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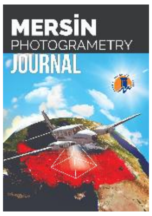

Investigation of phenological stages of wheat plant using vegetation index

Yunus Kaya*[1], Nizar Polat[1]

[1]*Harran University, Faculty of Engineering, Geomatics Engineering, Şanlıurfa, Turkey*

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ABSTRACT

Agriculture has a significant place in our country's economy because of its ecology and climatic conditions suitable for agriculture and having rich lands. Among the agricultural products in Turkey, the most produced crop is wheat. Therefore, wheat has a significant contribution to the national economy and food resource. Today, due to the rapid growth of the population in the global and regional scale and the insufficiency of agricultural areas, it has become very important to obtain maximum efficiency in the existing agricultural areas. For this reason, it is necessary to monitor and record the phenological stages of agricultural plants. At this point, multi-band satellite images provide serious convenience during the collection and analysis of the necessary data. In this study, the phenological stages of the cultivated wheat plants were investigated in the General Directorate of Agricultural Enterprises located in the Ceylanpınar district of Şanlıurfa province. In this context, using the data of Landsat-8 and Sentinel-2A multi-band satellite data for 2017 and 2018, the vegetation index for phenological stages were examined.

1. INTRODUCTION

The world's population is increasing rapidly, especially through developing countries. Improvement of the health conditions and the development of the level of consciousness of people play an important role in this increase.

The increase in the population and the decrease in natural resources have made the measurement and monitoring of the environment important (Yılmaz et al., 2018). At this point, agricultural areas have extensive importance. Because while the world population is constantly increasing, our agricultural areas remain the same and even our agricultural areas are decreasing due to some irregular urbanization. In this case, the existing agricultural areas should be used at an optimum level. Wheat is the most important agricultural product in Turkey. Wheat plant is a one-year plant and has different species that can grow under any climate conditions. Therefore, wheat is produced in many parts of the world. According to the Turkey Statistical Institute (TSI) data; between 2001 and 2017, wheat accounted for 62 percent of the crops planted. Also, between 2001 and 2017, 39 percent of the amount of the product obtained is wheat (URL-1). According to the statistics of TSI data, the place and importance of the wheat plant in Turkey agriculture is seen clearly. Various studies have been carried out for many years to obtain maximum yield from the wheat plant.

In agricultural production, it is very important to estimate the pre-harvest yields of the product, especially in the direction of domestic and foreign market conditions. In field and yield determination studies performed with classical measurement techniques, reliable results are often not obtained, and an extremely high cost and a long time is spent. New techniques and technologies developed in recent years have made it possible to perform these processes in a cheaper, faster and more reliable way. Among these new technologies, remote sensing technique (Karakus et al., 2017) is the most important one (Sönmez and Sarı, 2005).

* **Corresponding Author**

*(yunuskaya@harran.edu.tr) ORCID ID 0000-0003-2319-4998
(nizarpolat@harran.edu.tr) ORCID ID 0000-0002-6061-7796

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By analyzing the satellite data, comments can be made about the plant in the field. As is known, plants absorb most of the energy in the blue and red wavelengths and reflect most of the energy in the green and near-infrared (NIR) band (Esetlili et al., 2015).

In this study, phenological stages of the wheat plant were investigated with the help of Normalized Difference Vegetation Index (NDVI) values. The development stages of the wheat plant consist of 4 main periods (germination/seedling stage, tillering & stem extension, heading & flowering (pollination) and maturity). The wheat plant is generally planted in November. The stages of wheat vary according to climate change and precipitation, but on average they are as in the table below (Table 1).

Table 1. Phenological stages of wheat plant

STAGE	
Germination/Seedling stage	February
Tillering & Stem extension	March
Heading&Flowering (pollination)	April
Maturity	May
Harvest start	End of May

Chandel et al. (2019) used the Normalized Difference Vegetation Index (NDVI) and the Normalized Difference Water Index (NDWI) to determine the relationship between crop-biomass and nitrogen levels in the growth stages of wheat-based on the coefficient of variability. In the study, the highest NDVI value was observed in the heading stage. In addition, 96% agreement was observed between NDVI and product-biomass at the maturation stage. Both NDVI and NDWI regression models correlate positively with grain yield and can be used to estimate the yield of wheat crop.

2. METHOD

2.1. Satellite Data

In this study, 20 satellite images with different spatial resolutions were used to examine the phenological stages of the wheat plant. LANDSAT 8 (URL-1) and SENTINEL-2A (URL-2) data were used in the study.

2.2. Vegetation Index

There are numerous vegetation indices in the literature to determine vegetation using satellite imagery. NDVI (Normalized difference vegetation index), SAVI (Soil adjusted vegetation index), OSAVI (Optimized soil-adjusted vegetation index), EVI (Enhanced vegetation index) are some of them. NDVI is the most commonly used vegetation index (Comert et al., 2019; Orhan et al., 2019). Plants absorb most of the energy in the blue and red wavelengths while reflecting most of the energy in the green and near-infrared (NIR) band so that the plant can be easily distinguished from other land covers. This can be formulated with NDVI (Çatal Reis and Bayram, 2015). The NDVI value is calculated by the equation (1) and takes a value between -1 and +1.

$$NDVI = \frac{(\mathrm{NIR} - \mathrm{Red})}{(\mathrm{NIR} + \mathrm{Red})} \quad (1)$$

If the NDVI value approaches -1, the vegetation density decreases and if it approaches +1, the vegetation density increases. NDVI is high when green plants completely cover the pixel and low when no green plants are present. Being normalized also eliminates different sun angle effects (Kayahan, 2013).

3. APPLICATION

The study area is 'The General Directorate of Agricultural Enterprises' located in the Ceylanpınar district of Şanlıurfa (Figure 1).

Figure 1. Study area

In this study, wheat plant analysis for 2016-2017 and 2017-2018 seasons was performed. LANDSAT-8 and SENTINEL-2 satellite images downloaded from the internet were used by selecting images in which the study area was clear and cloudless. 8 LANDSAT-8 satellite images and 12 SENTINEL 2 satellite images were used in the application (Table 2). NDVI values; It was created in SNAP software for ENVI and SENTINEL-2 images for LANDSAT-8 images.

Table 2. Dates of used satellite images (S: Sentinel, L: Landsat)

MONTH	2016-2017	2017-2018
December	9.12.2016(S)	8.12.2017(L)
January	8.01.2017(S) 18.01.2017(S)	9.01.2018(L)
February	23.02.2017(L)	2.02.2018(S)
March	9.03.2017(S)	9.03.2018(S) 19.03.2018(S)
April	28.04.2017(S)	3.04.2018(S) 8.04.2018(S) 13.04.2018(S) 23.04.2018(S)
May	14.05.2017(L) 30.05.2017(L)	17.05.2018(L)
June	15.06.2017(L)	18.06.2018(L)

In this study; 6 sample wheat fields were selected (Figure 2-6) and NDVI values were calculated. The minimum, maximum and average NDVI values calculated for both seasons were compared (Figure 7, 8 and 9).

Figure 2. Sample areas

Figure 3. RGB images of wheat field at different dates for 2016-2017 season

Figure 4. NDVI images of wheat field at different dates for 2016-2017 season

Figure 5. RGB images of wheat field at different dates for 2017-2018 season

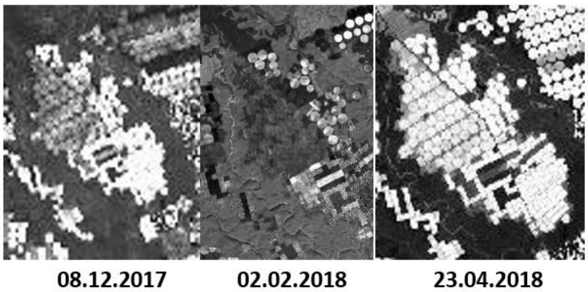

Figure 6. NDVI images of wheat field at different dates for 2017-2018 season

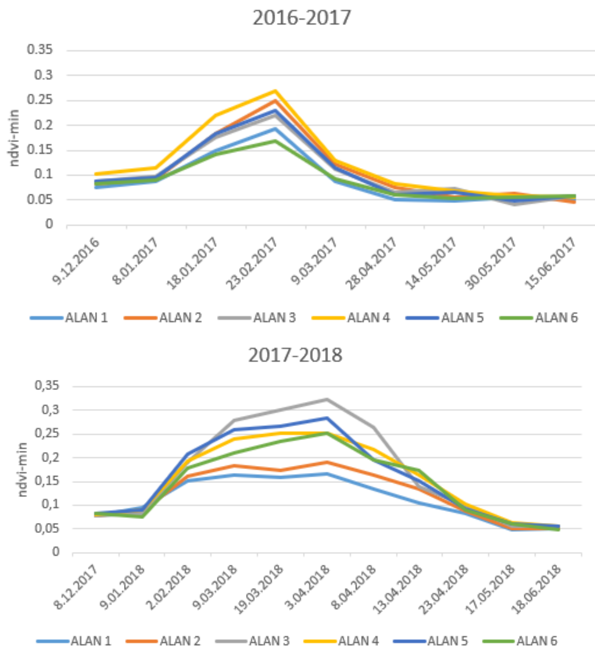

Figure 7. Minimum NDVI values for the 2016-2017 and 2017-2018 seasons

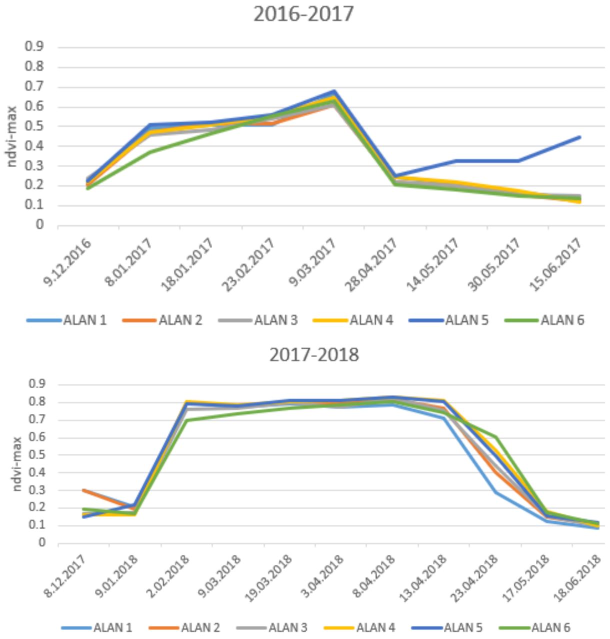

Figure 8. Maximum NDVI values for the 2016-2017 and 2017-2018 seasons

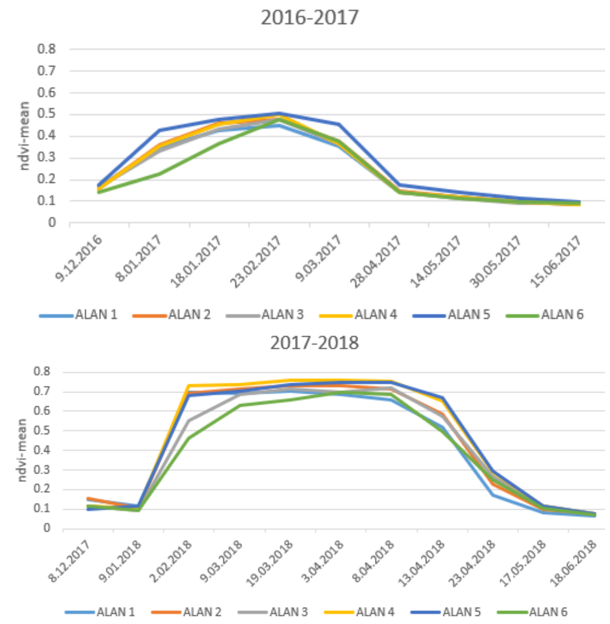

Figure 9. Mean NDVI values for the 2016-2017 and 2017-2018 seasons

4. RESULTS

In this study, NDVI values generated from satellite images of two different seasons were examined. The highest NDVI value in the 2016-2017 season was observed in the stage of tillering. NDVI started to rise during the germination stage and decreased during the heading stage. In 2017-2018 season, the mean NDVI value reached its highest value during germination and tillering period. However, the highest NDVI value in the 2016-2017 season was 0.5069 on 23 February and 0.7599 on 19 March in the 2017-2018 season. This difference may be due to reasons such as the quality and quantity of fertilizer, amount of rainfall, climate diversity.

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