

# Estimating the conditions of sunflower crop using NDVI and Vegetation Coverage Temperature (VCT) in the Semiarid Region of La Pampa in Argentina.

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## ABSTRACT

- The factors that determine the success of the crop is water content in the soil profile explored by the roots, where soil and management condition affect the storage and availability. Because of the sites defined by the altimetry and crops predecessors affect the behavior of water content stored in the soil available for plants.
- The aim of this work was to analyze the relationship between different vegetation parameters such as growth rate estimated from Normalized Difference Vegetation Index (NDVI) and Leaf Area Index (LAI) and the vegetation coverage temperature (VCT) in sites delimited by altimetry and different crops predecessors. As a hypothesis, the rate of crop growth estimated from NDVI is related to the differences between sites by water useful and altimetry.
- The experience was carried out during the agricultural season 2010-2011 in a field with sunflower crop located just east of La Pampa. The crops predecessors were soybeans and corn crop (half of lot). During the planting and flowering was measured water useful up to a depth of 3.2 m. We analyzed the rate of growth of the crop, with this purpose was used information of NDVI obtained from satellite imagery LANDSAT TM and was detected water stress through measurements of VCT using a portable sensor that measured in the thermal portion.
- The results showed a high rate of growth of the crop in sites where the predecessor was corn crop, due to a higher water content in the soil 233 mm for sites of low height in the field and 216 mm for sites with high altimetry in the field. In sites where the predecessor is a soybean crop growth rates were lower than the observed, coinciding with a lower content of water of soil (164 and 127 mm for sites high and low respectively). The water content in the soil in flowering will be significantly reduced to values situated between 10 and 60 mm for of low height and high altimetry in the field. This weaknesses in the water status of the soil was corroborated with measurements of VCT where an inverse relationship was found with the LAI (0.56) and with the water content (0.62), suggesting that this variable is an indicator of the water deficit of the crop.
- In the conclusions, there is evidence that the use of technologies, such as offers satellite image and VCT provide information about the condition of the crop, which is viable for determinations of water stress.
- In regions where water is the main limiting factor, the use and knowledge of the environments determined by altimetry and managements conditions allows be efficient in the production of sunflowers.

**Key word:** Satellite image- NDVI- Vegetation Coverage Temperature - Sunflower

## INTRODUCTION

In Semiarid Pampean Region (RSP), the contribution of rainfall in general not satisfy the crop water demand, which is to ensure the success of the crop is important the water stored in the soil prior to planting. However, different aspects of the relief and the predecessor crop condition the water storage in the profile, since most coverage stubble improves water ingress into the profile, avoiding the impact of raindrops, reducing soil potential to crusting and erode (Dardanelli, 1998).

This shows that in places where sunflower is grown in different environments this ability, which has a significant effect on crop productivity. The application of methods which uses satellite data and remote sensing to analyze the evolution of crops, through the interpretation of the parameters that express plant. Information from satellite images through the use of various indices such as Normalized Difference Vegetation Index (NDVI) reveals the reflective characteristics of vegetation in different phenological stages. These are due to the chemical composition and physical properties that they possess (Hoffer, 1978). The NDVI is a vegetation index that relates the reflectance in the wavelength in the infrared channel (0.78 to 0.9  $\mu\text{m}$ ) and red (0.63 to 0.66  $\mu\text{m}$ ) (Rouse, 1973) and is directly related to various parameters such as biomass plants, percentage of vegetation cover, leaf area (Asrar, et al, 1989, Baret et al, 1991). This information generated from the NDVI is used, in many cases to detect seasonal changes in vegetation occurring where different methods have been developed to monitor status of crops and natural vegetation. (Akiyama et al., 2002, Xiao et al. 2002). Moreover, the presence of a marked water deficit, the NDVI can be considered a conservative indicator of the status of the plant, as in later stages to water stress not produce changes in NDVI values due to the presence of a remnant of green material, but the temperature of plant cover (TCV) increases rapidly in the presence of water stress. (Goetz, 1997). The NDVI associated with the VCT can be an indicator of hydric status at which the plant is subjected (Carlson et al, 1994; Goetz, 1997). The aim of this study was to analyze the response of different parameters such as growth rate, estimated cycle length from as NDVI, LAI and crop VCT in different environments defined by the relief and management, mainly the water content the soil profile and crop predecessors.

## MATERIALS AND METHOD

The experiment was conducted during the 2010-2011 year on a sunflower crop. The field is located Quemú-Quemú department in the province of La Pampa. The crop was sown on 25 October, and total seedling emergence began between 6 to 11 November. The predecessor crop were (half batch) soybeans and corn.

Water content in the soil were estimated up to 2.4 m, and each 0.4m at the time of sowing and during the flowering stage through a georeferenced grid. LAI data were obtained by measuring the width of the leaf of each plant and joined the estimating equation proposed by Aston, 1967. VCT was measured using a portable radiometer Raytek. The sensor measures the temperature of the surface emissivity observed in the wavelength of 8-14 microns. VCT measurements were performed during the measurement of IAF, locating the sensor at the top of the canopy. The measurement times were between 11.00 and 15.00 hours. For estimating seasonal crop parameters were used multitemporal NDVI data, relieving 83 points georeferenced classified by altimetry and predecessor crop. These were related to the information content of water in the soil, IAF and VCT. Multitemporal NDVI data were obtained from satellite images Thematic Mapper (TM) sensor LANDSAT series. The information allows for multitemporal NDVI phenological curve of each sample tested, which was constructed from images obtained on the dates of 11 November, 15 December 2010, January 14 15 February and 11 March 2011. These were projected to Transverse Mercator system Datum WGS 84 and georeferenced using Gauss Krugger 228-85 panchromatic image ( pixel spatial resolution 15 m), using control points correction between two images, (Bernstein, 1978). Radiometric calibration was performed which involves a process in which the ND became satellite level radiance at the top of atmosphere (TOA) (Chander et al., 2003; Chander et al., 2007). Finally, atmospheric correction was performed the TOA radiance, surface reflectance obtained assuming a Lambertian surface and cloud-free conditions, using the method Object Dark Subtraction (DOS) (Chavez, 1996). The information allowed the construction of multitemporal phenological curves for each sample and analyzed using the software Timesat (Jönsson et al, 2009), which returns information about seasonal patterns as the beginning and end of the phenological season, a period which is the maximum NDVI value, cycle length and growth rate for each sample.

The results extracted from TIMESAT were analyzed using analysis of variance using the SAS statistical package.

## RESULTS

The water content in the soil of sowing were higher, finding values of 212.6 mm and 218.6 mm for low and high sites altimetry and the predecessor corn. The sites for the predecessor soybean had 200.8 and 187 mm. for the low and high altimetry respectively. However it is not significant differences ( $p > 0.05$ ) between treatment means. The water contents in flowering were low due to low rainfall recorded from October to December which prevented recharge profile according to crop requirements.

This shows that the predecessor crop affect the water contents of sowing. These data are consistent with those found by Duarte (1999) concluded that in addition to the growing predecessor, the amount of residue remaining at the time of sowing produces a significant impact on water storage for the sunflower crop.

The water accumulated during the fallow period affects growth in the early stages of the crops to ensure the availability of water in the critical period of cultivation (Andrade and Sadras, 2000), showing that the management of water in the soil profile is essential for the development of summer crops in arid and semiarid areas. Figure 1 a y b shows the water content for each site evaluated where the profiles at sowing were high water contents, whereas in flowering state the contents water were minimal due to rainfall deficiencies

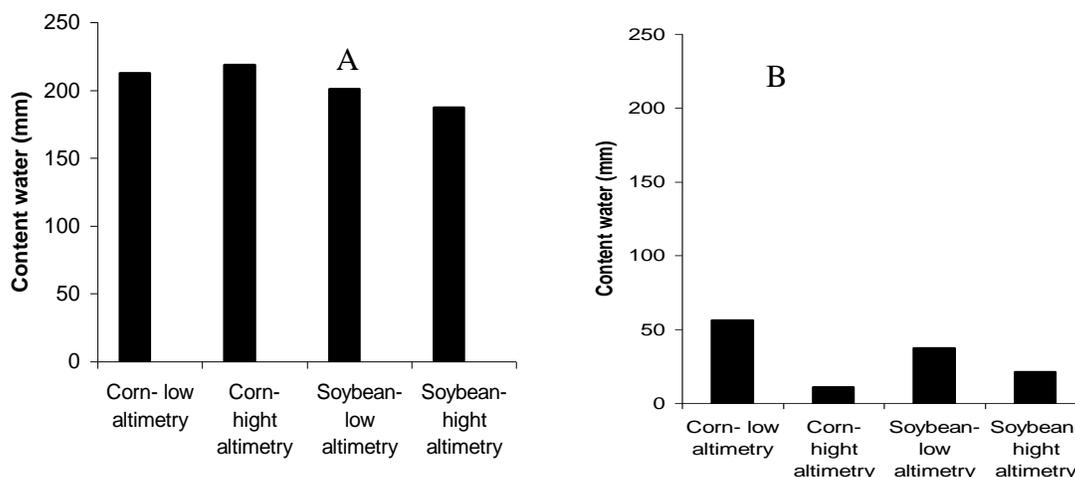


Fig 1. Water content in the soil at sowing (a) and in the flowering stage (b) distributed by altimetry predecessor crop

Figure 2 shows the response average NDVI multitemporal crop in each environment defined by the predecessor crop and altimetry. Multitemporal NDVI response allows reconstructing the crop cycle recorded in each environment. From the date of November 11 through January 14 describes the crop growth stage, showing differences in development between environments, given by the difference in slopes between the curves. The crop flowering stage, observed around January 14 is shown by the maximum values of LAI, NDVI spectral response which is represented by its maximum value. After this begins the stage of senescence in which NDVI values begin to decrease. Multitemporal responses can be analyzed to obtain information related to the seasonal parameters in turn related to other aspects associated with the environment in which the crop develops.

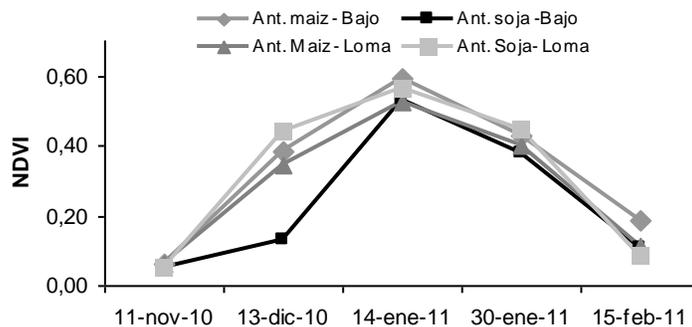


Fig 2. Cycles of growth and development of the samples obtained from NDVI data distributed by relief and predecessor crop.

Table 1 shows the result of the evaluation of multitemporal NDVI data of 83 samples classified by the predecessor crop and altimetry. The analysis by Timesat show significant difference ( $p < 0.05\%$ ) for growth rate of the samples located in sites with corn predecessor and high altimetry. The highest rate of growth was due to increased water content in the soil of sowing on sites with low corn and altimetry predecessor, showing that the more coverage they provide corn stover contribute to more efficient water storage. The lower growth rate corresponding to the samples classified as high altimetry and soybean predecessor, demonstrating that in years of low rainfall the water stored in the soil affects crop demand. The importance of water stored in the soil of sowing and precipitation occurring during the growth cycle are related to biomass production and yield (Micucci et al. 2002b).

Table 1 Summary of seasonal parameters of the samples distributed by altimetry and predecessor crop

Ambiente	Princ. estación	Final estación	Longitud estación (días)	Periodo máx. valor NDVI	Máx. Valor NDVI	Tasa de crecimiento
Amb. Bajo Ant. Maíz	7-12-10	9-2-11	64 a	15-1	0,5532 a	0,2634 a
Amb. Bajo Ant. Soja	25-11-10	10-2-11	77 b	17-1	0,5570 b	0,2622 b
Amb. Loma Ant. Maíz	7-12-10	8-2-11	65 b	18-1	0,5399 b	0,2529 b
Amb. Loma ant. Soja	9-12-10	7-2	60 b	18-1	0,4952 b	0,2288 b

However, differences in growth rates inferred from the behavior of other parameters such as length of growing season, period of maximum NDVI value.

Samples located in low relief associated with periods of earliest growth principle, which generates a length of the growing season more broadly. Figure 3 shows the response of the IAF and the water content in the soil at flowering, showing average data for altimetry and predecessor sites. Note the influence of the environment with low relief with a higher content of water content in soil is related to high LAI values, coinciding with a higher growth rate of the crop

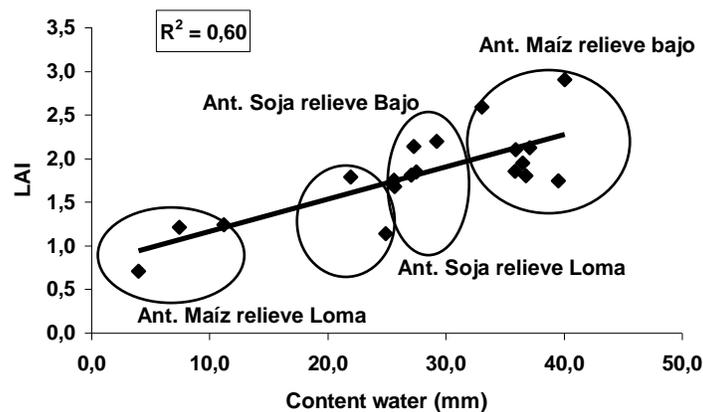


Fig. 3 Relationship between LAI and water content and soil at flowering

The evaluation of VCT response shows an inverse relationship with the water content in soil, LAI and NDVI at flowering, which shows that conditioned by the relief sites and predecessor crop influence on water content, which coincides with data Andrade et al, 2000 which concluded that higher LAI values were achieved with higher water content in the soil.

For this reason the samples located in high relief environments and predecessor crop that provide low crop residues during the fallow show lower values of LAI and NDVI values coinciding with higher radiative temperature, expressing the presence of water stress.

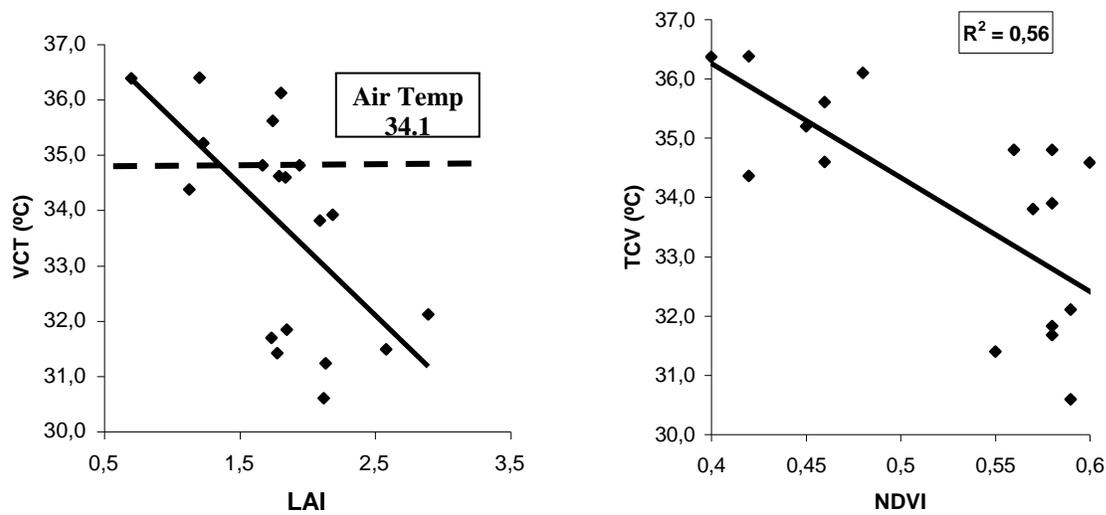


Fig 4 Relationship between VCT data and LAI (A) and NDVI (B)

## CONCLUSIONS

The use of multitemporal NDVI images allows the reconstruction of the crop cycle and this tool analyzes the behavior of the crop within the environments. Moreover, the detection ability of the environments defined by the predecessor crop and altimetry affect AU content in the soil. This situation is reflected in the information provided through the measurement of plant parameters that are manifested by multitemporal NDVI data. The detection of deficiencies in available water conditioning environments is manifested by the radiative temperature response between vegetation and the NDVI, which corroborates the presence of water stress.

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