RESUMEN

Los rendimientos de cultivos en la región pampeana argentina son frecuentemente afectados por la variabilidad en la disponibilidad de agua en el suelo. Así, surge la necesidad de desarrollar metodologías que permitan estimar las condiciones hídricas y su incidencia en los cultivos. En este sentido, la teledetección tiene la capacidad de brindar información espacial con la posibilidad de integrarla temporalmente.

El objetivo fue analizar la relación entre la disponibilidad de agua en el suelo y el rendimiento de cultivos de la región pampeana de La República Argentina mediante el TVDI, índice de estrés hídrico que combina la temperatura de superficie (Ts) e índice de vegetación. Mediante imágenes producto Aqua/MODIS de Ts, composición de 8 días (MYD11A25) y de índice de vegetación mejorado (EVI), composición de 16 días (MYD13A25), de 1 km de resolución espacial, se calculó el TVDI para los períodos críticos de los principales cultivos de grano fino y grueso de las ecorregiones: Pampa arenosa, Pampa endorreica, Sierras septentrionales bonaerenses y Planicies poligenéticas de La Pampa. El estudio comprendió los meses de octubre a marzo de 2002-2003 (período húmedo), 2007-2008 (período seco), 2009-2010 y 2010-2011 (períodos normales).

En cuanto a los resultados, los mapas mensuales de TVDI mostraron que dicho índice es capaz de reflejar la variabilidad espacial y temporal de las condiciones hídricas en la región pampeana. Se confirmó la fuerte relación lineal entre dicho índice y el contenido volumétrico de agua en el suelo integrado a 10 y 20 cm de profundidad medido a campo. Los coeficientes de determinación (r^2) fueron 0,82 y 0,60 para dichas profundidades, respectivamente. En cuanto a los parámetros de la validación, la raíz cuadrada del error cuadrático medio (RMSE) fue de 11%; bias (MBE), 11%; error relativo (RE), 0,38; índice de concordancia de Willmott (*d*), 0,84 y r^2, 0,70. Estos resultados muestran la potencialidad del TVDI para el estudio hidrológico del sistema suelo-agua-planta. A su vez, el TVDI calculado con imágenes de 1 km se presenta como una metodología apta para el estudio de la humedad del suelo a escala regional, sin necesidad de información secundaria.

Se comprobó la buena correlación entre TVDI y rendimiento de soja, maíz y trigo en las 4 ecorregiones analizadas. Los parámetros de la validación fueron: RMSE entre 85 kg ha^{-1} (13,5% del rendimiento medio) y 683 kg ha^{-1} (19% del rendimiento medio); MBE entre 99 kg ha^{-1} y 270 kg ha^{-1}; RE entre 0,12 y 0,22; índice *d* entre 0,81 y 0,98 y r^2 entre 0,68 y 0,84. Estos resultados son similares a los reportados en otros trabajos utilizando modelos más complejos. Además, se logró una adecuada estimación del rendimiento de trigo con 1 mes de anticipación y de 2-3 meses para el cultivo de maíz y soja. Estos resultados son comparables y aún más alentadores a los reportados en trabajos sustentados en métodos tradicionales como el NDVI. Finalmente se brinda una metodología poco explorada en la región para el monitoreo hídrico del sistema suelo-planta-agua y la estimación del rendimiento de cultivos a escala regional.

ABSTRACT

Crop yields in Pampa region are frequently affected by the variability in soil water availability. Thus, there is the necessity of easily applicable methods to estimate surface water conditions and its effect on crops. In this sense, remote sensing is able to provide spatial information with the possibility of integrating it temporarily.

The objective was to analyze the relationship between soil water availability and crop yield on Pampa Region of Argentina through TVDI, a stress index that combines land surface temperature and vegetation index. Through Aqua/MODIS global Land Surface Temperature (Ts) and Emissivity 8-day (MYD11A25) and Vegetation Indices 16-day L5 images global 1 km (MYD13A25), the TVDI was calculated for the main stage of growth of the main crops on sandy Pampa, endorheic Pampa, hilly Pampa and polygenetic plains of La Pampa. The study included months from October to March of 2002-2003 (wet period), 2007-2008 (dry period), 2009-2010 and 2010-2011 (normal period).

About results, the images of monthly TVDI shown that this index is capable to show the spatial and temporal variability of hydric conditions on Pampa region. On the other hand, the strong linear relationship between TVDI and soil water content on 10 and 20 cm depth was proved through data collected on an agricultural area in the centre of Buenos Aires province. The correlation coefficients were 0.82 and 0.60 for those depths, respectively. About the parameters of validation, root mean square error (RMSE) was 11%, bias (MBE), 11%, relative error (RE), 0.38, concordance index (*d*), 0.84 and correlation coefficient (r^2), 0.70. These results indicate the potential of the TVDI for hydrological studies of soil-water-plant system. Moreover, the TVDI at 1 km spatial resolution is suggested like a method suitable for analysis of soil moisture at regional scale, without auxiliary information.

On the other hand, a strong relationship between TVDI and crop yield variability was found on three of the most important crop (soy, maize and wheat) in the 4 analyzed ecorregions. The parameters of validation were: RMSE between 85 kg ha^{-1} (13,5% of mean yield) and 683 kg ha^{-1} (19% of mean yield); MBE between 99 kg ha^{-1} and 270 kg ha^{-1}; RE between 0,12 and 0,22; *d* index between 0,81 and 0,98 and r^2 between 0,68 and 0,84. Such results were similar to those shown in other works with more complex models. Moreover, wheat yield could be estimated 1 and maize and soy 2-3 months before harvest. These results are similar or better than those obtained in other works using only NDVI. Finally, is intended to propose a

new method for the Pampa Region to monitor hydric conditions in soil-water-plant system and crop yield at regional scale.

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