Leaf temperature of sunflower as affected by nitrogen and water status

Menon Parameswaran
Institute of Land and Food Resources
The University of Melbourne
Dookie College, Victoria 3647, Australia
Fax: +61 358 339201
m.parameswaran@landfood.unimelb.edu.au

ABSTRACT

A preliminary study was carried out to monitor leaf temperature (LT) as affected by plant nitrogen and water status of sunflower. Thermal characteristics of foliage are considered to be linked to transpiration that is indirectly affected by physiological status such as nutrient (eg. N) and water. Plants were grown in the glasshouse under optimal conditions of water and variable nitrogen levels until full flowering, at this stage they were transferred to different soil moisture levels. Temperature of the top leaves was measured by an infrared thermometer on a clear sunny hot day when plants showed clear signs of water stress. Relative water content (RWC) and leaf water potential (LWP) of the upper leaves were measured to quantify plant water status. Leaf samples were collected and later analysed for their total nitrogen content (N). Results have shown that altering plant water and nitrogen status resulted in changes in LT with the associated changes in leaf RWC, LWP and N. Statistically significant correlations were found between LT and RWC,LWP measurements; however, the correlation between LT and N status was proven to be not significant. Remote sensing of foliage temperature can provide a rapid means of assessing the progression of crop water stress and to aid in irrigation scheduling. its usefulness, however, in estimating plant nitrogen status appears limited.

Key words: Leaf Temperature, Water Content, Leaf Water Potential., Nitrogen Content

INTRODUCTION

Water status in plants is governed by the soil, plant and atmospheric conditions. An imbalance in any of these components may lead to changes in transpiration due to the modification of plant growth characteristics. Among all morphological characteristics, expansive growth of leaves and stems is the one most sensitive to water and nitrogen stress in sunflower (Hsiao,1990; Merrien 1992; Parameswaran, 1992).

Under conditions of water shortage, plants can reduce transpiration to low level, thus altering the thermal characteristics of leaves (Keefer, 1989; Dunin et al.,1991). The use of canopy temperature to monitor water stress in plants is based upon the fact that the leaf temperature decreases as transpiration is increased (Nielsen and Anderson,1989). Infrared thermometry is considered to be an easy technique to monitor such changes in foliage temperature of plants (Smith et al ,1985; Peñuelas, J. et.al. 1992) as affected by environmental and plant factors.

The aim of this experiment was to monitor the effect of water and nitrogen status on leaf temperature by infrared thermometry and to examine the usefulness of temperature recordings for gauging water and nitrogen status of sunflowers.

MATERIALS AND METHODS

The experiment was conducted at the University of Melbourne – Dookie College in 1999-2000.

Sunflower plants (*Helianthus annuus L.,* cv Hysun 45*)* were grown in pots in the glasshouse under optimal conditions of water and varying levels of nitrogen (N0, N1 , N2 , N3 and N4 ; a single unit of N being 25 kg ha -1) until full flowering, at this stage they were transferred to different soil moisture levels. Two water treatments based on the available water content of soil were introduced: low water (W1) and unrestricted water (W2) respectively (Fig.1). The Nitrogen–water treatments were factorially combined and arranged in a completely randomised design with 3 replications in each case.

Plants were regularly watered until flowering. Upon clear signs of water stress, temperature of fully expanded upper three leaves was measured using a hand-held infrared thermometer (Model 2302, Everest Interscience Inc.,CA) at a constant distance (approximately 5cm at 600 angle) from each leaf. Measurements were taken at the centre and either end of the selected leaves from both east and west directions and the values averaged to work out leaf temperature (LT) . The output was regularly compared against the temperature of a fixed blackbody standard.

Fig. 1.The plants were transferred to different water levels at flowering

Once the leaf temperature was measured, nearby leaves were severed and used for RWC, LWP and N measurements using methods as outlined by Parameswaran et al.,1984 Turner,1988).

Data was analysed using analysis of variance and regressions between different variables namely relative water content (RWC), leaf water potential (LWP), LT and leaf nitrogen content (N) were calculated and plotted.

RESULTS

As might be expected RWC and LWP and LT measurements were significantly influenced by the imposed water and to a lesser extent by the nitrogen treatments (Table1).

Table 1, RWC, LWP, LT and leaf N content as affected by different treatments

Water Status	N levels	RWC %	LWP MPa	LT 0C	N mg g-1 dry weight
	N0	55a	-1.3a	35.2a	23.0
	N1	58a	-1.5a	38.8b	27.9
W1	**N2**	57a	-1.4a	38.2b	27.2
	N3	37b	-1.8b	38.8b	30.7
	N4	40b	-3.3c	38.0b	33.6
Mean		**49c**	**-1.9d**	**37.8c**	**28.5**
	N0	74d	-0.6e	27.5d	25.4
	N1	74d	-0.8ef	27.3d	25.2
W2	**N2**	71de	-0.9f	26.7d	25.3
	N3	72d	-1.1f	27.5d	30.8
	N4	67e	-1.1f	27.5d	33.7
Mean		**72f**	**-0.9g**	**27.3e**	**28.1**

Values are significant at $p < 0.001$. Mean values in each column followed by same letters are not statistically significant. ***N-content****: significant differences were observed between nitrogen levels only (LSD <0.001 = 3.4): water levels and interactions were not significant.*

Leaf temperature was affected by plant water status and increased progressively from W2 treatment to W1. Compared to W2, LT values in W1 treatments showed increases to the

magnitude of approximately 40%. Within this general trend however, lesser effects due to varying nitrogen levels were apparent. The changes in N content between different N treatments within a particular level of stress showed consistent increases, but proved to be significant only between no nitrogen control and treatments.

Fig.2 (a*):*Relationship between RWC and LT; (b): LWP and LT as affected by nitrogen and water treatments; (c):Changes in LWP as affected by leaf nitrogen content (mg - g dryweight) and (d):LWP as affected by varying nitrogen and water supply.

The effect of N on RWC was minimal. However LWP tended to lower with increased levels of N content in leaves (Fig.2d). At low levels N had little effect on LWP whereas at high N the effects of N were strongly expressed in lower LWP values.

DISCUSSION AND CONCLUSION

The growth, development and water use of sunflower are closely related to its water and nitrogen status (Merrien, 1992). Among all morphological characteristics in sunflowers, expansive growth of leaves is one of the most sensitive to changes in nitrogen and water status (Sadras et al.,1993). Not only does leaf area decrease with nitrogen and water stress, transpiration rate can also change, as has been demonstrated by other studies (Dunin et al ,1989).

LWP was inversely related to the N content of the sunflower leaves although the regression r2 was only 26% (Fig.2c). The findings of this study once again support the view that high N supply aggravates or promotes plant responses to water stress (Parameswaran et al.,1984; Seligman et al.,1983).

Direct measurements such as RWC and LWP have often been used by researchers to determine the current water status in plants. These measurements are, however, considered to be time consuming and cumbersome for practical irrigation scheduling.

As indicated by this study, leaf temperature is closely related to RWC and LWP and it follows that plant water status in sunflowers may be inferred from measurements of changing leaf temperature. Similar studies by showed that the foliage temperature of plants was significantly affected during water stress.(Dunin et al., 1989; Peñuelas et al. 1992).

Leaf temperature may thus prove beneficial as an easy, non-destructive and measurable indicator for scheduling irrigations in the field under prevailing weather conditions. With this in mind, the clearly visible top leaves of a plant can be used as a water stress indicator, whose LTs can be measured with less difficulty. It should be stressed that the field measurements are likely to be affected by ambient meteorological conditions.

The method however does not provide the answer to how much water one should apply to the crop. As was found in this study, LT measurements of leaves at different N content did not seem to alter much despite demonstrable changes in LWP under high N levels (see Fig. 2d). The use of infrared thermometry to monitor nitrogen status of sunflower is yet to be established.

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