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University	**: İstanbul Technical University**
Institute	**: Informatics Institute**
Science Programme	**: Applied Informatics**
Programme	**: Geographical Information Technologies**
Supervisor	**: Assoc. Prof. Dr. B. Berk ÜSTÜNDAĞ**
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ABSTRACTWHEAT YIELD ESTIMATION USING DSSAT CROP SIMULATION MODEL AND INDICES OBTAINED FROM REMOTE SENSING: ISLAHIYE AND NURDAGI CASE

Ömer VANLI

Wheat is the most important food source in the world, which is cultivated in almost every region in our country. In 2017, the average annual production in our country is around 20.6 million tons. Along with traditional agricultural production, scientific agricultural techniques have started to be applied along with developing technology. Crop simulation models, which are one of the scientific and technological agricultural applications, provide information about the outputs such as risks and yields caused by the interaction of components such as weather, soil, management and plant genetics. It is also widely used as a reliable tool for emerging estimates. DSSAT is an active model developed for IBSNAT, an internationally important project based on the idea that systems analysis and simulation approach should be used to find alternative ways to improve agro-ecosystem performances and is currently in use by all researchers around the world. CERES-Wheat model is a decision support system under the roof of DSSAT. All growth stages are modeled on the radiation use efficiency (RUE) approach. The DSSAT model has been successfully applied in field based modeling studies involving homogenous soil and climatic factors in general after plant variety calibration, genetic coefficient determination and performance test. Meanwhile, in order to increase the effectiveness of the models, it is tried to make district or region based researches. However, DSSAT generally uses spatial analysis, integration with GIS and CRAFT regional estimation tools to achieve this, especially in this area which is very difficult due to soil heterogeneity. Another area of using DSSAT model, which can be used in conjunction with global climate models, is the ability to determine the impact of agriculture in the future. The observed and measured data obtained from the growth, development and yields of the fields were used to evaluate the impact of climate change as well as the calibration of the model.

The study area is İslahiye and Nurdağı agricultural plains within the borders of Gaziantep province. This region is located in a fertile valley between the sof and amanos mountains and has favorable climate and soil properties for agricultural production. Planned agricultural production in this region means to grow high quality products of economic value.

Among the total of eighteen wheat fields in the 2016-2017 growing season, high yield (TUKU, TUKO, TUMA, TUSE) fields were used for model calibration and medium yield (TUSA, TUBI, TUCE, TUGO) fields were used for model performance testing. Observed and measured parameters such as temperature, precipitation, relative humidity, sunshine duration and intensity, pressure, wind speed and direction, and finally evaporation were used from the climate data. Soil data, which is the most important component in plant production, general soil information, soil surface information and soil profile parameters such as structure,

structure, pH, organic matter and nitrogen were provided. Management data, which is another data group, included information such as planting date, planting method, planting depth, number of plants per m^2, fertilizer and irrigation amount, harvest amount and date. Finally, as the observed data which is the real field data which is important for the comparison of the model result, the above-ground weight, stem and leaf weight, number of siblings yield, biomass, flowering and physiological maturity time and LAI values were formed. The plant phenology and development (P1V and P1D), then growth (P5, PHINT) and finally yield (G1, G2, G3) parameters were calibrated. The performance of the model was evaluated using RMSE and % error between observed and simulated values. In order to determine the effects of climate change in the region, the study areas in İslahiye and Nurdağı were examined in the RCP 4.5 and 8.5 scenarios of 3 global climate models for mid-century (2036-2065) and end-century (2066-2095). In order to determine the effects of climate change in the region, the study areas in İslahiye and Nurdağı were examined in the RCP 4.5 and 8.5 scenarios of 3 global climate models for mid-century (2036-2065) and end-century (2066-2095). According to previous climate change forecasts, global temperature will increase by 2.5 ° C in 2050. The increase in temperatures predicts that it may reduce future agricultural productivity, especially in semi-arid regions such as our country.

Apart from all these, another technological tool used in agricultural field is remote sensing images. It has been shown in many previous studies that the calculation of land classification and vegetation indices from the radiation reflected from the canopy and thus the regional yield values can be determined. As in the DSSAT crop model study, fields in the same region were selected in the yield estimation study by using indexes such as NDVI. Among the data used, island / parcel numbers, parcel area, sown crop type, irrigated / dry agriculture, yield values, sowing / harvest dates were selected from farmers' registration system data.As the processing of this data, the polygons taken from the sites of General Directorate of Land Registry and Cadastre were converted to .kml format in Google earth program and shapefile was created in QGIS program and made ready for analysis. Another used data is the landsat images that were studied on a total of 13 images from 17 November 2016 to 29 June 2017. In addition, different classification methods such as maximum likelihood, support vector machines, condition-based, nearest neighborhood were also tested for determination of wheat fields. Afterwards, semi-automatic classification (maximum likelihood) in QGIS program was performed. First of all, image conversion and atmospheric corrections were made for this purpose. After merging all bands, the training shapefile was created. A total of eight machine learning algorithms were applied for the spatial distribution of wheat. NDVI values were calculated at 16-day intervals for each field throughout the season and a yield prediction model was developed with Bootstrapping method. Model formulation with coefficients by LASSO regression was used for regional yield estimates. Significant values were obtained from all analysis results. Regarding the genetic coefficients for the Golia variety, the days for optimum vernalization (P1V) were partially high. The photoperiodic requirement (PID) and thermal time (P5), which causes grain filling, were also slightly higher. While G1 and G2 were found to be balancing each other, G3 coefficient was found to be good value as a parameter related to biomass production and plant height. At the end of the calibration, the measured and simulated values of the maximum LAI were close to each other with -5.26 % error and 0.21 RMSE, while yield was below the measured value with -11.32 % error and 586 kg / ha RMSE. It showed a close agreement with -9.56% error and 896 kg / ha RMSE in aboveground plant weight.n According to the results of climate change projection in Turkey's southeast, in the mid-century (2065) Tmax will increase from 1.6 °C (RCP 4.5) to 2.3 °C (8.5 RCP); Tmin will increase from 0.6 °C (RCP 4.5) to 1.9 °C (RCP 8.5), and at the end-century (2095) Tmax will increase from 2 °C (RCP 4.5) to 4 °C (RCP 8.5), Tmin will increase from 1 °C (RCP 4.5) to 3.4 °C (RCP 8.5) In the future temperature increase, wheat yield will

decrease in islahiye with 16.3 % by the mid-century and with16.8 % by the end-century. In Nurdagi, the model showed that it will decrease with 13.4 % in the mid-century and 14.4 % at the end-century. In relation to the NDVI index results of regional yield research, the relationship between observed and estimated yields showed a close agreement for both regions. While it was recorded as RMSE values which were higher at 145 kg / ha for 5 years in Nurdagi, a closer value was recorded with RMSE at 70 kg / ha in İslahiye. In the Nurdagi region, the % error between observed and estimated yield ranged from 1.96 % to 10.61 % for 5 years. However, the error in the Islahiye region ranged from 0.81% to 7.65%. As a result, it has been concluded that the calibrated DSSAT CERES-Wheat model and NDVI indices are very useful methods and can be used easily for other regions and other plants of our country.

Keywords: DSSAT, CERES-WHEAT, Climate Change, NDVI

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ÖZET

DSSAT BİTKİ SİMÜLASYON MODELİ VE UZAKTAN ALGILAMA VERİLERİNDEN ELDE EDİLEN İNDİSLER KULLANILARAK BUĞDAY VERİM TAHMİNİ: İSLAHİYE VE NURDAĞI ÖRNEĞİ

Ömer VANLI

Buğday ülkemizde de hemen her bölgede tarımı yapılan dünyanın en önemli besin kaynağı durumundadır. 2017 yılında ülkemizde ortalama yıllık üretim miktarı 20.6 milyon ton civarındadır. Geleneksel tarımsal üretimle birlikte, gelişen teknoloji ile beraber bilimsel tarım teknikleri de uygulanmaya başlamıştır. Bilimsel ve teknolojik tarım uygulamalarından olan bitki benzetim modelleri iklim, toprak, bakım ve bitki genetiği gibi bileşenlerin interaksiyonu ile ortaya çıkan risk ve verim gibi çıktılar hakkında bilgiler sağlamakla birlikte ortaya çıkan tahminler için de güvenilir bir araç olarak yaygın olarak kullanılmaktadır. DSSAT, sistem analizi ve benzetim yaklaşımı ile agro-ekosistem performanslarını iyileştirmek için alternatif yollar bulmak için modellerin kullanılması gerektiği fikrine dayanan uluslararası düzeyde önemli bir proje olan IBSNAT için geliştirilmiş ve dünyadaki tüm araştırmacılar tarafından halen kullanılan aktif bir modeldir. CERES-Buğday modeli, DSSAT çatısı altında bulunan bir karar destek sistemidir. Tüm büyüme aşamaları, radyasyon kullanım etkinliği (RUE) yaklaşımı üzerine modellenmektedir. DSSAT modeli ise, deneysel çalışmalarla bitki çeşit kalibrasyonu, genetik katsayı tesbiti ve performans testinin ardından genel olarak homojen toprak ve iklim faktörleri barındıran tarla bazlı modelleme çalışmalarında başarıyla uygulanmaktadır. Bu arada modellerin etkinliğini arttırmak için ilçe veya bölge bazlı araştırmalar da yapılmaya çalışılmaktadır. Fakat özellikle toprak heterojenliği nedeniyle oldukça zor olan bu alanda DSSAT bunu gerçekleştirmek için genellikle konumsal (spatial) analiz, CBS ile uyum ve CRAFT bölgesel tahminleme araçlarını kullanmaktadır. Küresel iklim modelleri ile birlikte kullanılabilen DSSAT modelinin bir diğer kullanım alanı da, gelecek zamanlardaki tarımın etkilenme durumunu tespit edebilmesidir. Tarlalardaki büyüme, gelişme ve verimde elde edilen gözlemlenen ve ölçülen verileri, modelin kalibrasyonu yanında iklim değişikliğinin etkisini değerlendirmek için de kullanılmıştır.

Çalışma alanı, Gaziantep ili sınırları içerisinde bulunan İslahiye ve Nurdağı tarımsal ovalarıdır. Bu bölge Sof ve Amanos dağları arasındaki verimli bir vadide bulunup, tarımsal üretim için elverişli iklim ve birinci sınıf tarım toprağı özelliklerine sahiptir. Bu bölgede planlı tarımsal üretim yapılması demek, ekonomik değeri yüksek kaliteli ürünler yetişmesi anlamına gelmektedir. 2016-2017 yetiştirme sezonundaki toplam on sekiz adet çiftçi buğday tarlaları içerisinden yüksek verimli (TUKU, TUKO, TUMA, TUSE) tarlalar model kalibrasyonu için, orta verimli (TUSA, TUBI, TUCE, TUGO) tarlalar ise model performans testi için kullanılmıştır. Kullanılan veriler olarak, iklim verileri yani sıcaklık, yağış, oransal nem, güneşlenme süresi ve şiddeti, basınç, rüzgâr hızı ve yönü, buharlaşma gibi gözlemlenen ve ölçülen parametreler kullanıldı. Bitki yetiştirmedeki en önemli bileşen olan toprak verileri

yükseleceğini göstermiştir. Gelecekteki sıcaklık artışının buğday verimi üzerinde ise, İslahiye olarak yüzyıl ortalarında % 16.3, yüzyılın sonunda ise % 16.8, Nurdağı'nda ise yüzyıl ortasında % 13 oranında azaltacağı beklenirken yüzyıl sonunda % 14.4 oranında azaltacağını model göstermiştir. Diğer bölgesel verim analiz çalışması olan görüntülerin NDVI indeks sonuçları ise, gözlemlenen ve tahmin edilen verim arasındaki ilişki, her iki bölge için de yakın bir uyum göstermiştir. Nurdağı'nda 5 yıl boyunca 145 kg/ha ile daha yüksek olan RMSE değerleri olarak kaydedilirken, İslahiye'de yaklaşık 70 kg/ha RMSE ile daha yakın bir değer kaydedilmiştir. Nurdagi bölgesinde, gözlemlenen ve tahmin edilen verim arasındaki % hata, 5 yıl boyunca % 1.96 ile % 10.61 arasında değişmiştir. Ancak, İslahiye bölgesindeki hata, % 0.81 ile % 7.65 arasında değişmiştir. Sonuç olarak, kalibre edilmiş DSSAT CERES- Buğday modeli ve NDVI indekslerinden oluşmuş bölgesel verim tahminleri oldukça faydalı birer metotla bulundukları ve ülkemizin diğer bölgeler ile diğer bitkiler için de kolaylıkla kullanılabileceği sonucuna varılmıştır.

Anahtar Kelimeler: DSSAT, CERES-BUĞDAY, İklim Değişikliği, NDVI

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