Measurement of Water Use by Canola with Sap Flow Gauges

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Introduction

Heat balance method of measuring sap flow has been used to estimate transpiration in many plants including field crops. Although, a number of different sap flow systems have been studied, the constant heat input system is the most commonly used. Advantages of sap flow system are 1) sensor attachment will not affect the transpiration behavior of the plant 2) reliability of the data can be studied from raw data 3) the potential accuracy is high 4) long term observations are possible.

Canola is an important crop in the Canadian prairie. Sap flow systems have not been used to assess transpiration by canola. Information on real time transpiration in response to variations in weather conditions like solar radiation, wind, temperature and management practices like plant population are not available. Information will be extremely useful in adaptability studies of canola in drier and warmer semiarid prairie conditions.

Theory

The heat balance method measures sap flow in plants by heating a small section of the stem and measuring the amount of heat transported away from the heater due to sap movement (Fig. 1).

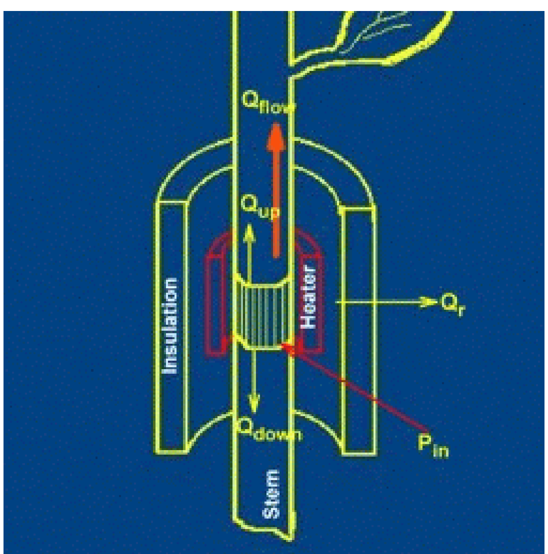

Figure 1. Heat Balance Method

The energy balance equation is

Pin=Qv+Qr+Qflow

Where, Pin is power input to the stem
Qv is vertical heat conduction
Qr is radial heat conduction
Qflow is heat convection by sap

Pin power supply to Teflon coated flexible heater of known resistance. Heater should encircle stem completely. Qv consists of Qup and Qdown. It is measured by thermocouples placed above and below heater strip. Qr is calculated by multiplying thermal conductance constant of gauge installation (Ksh) to temperature difference between inner and outer surfaces of cork substrate. Ksh is obtained when sap flow is at its minimum. Remainder is Qflow. Qflow is converted to sap flow by F=Qflow/Kp x dT

Where,	F	is sap flow (g h-1)
	Kp	is specific heat of water
	dT	is temperature increase of sap

Experimental Details

<u>Greenhouse Trial 1999</u>

Objective: To evaluate accuracy of the sap flow system and importance of stem size on accuracy.
Replication: >9.0mm stem 5 plants and
<9.0mm stem 3 plants
Observations: Sap flow and transpiration (by weighing pots) were measured each hour. Separate regression for >9.0 and <9.0mm was used to find out accuracy of sap flow gauges.

<u>Growth Chamber Trial 2000</u>

Objective: To determine effect of temperature on sap flow and accuracy of sap flow system.
Temperature: Midday temperatures from 16/15 to 40/15oC were randomly imposed over an 8 day period.
Replication: 8
Observations: Cumulative sap flow and transpiration were measured each day. Temperature effects on diurnal trends in sap flow was also measured.

<u>Field Trial, Swift Current 2000</u>

Objectives: (1) To Measure transpiration response of canola to variations in solar radiation.
(2) To determine plant population effect on plant transpiration.
Plant Populations: 10 and 80 Plants m-2.
Replication: 3
Observations: Hourly and daily sap flow, weather data over a 6 day period. Effect of solar radiation on transpiration was determined by regression analysis.

<u>Plant Material</u>

Argentine Canola; Quantum for indoor studies and Arrow for field studies were used.

<u>Gauge Installation</u>

Sap flow gauges (SGA-10, Dynamax Inc, Houston) were installed at the base of the stem (Fig. 2). Two to three bottom leaves were removed before gauge installation. Weather shield and at least three layers of aluminium foil was wrapped around the system to seal the system from temperature fluctuations. Ksh values for gauge installation were either obtained by detopping (indoor studies) or from the low sap flow period data (field studies).

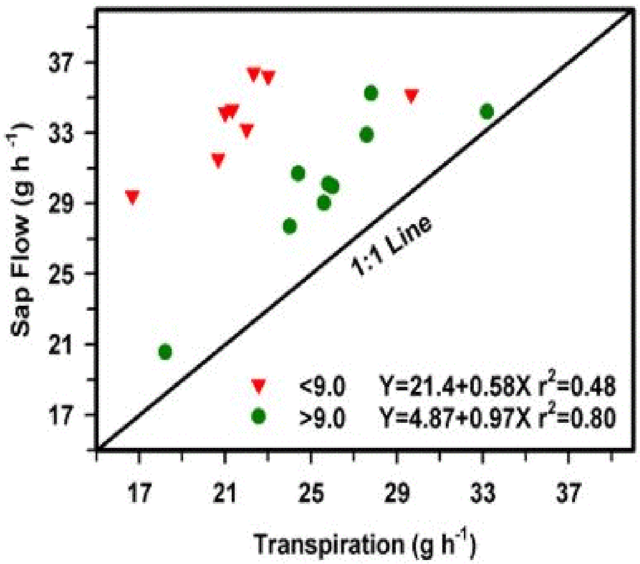

Fig. 2. Sap flow and transpiration relationship in canola under green house conditions. Effect of stem thickness (<9.0mm presented with inverted triangles and >9.0mm presented with circles) on the accuracy of the sap flow system is also presented.

Results and Discussion

Accuracy of Sap Flow System

Sap flow system adaquately estimated transpiration by canola. The relationship between hourly sap flow and transpiration under green house conditions was significant (r^2=0.80). However, the sap flow system always overestimated transpiration. Stem size had significant influence on the accuracy of sap flow gauges.

Temperature Response

Sap flow and transpiration increased in response to temperature up to 36/15 ^{o}C and decreased thereafter. A strong relationship between daily sap flow and daily transpiration (r2=0.99) was observed in the temperature range from 16/15 to 40/15^{o}C. However, the sap flow system always overestimated transpiration.

Effect of Solar Radiation.

Solar raditaion had a significant influence on sap flow (r^2=0.91 to 0.97) (Fig. 5 and 6,bottom), however the relationship was stronger at optimum plant population.

Effect of Plant Population.

Canola from lower plant population initiated water use (sap flow) earlier in the day and used much higher amounts of water compared to plants from the higher population. When water use was expressed per unit surface area, differences between population denisities narrowed on the sunny days compared to cloudy days. Wind seemed to affect canola response to solar radiation only for the lower plant population.

Conclusions

The sap flow system showed promise for estimating transpiration in canola. Camparing sap flow and transpiration at different temperatures (at different sap flow) reconfirmed the strong relationship between them. Sap flow in canola was related to solar radiation, and transpiration surface area. However, under low population and low light intensity other microclimatic factors like wind might influence sap flow. Sap flow gauges should be tested on other canola and mustard species.

Acknowledgements

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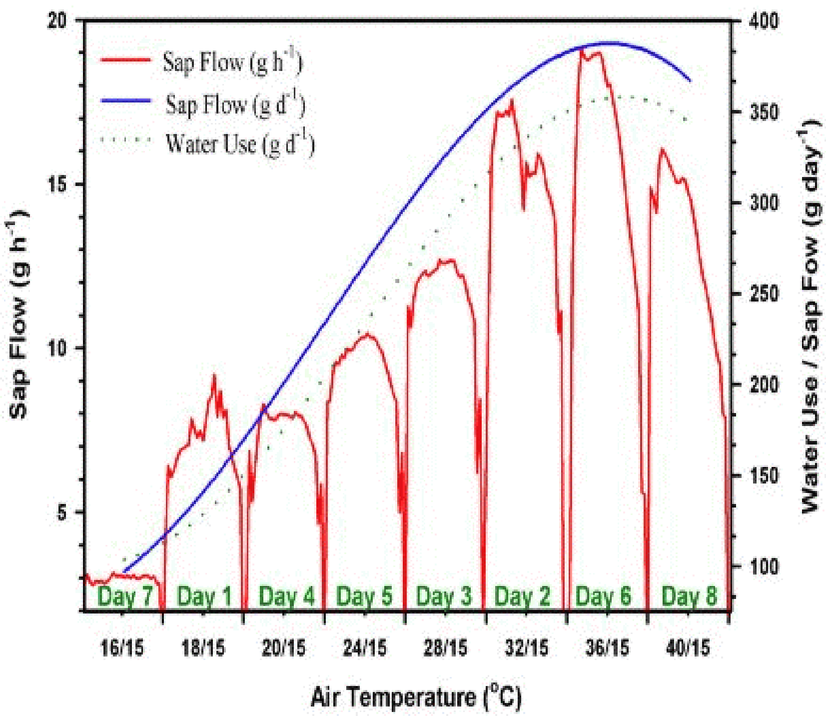

Fig. 3. Temperature effect on transpiration, hourly and daily sap flow. The relationship between daily sap flow and transpiration was highly significant (Transpiration=3.07+0.90*SapFlow; r^2=0.99 n=8)

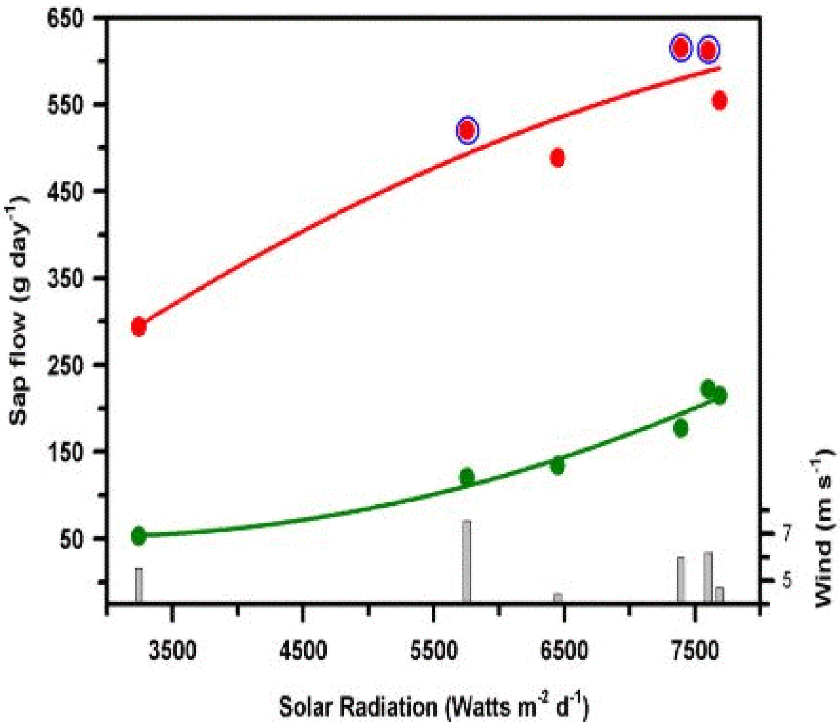

Fig. 4. Effect of solar radiation on sap flow of canola under two plant populations. The data points encircled with blue rings suggest the possible role of wind on sap flow at lower plant population

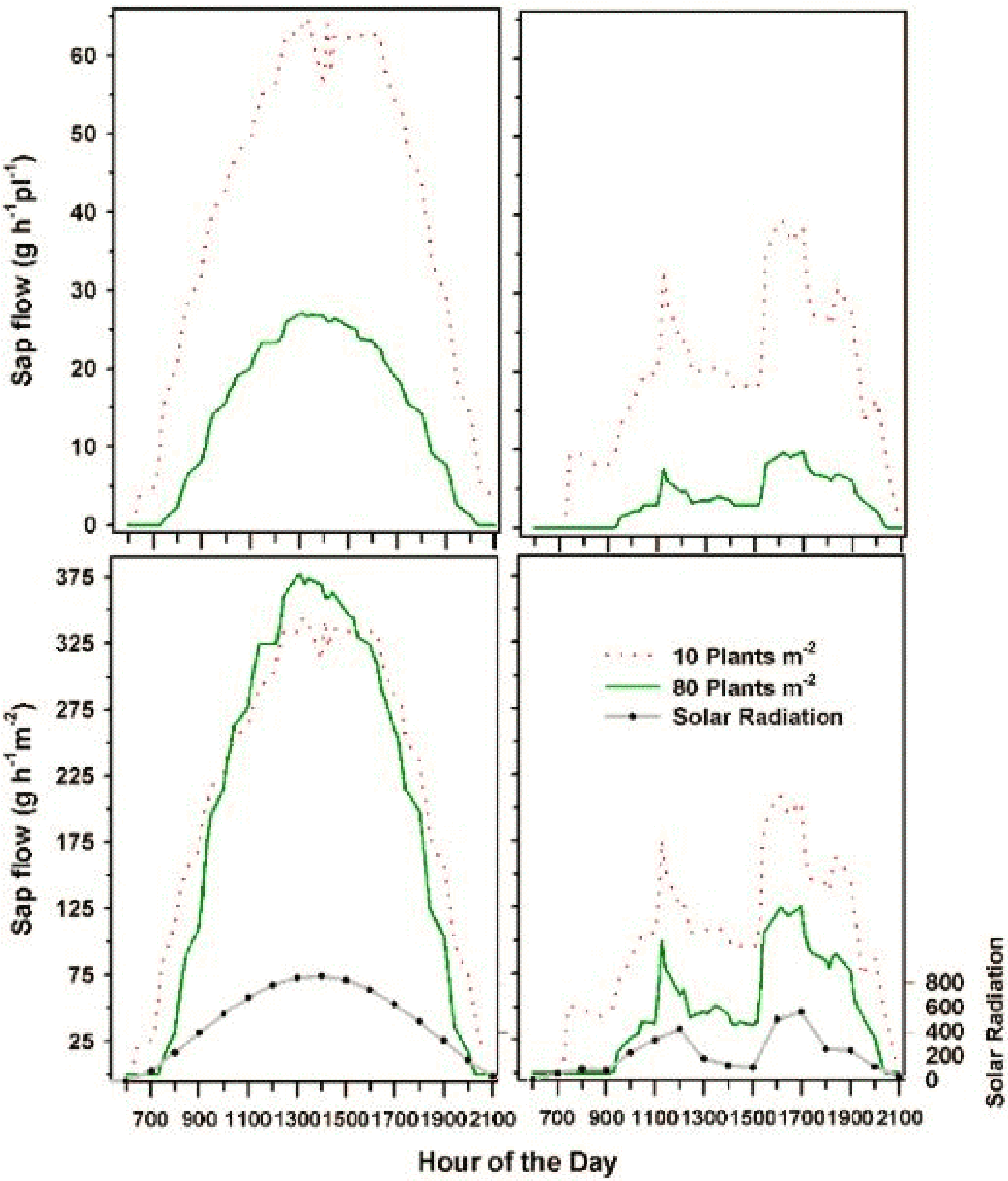

Fig. 5. Effect of plant population on sap flow of canola under sunny and cloudy days. Sap flow is expressed per plant (top) and per unit surface area (bottom). Two different populations were used to get different size plants.