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Linacre's Simple Model for Water Loss in a Leaf

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Abstract
Linacre (1964) shows that humidity and wind speed affect transpiration and cooling in a leaf. Specifically, cooling of a leaf increases because of dry and calm air. Transpiration is the water passing through the leaf surface to the air. Linacre sets up a relatively simple model for rate of water loss in a leaf growing from wet soil. To start, three equations are given, which are developed.

$$R = LE + H \quad (1)$$
$$H = (T_s - T_a) / r_x \quad (2)$$
$$LE = (e_s - e_a) / (r_i + r_e) \quad (3)$$

Eq. (1) gives the radiation to the air, Eq. (2) is for heat flux from the air and Eq. (3) is proportional to the water loss rate.

Keywords: Humidity, Wind Speed, Water Loss Rate, Radiation Transpiration Temperature

Introduction

Fig 1 is from Linacre, page 392.

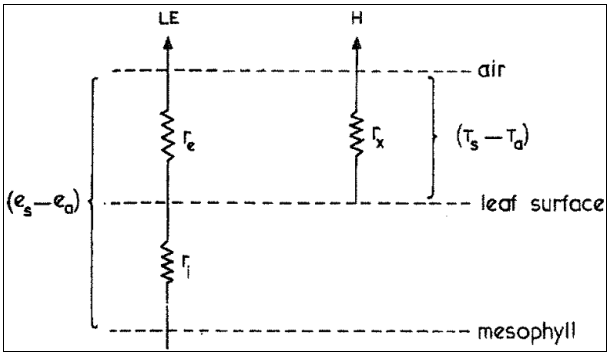

Fig 1: Modal of the diffusion resistances assumed to exist about a leaf

LE and H combine to give R, the radiation flux.Both r_e and r_x are connected in the following way, being concerned with diffusion through the same physical barrier.

$$r_e = a\, r_x \quad (4)$$

where a is the psychometric constant taken as 0.5 mm Hg/°C (Bowen (1926), Albrecht (1950) and Ferguson (1952)) [2, 3, 4]. Also, e_s and T_s are related in the following way because thin leaves have the internal liquid and leaf surface at the same temperature. This is because there is good thermal conductivity of the leaf contents and the small distance between the leaf liquid and leaf surface.
Linacre remarks that this relationship is assumed, based on standard tables for the saturated vapor pressure of water Fowle (1934) [5].

$$e_s = f(T_s) \quad (5)$$

Using some algebra, we combine (3) and (5) and (1) with elimination of H using (2) to get, with (4).

$$(r_i + a\, r_x)\, LE = f((R - LE)\, r_x + T_a) - e_a \quad (6)$$

Now, Eq. (6) has to solved with assumed values because it has LE on both sides.

Discussion

To get the values of Eq. (6) Linacre used the following assumed values with three iterations and this is in Table 1 from Linacre, page 394, except Linacre's Eq. (7) is this author's Eq. (6).

Table 1: Example of the calculation of the Latent Heat Flux and the surface Temperature from Eq. (7)

The following values have been assumed:
r_i = 20 mmHg · cm² · min/cal
r_x = 30° C. cm² · min/cal
e_a = 10 mmHg
R = 0.6 cal/cm² · min
T_a = 20° C

	1st trial	2nd	3rd
LE: cal/cm² · min	0.30	0.40	0.42
$R - LE$: cal/cm² · min	0.3	0.2	0.18
r_x $(R - LE)$: °C	9	6	5.4
$T_a + r_x$ $(R - LE)$: °C i.e. T_s	29	26	25.4
$f(T_s)$: mmHg i · e · e_s	30.1	25.2	24.4
$e_s - e_a$: mmHg	20.1	15.2	14.4
$r_i + a \cdot r_x$: mmHg · cm² · min/cal	35	35	35
$(e_s - e_a)/(r_i + a \cdot r_x)$: cal/cm² · min i.e. LE	0.57	0.43	0.41

Then Linacre remarks that the treatment predicts the effect of changes in climate on water loss and depends on wind, radiation, temperature and humidity. Eq. (6) is useful in showing the influence of a change of wind speed on transpiration because decreasing wind speed causes an increase of r_x, the exernal resistance.

Transpiration matters in cooling the surface of a leaf and is estimated by using a formula implied in Eqs. (5) and (6). Thus, we have.

$$T_s = (R - LE)\, r_x + T_a \quad (7)$$

From (7) we see that the cooling effect is LE r_x, which depends on the water loss rate E and everything that governs this.

Also, it is important to note that a small leaf is quite different from a crop. Linacre's model also shows that wind reduction depends on humidity. Linacre's final statement includes, "the dry-surface and the leaf temperature clearly increases as the ambient air becomes more dry and more calm."

Nomenclature

R	net radiation flux to the area (cal/cm²-min)
L	latent heat of evaporation (about 580 cal/gm)
E	water loss rate (gm/cm²-min)
LE	latent heat flux (cal/cm²-min), which is proportional to the water loss rate
H	sensible-heat flux from the area (cal/cm²-min)
T_S	temperature of the leaf surface (°C)
Ta	ambient air temperature (°C)
r_x	external heat-diffusion resistance (°C-cm²-min/cal)
e_s	vapor pressure of the liquid surface within the leaf (mm Hg)
e_a	ambient vapor pressure (mm Hg)
r_e	external vapor-diffusion resistance (mm Hg-cm²-min/cal)
r_i	internal vapor diffusion resistance, between the liquid and leaf surface (mm Hg-cm²-min/cal)
epidermis	a skin like layer in seed plants and ferns
humidity	amount of moisture or water vapor in the atmosphere
mesophyll	inner green tissue of a leaf, lying between the upper and lower layers of epidermis
transpiration	passage of water in the form of vapor through the leaves of a plant

Conclusions

There is a more complicated model by Seginer (1971) [6], but the author chose this simple model for this paper. Linacre solved this one by noting that LE is on both sides of Eq. (6) and that means it has to be solved by iteration. This paper is a brief summary of the one by Linacre.

Acknowledgements

God is pro-life. ENOCH said, Behold the Lord cometh with his myriads of holy ones (JUDE 14) and ELIJAH went to heaven in a fiery chariot (II KINGS 2:11). So, both obtained eternal life. Surely the Virgin Mary determines the fate of Satan and the evil spirits. (GENESIS 3:15)

References

1. Linacre ET. Calculations of the Transpiration Rate and Temperature of a Leaf Arch. Meteor. Geophys. Bioklim. 1964; 13(3):391-399.
2. Bowen IS. Ratio of Heat Losses by Convection and by Evaporation from Any Water Surface Phys. Rev. 1926; 27:779-787.
3. Albrecht F. Methods of Measuring Evaporation from Natural Surfaces Arch. Met. Geoph. Biokl. 1950; 2:1-38.
4. Ferguson J. Rate of Natural Evaporation from Shallow Ponds Austral. J. Sci. Res. 1952; 5:315-330.
5. Fowle FE. Smithsonian Physical Tables, 8th Ed. 1934, 232-233.
6. Seginer I. Wind Effect on the Evaporation Rate J. Appl. Meteor. 1971; 10:215-220.