Accuracy of vegetation evaporation ratio formulae for estimating final wheat yield

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Abstract

Vegetation evaporation ratio was here defined as the ratio of actual vegetation evaporation rate to potential vegetation evaporation rate. The accuracies of 5 different yield formulae based upon 5 different ways of combining vegetation evaporation ratio simulated for the different growth stages of wheat were compared. Additive, multiplicative and exponential combination methods were tested on wheat grown under 29 different water stress treatments. The multiplicative model proved most accurate, closely followed by the additive and exponential models and a model utilising a single vegetation evaporation ratio for the entire season, in that order. Mean absolute errors ranged from 9 to 12% of the mean of the measured values. This accuracy is acceptable for decision support purposes.

Notation

D	atmospheric saturation vapour pressure deficit (kPa)
E_{o}	reference crop evaporation (here short grass) (mm)
E_{s}	evaporation from the soil surface (mm)
Eso	potential soil evaporation (mm)
E_v	evaporation from the vegetation component of the cropped surface (mm)
E_{vo}	potential evaporation from the vegetation component of the cropped surface (mm)
$F_s = E/E_u$	soil evaporation ratio - the fraction of reference crop evaporation rate equivalent to actual soil evaporation rate
$F_v = E_v/E_{v_o}$	vegetation evaporation ratio - the fraction of potential (water non-stressed) vegetation evaporation rate equivalent to actual vegetation evaporation rate under the existing atmospheric evaporative demand and soil water conditions
Fl	green leaf fractional radiation interception- the fraction of incoming solar radiant flux density intercepted by live vegetative cover
$k_y = E/E_o$	the soil surface evaporation coefficient quantifying the ratio of actual soil evaporation rate to reference crop evaporation rale underthe same atmospheric conditions
$k = E_w/E_o$	the potential soil evaporation coefficient quantifying the ratio of potential soil evaporation rate of a given soil surface to reference crop evaporation rate under the same atmospheric conditions
$k_v = E_v/E_o$	the vegetation evaporation coefficient quantifying the relationship between actual vegetation evaporation rate and reference crop evaporation rate under the same atmospheric conditions
$k_{io} = E_{vo}/E_o$	the potential vegetation evaporation coefficient quantifying the relationship between potential evaporation rate from the vegetation of a given crop to the reference crop evaporation rate under the same atmospheric conditions
L	crop total leaf area (green plus senesced) per unit of ground surface area
t	time elapsed since the last wetting event (d)
Y	wheat grain yield (kg-ha^{1})
Y_b	total dry biomass production over a given period (kg-ha-^{1})
Y_y	seasonal potential wheat grain yield (here 7 150 kg-ha-^{1})
Y/Y_o	relative grain yield
[}	yield-water stress response factor

In the text, subscripts will be used as follows:

i	the tth growth stage in a growing season with a total of G growth stages.
n	the nth value in a data set totalling N values
o	the potential, or maximum value
v	appertaining to the vegetative component of the crop
s	appertaining to the soil surface of the cropped area.

Superscripts:

A	simulated value of the relevant variable
—	arithmetic mean of the relevant variable

Following this notation the following hold:

$\hat{Y}_n$	simulated grain yield for the nth year (kg-ha-^{1})
Yn	measured grain yield for the n^{th} year (kg-ha-^{1})
$\bar{Y}$	arithmetic mean of the measured grain yields (kg-ha-^{1})
$\bar{\hat{Y}}$	arithmetic mean of the simulated grain yields (kg-ha^{1})

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Introduction

In recent times, plant water stress has been evaluated in terms of the ratio of actual to potential evaporation from vegetation. This ratio will be referred to as the vegetation evaporation ratio.

Early, simple growth models of Jensen (1968) related crop grain yields reduced by plant water stress to the ratio of actual to potential vegetation evaporation. Furthermore, Jensen (1968) showed that yield reduction per unit vegetation evaporation ratio (water stress sensitivity) varies with crop growth stage (see also Hanks and Hill, 1980). Jensen (1968) proposed a maize grain yield-vegetation evaporation ratio model of the form: