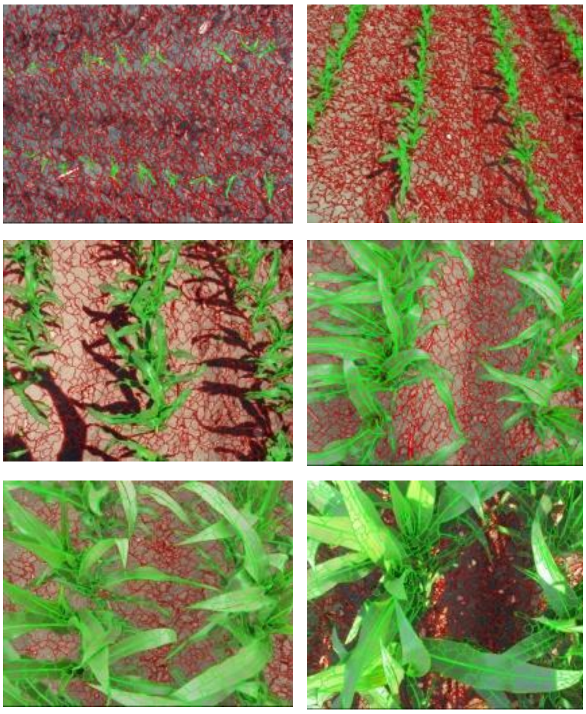

Figure 6. An example for digital camera images of 2014-3, corn plant images were segmented on 05.05.2014

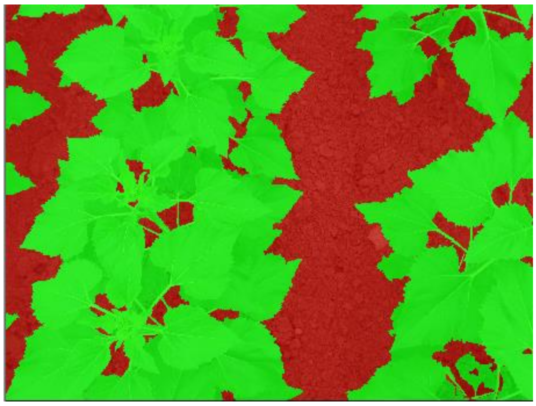

Figure 7. A digital camera image of 2014-3, sunflower plant image was classified sunflower and the other materials on 05.05.2014

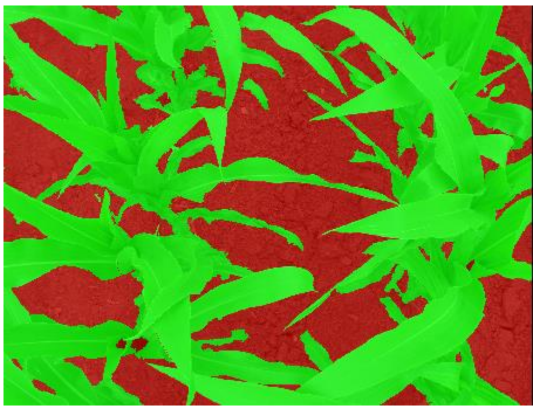

Figure 8. A digital camera image of 2014-4, sunflower plant image was classified sunflower and the other materials on 05.05.2014

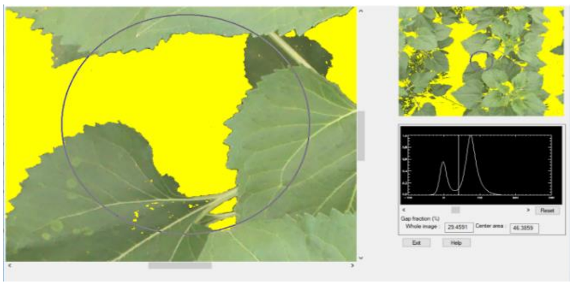

Figure 9. Digital camera images of 2014-23, sunflower plant image is classified by Green Crop Tracker software

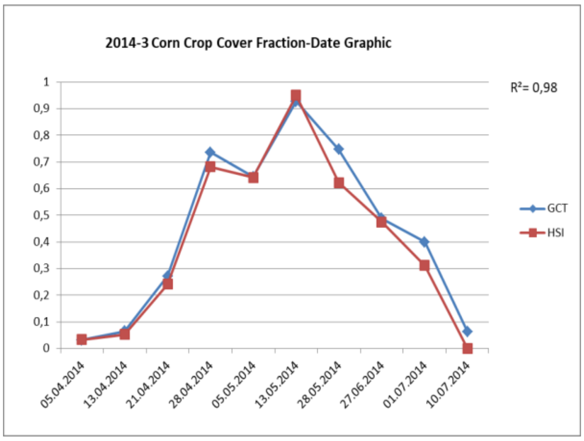

Figure 10. The relationship between two methods for 2014-3 corn field

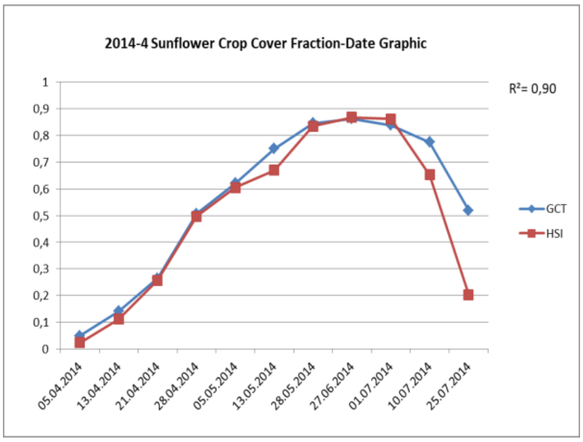

Figure 11. The relationship between two methods for 2014-4 sunflower field

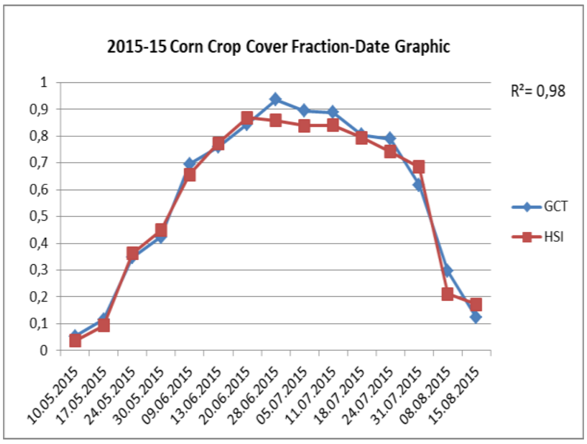

Figure 12. The relationship between two methods for 2015-15 corn field

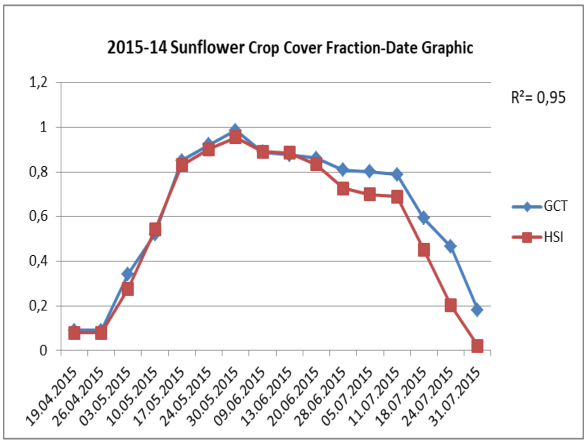

Figure 13. The relationship between two methods for 2015-14 sunflower field

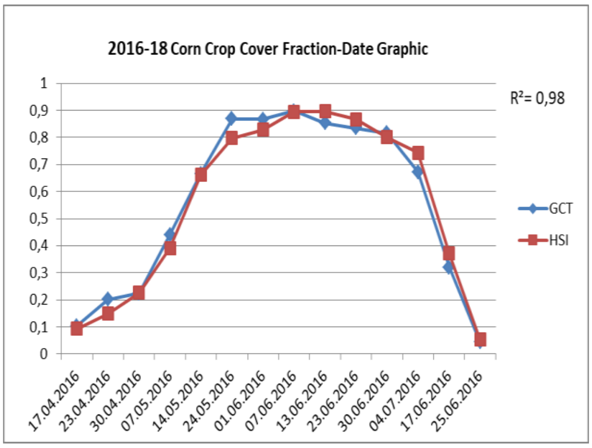

Figure 14. The relationship between two methods for 2016-18 corn field

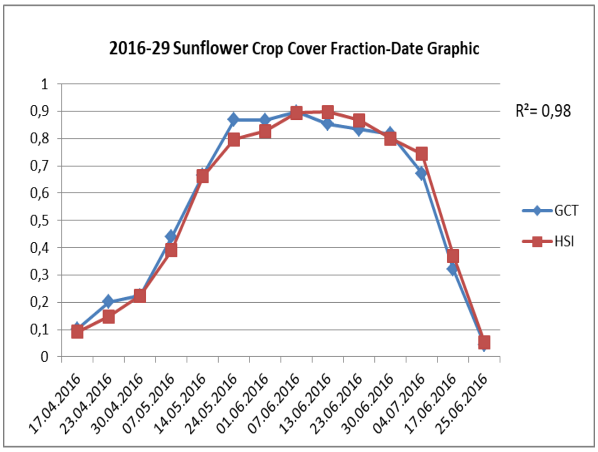

Figure 15. The relationship between two methods for 2016-29 sunflower field

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