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SUNFLOWER CROP GROWTH IN THE SOUTHERN ITALY

A.M. Castrignanò, N. Losavio, M. Mastrorilli, M.E. Venezian Scarascia,
Istituto Sperimentale Agronomico, C. Ulpiani 5, 70125 Bari, Italy

SUMMARY

In Puglia region characterized by high radiation load and frequent soil water shortage, sunflower crop was grown in a shallow soil during three seasons; sunflower plants were submitted to two different irrigation treatments: 50 and 100% of estimated maximum evapotranspiration.
The growth analysis data was fitted to a non-linear regression model utilizing three parameters (the initial plant dry weight, the specific growth rate and the leaf abscission constant) but their values are varying along with the climate conditions.
On the contrary, the bioclimatological index ECG (energy crop growth) that appeared significantly correlated with the biomass formed during biological cycle can be utilized in different environmental conditions.

INTRODUCTION

Mathematical models allows to formalize assumption about crop performance and provide a simple and direct approach in elucidating the effectors of potential crop yield. The objective of this work was to develop a simple function of sunflower growth which will give a good description of cumulated dry weight data over a whole season and in the maintime predict the response of the crop to various degrees of soil dehydration.

MATERIALS AND METHODS

Sunflower HS 90 was grown during the 1980,1981 and 1985 season in the south eastern Italy on a shallow clay soil with two irrigation regimes: well watered plants (mm 440 of irrigation water equal to 100% of estimated maximum evapotranspiration, ETM) and droughted plants (mm 200 of irrigation water equal to 50% of estimated ETM) in randomized blocks with 3 replications. The crops were sown on the first days of April. Approximately once a ten days plants were harvested, the leaf area measured and leaves, stems and heads separated, dried and weighted. Meteorological data was recorded near the trial field.
For predicting sunflower growth and development from emergence to physiological maturity a mathematical function was fitted to the sequential harvest data as suggested by Charles Edwards D.A. (1982):

$$W = W_o \exp(\mu t) / \left\{ 1 - \gamma W_o \left[1 - \exp(\mu t) \right] \right\} \quad (1)$$

were W is total dry matter; W_o is the initial dry matter; μ is the specific growth rate; γ is a leaf abscission constant and t is time.
The three parameters adopted have a biological meaning and allow to quantify the water shortage.
The analysis represents a valid general description of the whole plant growth and its application represent an improvement if utilized for the dry matter partitioned to leaves, stems and heads. However as the eq. (1) is a function of the time its parameters are dependent from different climate pattern.

Therefore the ECG index was introduced.
The used ECG variable is defined as "energy crop growth" index (Coelho et al., 1980)

$$ECG = (Rs/600) \cdot f(LAI) \cdot f(T) \cdot (ETe/ETp) \qquad (2)$$

where f(LAI) is (Linvill et al.,1978):

$$f(LAI) = \left[1 - \exp(-0.79 \cdot LAI)\right] \qquad (3)$$

The LAI values utilized in the ECG equation were obtained by the regression analysis of experimental data adopting a mathematical function reported elsewhere (Castrignanò et al., 1987).
The value 0,79 was adopted as the mean extinction coefficient for sunflower.
The f(T) is defined as (Hammer et al.,1982)

$$f(T) = \left[0.00252 \cdot (T - 6.6) - 0.0000327\ (T - 6.6)^2\right] \qquad (4)$$

from emergence to visible head and as

$$f(T) = 0.0014\ T \qquad (5)$$

for the period from visible head to physiological maturity.
The ratio ETe/ETp is varying between 0 and 1 and was estimated on the basis of the water budget along the whole plant life.
The constant 600 cal cm^{-3} is adopted to express the incoming radiation as the equivalent water depth.
As all variables except radiation are dimentionless the ECG is expressed as cm of water assuming that the whole incident radiation is converted in latent heat flux.
It was reasonable to assume that at a zero value of all functions it would be no growth rate.

RESULTS AND DISCUSSION

The field data of sunflower growth observed during 1980,'81 and '85 season in well watering and droughting conditions are fitting to a curvilinear function according to equation (1); in the figures 1 and 2 are reported the curves for the total dry matter respectively of well watered plants (1980,'81) and of droughted ones (1980,'81,'85).
The same function was utilized to describe the pattern of dry matter partitioned in leaves, stems and heads: in the figure 3 are reported the curves for the well watered plants (1981) and in figures 4 and 5 the curves for the droughted plants (respectively 1981 and 1985).
From these results it appears evident that the growth equation (1) is well fitted to observed data: however the curve parameters (Table 1) are differing between years.
The table 1 shows that among the different organs of the plant the heads appear to have the highest specific growth rate but its reduction-in droughted plants-is more drastic than in the other parts of plant; moreover the value of the

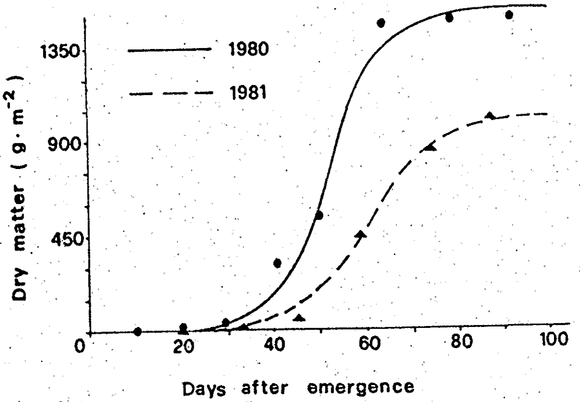

FIGURE 1. Total dry matter of well watered plants as a function of time.

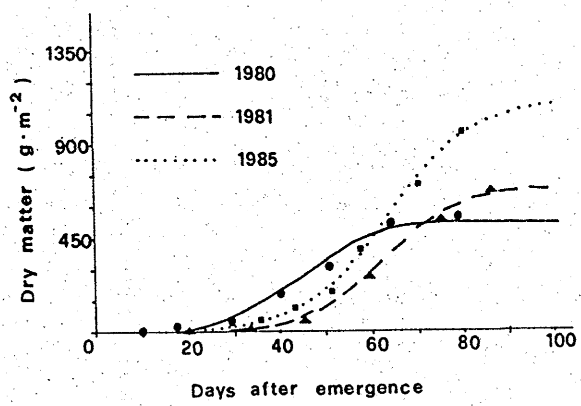

FIGURE 2. Total dry matter of droughted plants as a function of time.

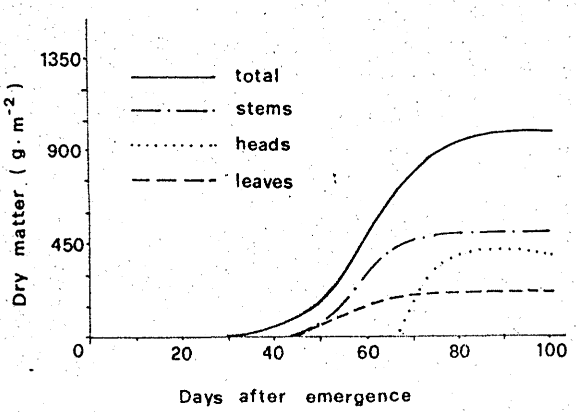

FIGURE 3. Total and partitioned dry matter of well watered plants ('81).

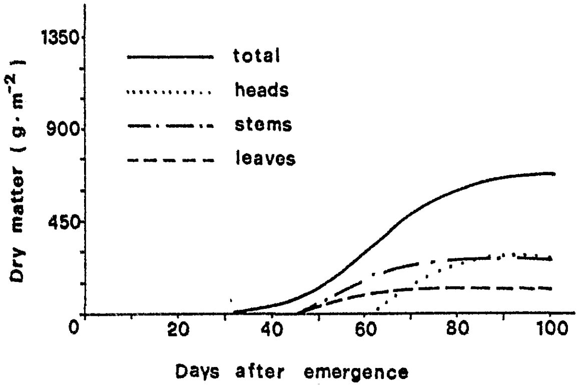

FIGURE 4. Total and partitioned dry matter of droughted plants ('81).

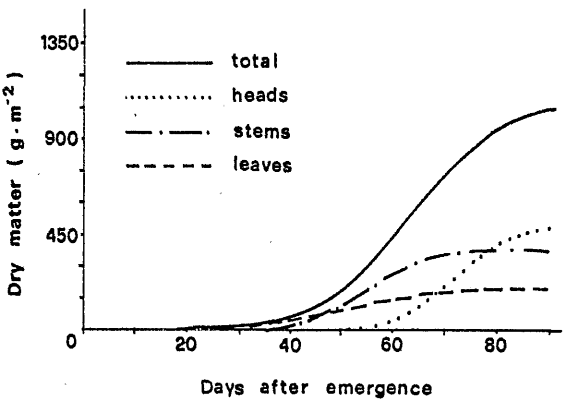

FIGURE 5. Total and partitioned dry matter of droughted plants ('85).

Parameters	1981 (watered)	1981 (droughted)	1985 (droughted)
μ_l d^{-1}	0.198	0.223	0.117
μ_s d^{-1}	0.234	0.256	0.192
μ_h d^{-1}	0.260	0.443	0.221
γ_l g^{-1}	0.005	0.008	0.005

TABLE 1. Estimated leaf, stem and head specific growth rate (μ_l, μ_s,μ_h) and leaf abscission constant (γ_l) obtained by fitting eq. (1) to experimental data.

leaf abscission constant is less variable between years and increases about two-fold due to soil water shortage.
The analysis enables us to attribute the quantitative difference in the growth of well watered and droughted plants to the separate, but simultaneous, effect of water deficit on leaf assimilation and leaf abscission.
However in the growth equation (1) the dry matter is plotted against the time during which the whole plant cycle occurs; but the same interval of time in two different years can be characterized by a different values of total rain, cumulated radiation, average air temperature and different ratios of actual to potential evapotranspiration that can influence differently the crop development and yield.
In order to utilize a single enviromental index in identifying the effect of the more important weather variables, the ECG index was plotted against cumulated dry matter of sunflower plants. In the figure 6 are reported the total dry matter of well watered (a) and doughted (b) plants in function of the ECG index.

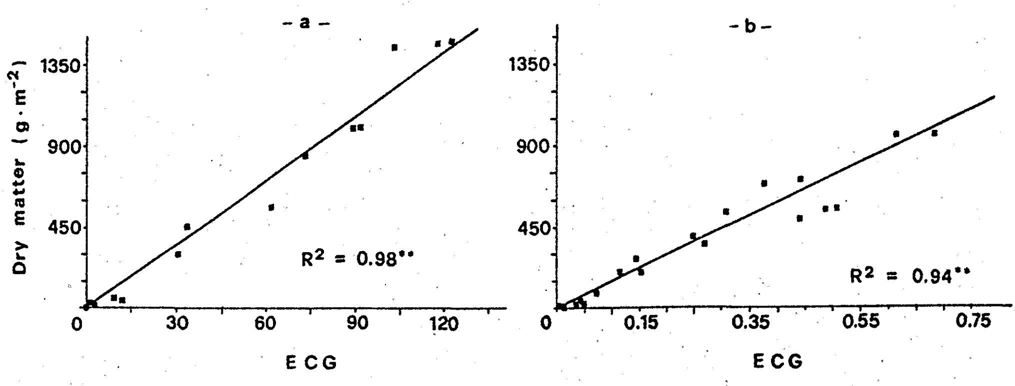

FIGURE 6. Total dry matter of well watered (a) and droughted (b) as a function of ECG index.

As we assumed that at zero level of any component of ECG there should be zero growth, the linear regressions between total dry matter on ECG index are forced through the origin; both linear regressions are fitting very well to observed harvest data and the coefficient of determination(R^2) are very high for both treatments. The slope (b) of the regression can be utilized to estimate the average accumulation of dry matter per unit ECG: the b value obtained for well watered plants is very different from that of droughted ones.

CONCLUSION

The experimental harvest data obtained in three seasons('80,'81,'85) were utilized to predict sunflower growth by two different methods.
The results of fitting data to equation (1) are differing between treatments and among seasons.
By introducing the ECG index that is considering the effects of temperature, soil moisture and solar radiation on crop growth the coefficients of determination resulted very high.

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