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EVALUATION OF CROP ALBEDO OF DIFFERENT SUNFLOWER CROP ROTATION CULTIVARS AND ITS EFFECT ON LATENT HEAT FLUX

Fatih Bakanogullari[1], Serhan Yesilkoy[1*], Nilcan Akataş[2], Levent Saylan[2]

[1]Kırklareli Atatürk Soil Water and Agricultural Meteorology Research Institute, Turkey
[2]Istanbul Technical University, Faculty of Aeronautics and Astronautics, Meteorological Engineering Department, Turkey

Corresponding author: serhan.mto@gmail.com

Abstract
Surface albedo is expressed as the fraction of incoming shortwave solar radiation reflected by the surface. Surface albedo is one of the primary factors influencing regional and global climates as well as ecological and biophysical processes especially in the study of water and energy fluxes of ecosystems. In these research areas, accurate determination of net radiation plays a vital role for determination of the fluxes. In this study, it is aimed to establish the crop albedo values of three sunflower cultivars in the northwestern part of Turkey where sunflower production is represented as country's production. It can be seen that crop albedo values are related to the crop and meteorological factors like crop phenology, soil moisture etc. Crop albedo also varies by each cultivars of sunflower. Moderate Resolution Imaging Spectroradiometer (MODIS) albedo values and in-situ measurements were compared within this study. In the light of this perspective, albedo is considerably sensitive parameter and has influence on the latent heat flux. Also, comparison between calculated latent heat flux from MODIS data and in-situ measurements were investigated.

Key words: Albedo, sunflower, latent heat flux, MODIS.

Introduction

Land surface albedo is an important variable which controls the energy budget between land-atmosphere interactions. Albedo measures the reflectivity of the surface. It gives information about the absorption of incoming shortwave radiation by the surface. It varies in time and space and mostly depends on land color, soil moisture, crop types, development period of crops and sky conditions. Some of the albedo studies in the literature are listed below. Changing in albedo is affected the micro and regional climate (Zhang et al., 2013). Doughty et al. (2011) investigated that increasing agricultural albedo can cause a 0.25 °C cooling regional climate in a small changes (0.01) of albedo. In order to calculate actual evapotranspiration (ET_a), net radiation (R_n), which controls the evapotranspiration mechanism, of over interested area must be properly determined.Crop albedo diurnal, seasonally or annually varies relation to earth-atmosphere energy balance. Crop albedo also has an important role in actual evapotranspiration with related to R_n. In order to determine the crop albedo is a complex process by atmospheric and surface conditions: diurnal solar position, cloudiness, soil type and soil water content (Giambelluca et al, 1999; Iziomon and Mayer, 2002). In developing countries, actual evapotranspiration is calculated by using net radiation which is calculated by using global solar radiation values from meteorological station. Therefore, it is important to well-estimate the net radiation which has component of surface albedo and global radiation. Thrace region locates northwestern part of Turkey in the European Continent, has the 75% total sunflower production of Turkey. Sunflower is planted in an area of 578 000 ha and produced 843 000 tons per year in Turkey. The purpose of this research, determining the variation of the albedo for three sunflower cultivars during the growing period of 2016. By the way, the influence of calculated and measured albedo on the estimated and measured net radiation and actual evapotranspiration of sunflower were also investigated.

Material and methods

The research field is located in the Kırklareli city, Northwestern part of Turkey. Meteorological data was collected from 6th April to 27th September 2016 during the growing season of sunflower at Atatürk Soil Water and Agricultural Meteorology Research Institute Directorate (40°43'42.43"N latitude, 26°26'42.69"E longitude) (Fig. 1).In this period, phenological development of sunflower varieties were observed and their leaf area index (LAI) values were biweekly measured by using LAI-2200C (LiCor, Nebraska). Incoming, outgoing short and longwave radiations, global solar and reflected radiations (CMP6 and CNR4, KippZonen, Delft), air temperature and relative humidity (Rotronic and Vaisala), soil water content at 3 different depths (CS616, Campbell Sci.), wind speed and direction (NRG Systems) values were continuously and simultaneously measured and the data were recorded by the datalogger (CR1000, Campbell Sci.) with an interval of 10, 30, 60 min. and daily time steps for three different parcels.

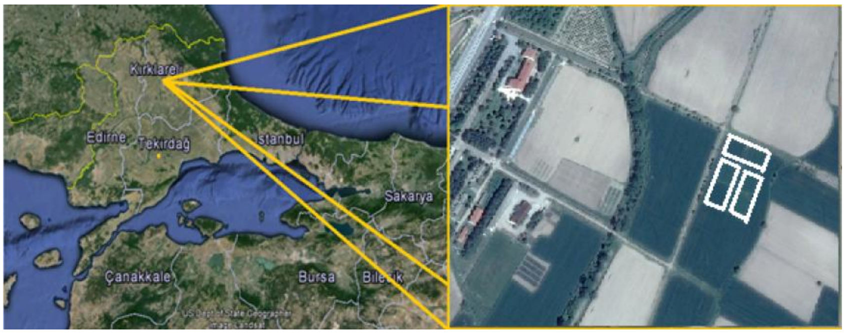

Figure 1. Atatürk Soil Water and Agricultural Meteorology Research Institute Directorate

Three different sunflower cultivars which are mostly planted in Thrace part of Turkey, were cultivated to determine albedo values. These cultivars' names are Tunca, Sanay, and Poinner and they represent Thrace Region by 99%. In order to calculate net radiation, global solar radiation measurement and albedo valuesare required (Eq. 1) (Allen et al., 1998):

$$R_{ns} = (1-\alpha)R_s \qquad (1)$$

where R_{ns}, net shortwave radiation (MJ m^{-2} day^{-1}); α, surface (here is sunflower) albedo; R_s, global radiation measurement (MJ m^{-2} day^{-1}).

Net longwave radiation (R_{nl}) and net radiation (R_n) can be calculated using equation 2 and 3:

$$R_{nl} = \sigma\left[\frac{T_{max,K}^4 + T_{min,K}^4}{2}\right](0.34 - 0.14\sqrt{e_a})(1.35\frac{R_s}{R_{so}} - 0.35) \qquad (2)$$

$$R_n = R_{ns} + R_{nl} \qquad (3)$$

$$R_{so} = (0.75 + 2x10^{-5}z)R_a \qquad (4)$$

where e_a actual vapor pressure; R_{so} (MJ m^{-2} day^{-1}), clear sky radiation; R_a, extraterrestrial radiation (MJ m^{-2} day^{-1}).

Evapotranspiration calculation from Penman Monteith equation,

$$\lambda ET = \frac{\Delta(R_n - G) + \rho_a c_p \frac{(e_s - e_a)}{r_a}}{\Delta + \gamma(1 + \frac{r_s}{r_a})} \qquad (5)$$

where G, soil heat flux; $e_s - e_a$, vapour pressure deficit of the air; ρ_a, air density at constant pressure; c_p, specific heat of the air; Δ, slope of the saturation vapour pressure temperature relationship; γ, psychrometric constant; r_s and r_a are the (bulk) surface and aerodynamic resistances, respectively. Evapotranspiration can also be determined by measuring the various components of the soil water balance (Eq. 5). The method consists of assessing the incoming and outgoing water flux into the crop root zone. Irrigation (I) and rainfall (P) add water to the root zone. Part of I and P might be lost by surface runoff (RO) and by deep percolation (DP) that will eventually recharge the water table. Water might also be transported upward by capillary rise (CR) from a shallow water table towards the root zone or even transferred horizontally by subsurface flow in root zone

$$ET = I + P + RO - DP + CR \qquad (6)$$

This study in Turkey is the only project about determination of vegetative surface albedo and its effect on evapotranspiration. In this study, it is emphasized that surface albedo is one of the most important parameter to estimate evapotranspiration.

Results and discussion

Diurnal profile of sunflower albedo values are asymmetrical changed (Ogundunte and Giesen, 2004; Bsaibes et al., 2009) in daily hours (Figure 2). The reason for this is incoming midday radiation is relatively higher than the other periods. Three different sunflower cultivars have considerably the same attitude and do not show significant changes from one another. Tunca cultivar is different in morning because this cultivar was sown on 31.05.2016 while other sunflower cultivars were sown on 06.04.2016.

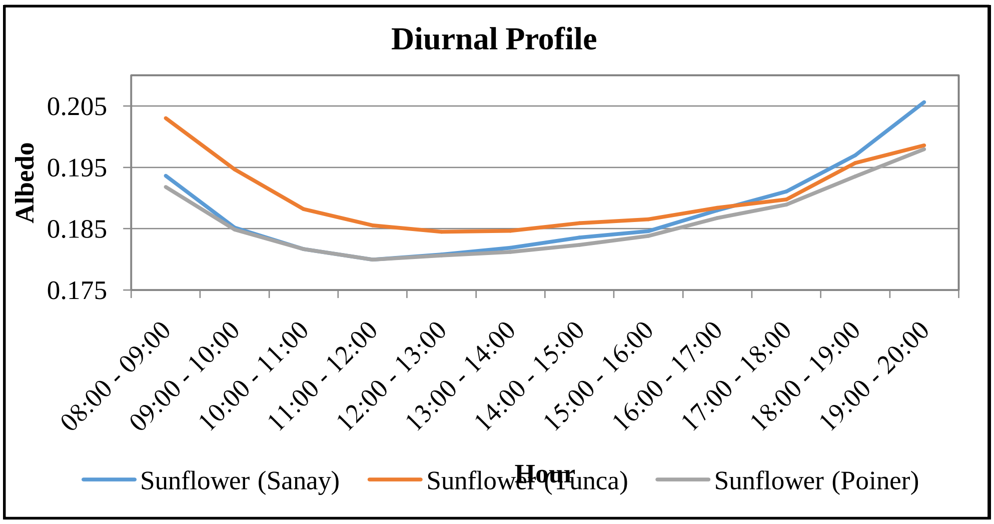

Figure 2. Diurnal Profile of Sunflower Albedo

Time series of the MODIS and measured albedo values can be found in Figure 3. According to this figure, MODIS data is not enough to represent the comparison with in-situ measurements.

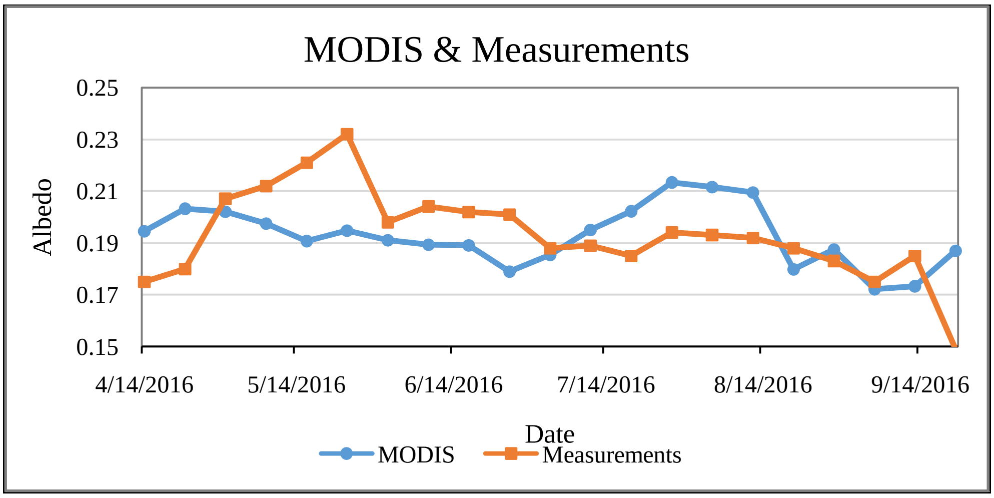

Figure 3. Time Series of MODIS and In-Situ Measurements

Time series of the daily mean albedo and precipitation data were given in Figure 4. Not only surface but also meteorological variables affect the surface albedo. Albedo values decrease in rainy days due to lack of global radiation and increasing soil moisture (Gascoin et al., 2009; Xiaodan et al., 2009). Because, precipitation from June to September is about 10 mm, summer 2016 was a drought period.

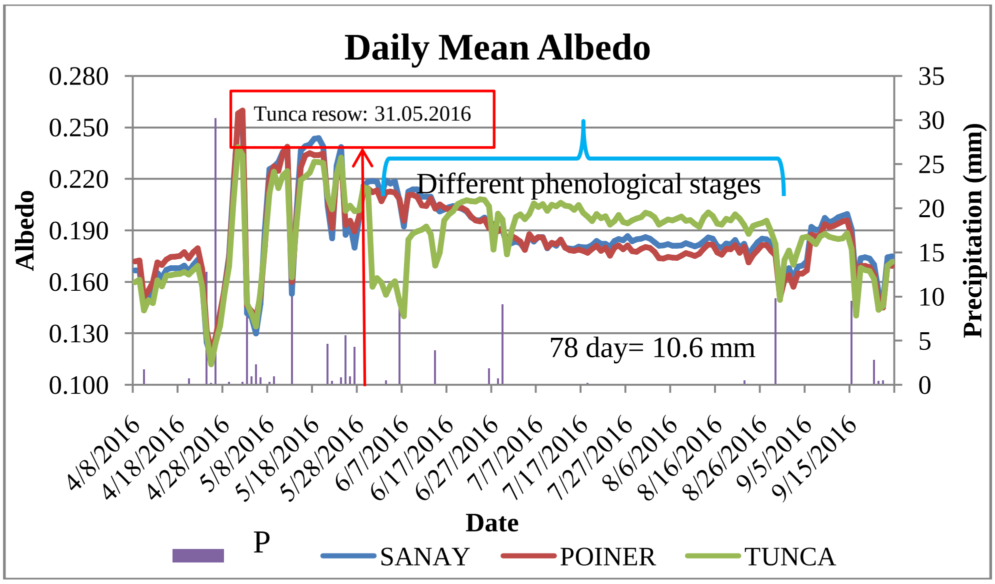

Figure 4. Daily mean albedo and precipitation time series

Albedo values of sunflowers were determined according to the phenological stages as shown in Figure 5. Soil was bare when crops were cultivated. From sowing to emergence period soil surface albedo was represented. After emergence, crop albedo has been increasing according to cultivars. The highest albedo values of sunflowers are in the leafing phenological stage. On the other hand albedo difference in this period is significant. Sunflower in leafing stages covers whole field and soil effect is not dominant. While sunflower albedo values are different in phenological stages, there is a not significant change between them.

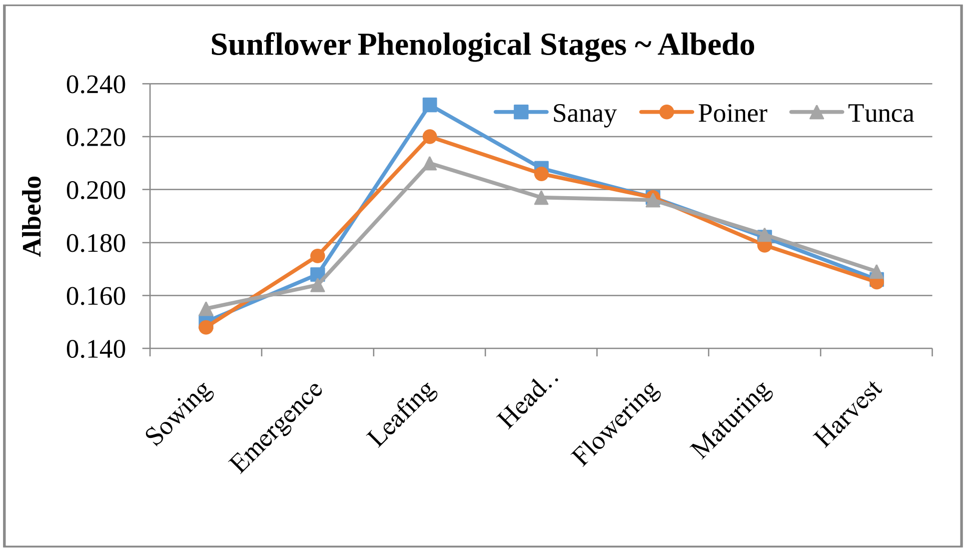

Figure 5. Crop Albedo Changes in Phenological Stages

Monthly evapotranspiration estimation with Soil-Water Balance method and FAO Penman Monteith can be found in Figure 6. Evapotranspiration values of Tunca cannot be found in April and May months because the sowing date is 31.05.2016. In July and August months, precipitation amount is 10.6 mm in 78 days. Therefore, crop water requirements estimation from Soil-Water Balance is decreased. Penman Monteith approachment depends on meteorological variables, that's why evapotranspiration values is considerably higher than the Soil-Water Balance method results in July and August. Evapotranspiration calculations of other months are close to each other. Total evapotranspiration of Sanay, Poiner, and Tunca cultivars were calculated as 524.2, 526.8, and 424.4

mm, respectively. Lower evapotranspiration of Tunca is caused by different sowing date. Total evapotranspiration in this period with Soil-Water Balance was calculated as 341.1 mm.

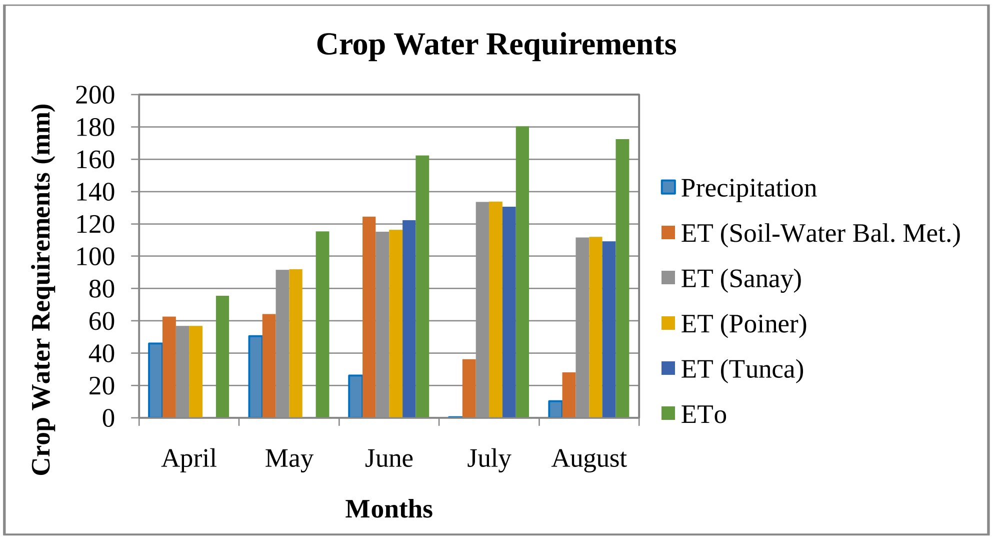

Figure 6. Monthly Crop Water Requirements

This study is the first throughout analysis of crop albedo in Turkey. Results of this research may provide reliable albedo values that are needed for determination of the actual evapotranspiration of winter wheat as well as calibration of remote sensing data. Additionally, daily mean albedo values were used for calculation of net radiation values. We recommend the usage of different albedo values for different phenological stages (e.g. while obtaining crop coefficients) instead of using a single albedo value for whole growing period.

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