Assessment of leaf area index in sunflower crop using non-destructive methods

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BOOK of ABSTRACTS

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Introduction

In sunflower crops, leaf area index (LAI) is a key indicator used for decision-making in irrigation and disease management (Debaeke and Estragnat, 2009). For developing crop models or calibrating remote sensing data, LAI should be determined dynamically from juvenile stage to maturity (Claverie et al., 2012). Several non-destructive methods are available for assessing LAI in field experiments through direct leaf area measurement using allometric relationships or through indirect measurement using gap fraction or intercepted radiation. Non-destructive methods that generally use optical sensors are fast to apply and allow the sampling of large areas. Sensors such as LAI-2000 PCA (LI-COR Inc., Nebraska; Welles, 1990) estimate LAI from light transmittance measurements. Others, such as hemispherical photographs (Demarez et al., 2008) provide canopy gap fraction from image analysis. Several criteria should be considered to select the relevant method: accuracy, robustness, relevancy, easiness and quickness.

Materials and Methods

In 2012 and 2013, a range of sunflower canopies were set up at INRA Toulouse (SW France) by varying irrigation (2 levels), N fertilization (2), plant density (5), row width (2) and cultivars (2). Plot area was 60 m². At 3 (2012) and 5 dates (2013), two indirect methods were compared to reference LAI. On 12 plants per plot, plant leaf area (PLA) was determined by measuring leaf length and width on alternate leaves (allometric method). Reference green LAI was calculated by multiplying PLA by plant density. Two additional measurements were performed in the row width using the LAI-2000 Plant Canopy Analyzer (LICOR) between 8:00 and 10:00 am. Hemispherical photographs were taken over sunflower canopies (1.50 m) with a Nikon E 8400 camera equipped with the FC-E9 fisheye lens (Fig.1).

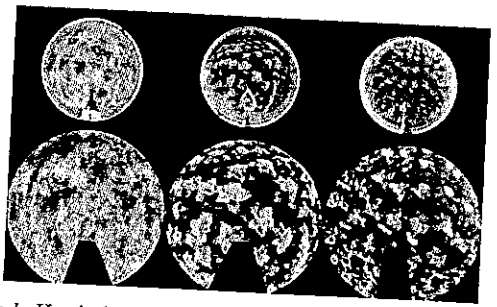

Figure 1. Hemispherical views on 31 May, 13 June and 4 July 2012

The CAN_EYE software was used to estimate effective and true LAI from unidirectional gap fractions measured in crops. CAN_EYE includes an automatic image classification and allows the processing of series of photographs which is mandatory to sample the spatial variability of the canopy. For sunflower, Demarez et al (2008) obtained the best LAI estimates with effective LAI.

Results and Discussion

Between flower bud stage and early anthesis, the two indirect methods (hemispherical photographs and LAI-2000) proved to be relevant methods to estimate green leaf area index of sunflower crops (Fig.2). At anthesis (higher LAI values), LAI was slightly overestimated by the two methods because of the contribution of capitulum to green area index and to the increasing senescent leaf fraction which resulted in less light transmittance. This was more pronounced in 2013 during the grain filling period, corresponding to dates 4 and 5 (data not shown). Less dispersion was observed for LICOR method but the bias was higher than with hemispherical photographs.

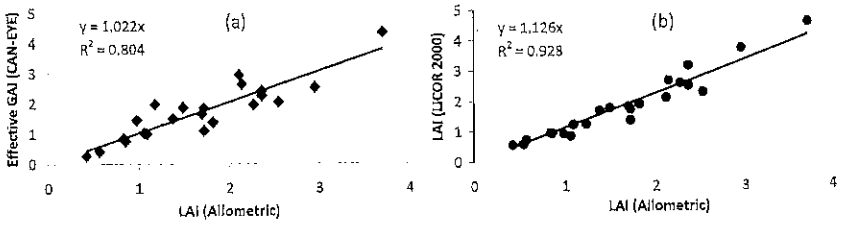

Figure 2. Comparison of allometric LAI with indirect measurements : (a) hemispherical photographs and (b) LAI 2000 PCA (LICOR) – Auzeville, 2012 (from bud stage to anthesis)

Conclusions

The two indirect methods could be used as satisfactory alternatives to the time consuming and spatially limited allometric methods currently used in sunflower for decision making and phenotyping purposes. After anthesis, these methods are probably less relevant to estimate green LAI but they could be used anyway as indicators of crop canopy.

Acknowledgements

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