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# EVALUATION OF A METHOD FOR CALCULATING DRY MATTER ACCUMULATION IN SUNFLOWER CROP

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## SUMMARY

The paper evaluate the performances of a mathematical function (Charles Edwards, 1982) in evaluating sunflower growth. The biological meaning of the parameters in the model and their ranges of variation in Mediterranean environment are here reported.

The maturity class of hybrids doesn't affect greatly the variability of parameters, they are influenced mainly by agrometeorological factors. The shapes of the curves describing dry matter accumulation for sunflower are related to air temperature; final biomass is well correlated to the bioclimatologic index "ECG" (energy-crop growth) calculated on the basis of solar radiation (Rs), leaf area index (LAI), air temperature (Ta) and soil water availability (SWA). Rs and Ta are directly measured, LAI is calculated according an exponential function and SWA on the basis of the soil water balance.

## INTRODUCTION

Over the last few years there has been a considerable increase in attempts at creating models which aim at forecasting the growth of crops on the basis of simple logical analysis of crop growth data. A general model was suggested by Charles Edward (1982):

$$W = \frac{Wo \exp(\mu \cdot t)}{1 - \gamma \cdot Wo\,(1 - \exp(\mu \cdot t))}$$

where W = total dry matter;
Wo = initial dry matter;

(*) The contribution of the Authors to the paper has been equal.

$\mu$ = specific growth rate;
$\gamma$ = leaf abscission;
t = time.

In a previous work (Castrignanò et al., 1988) this equation was fitted to sunflower field data in order to predict dry matter production of sunflower grown under different water regimes. The good agreement between observed and predicted values, enabled us to explore in this paper the limits of the proposed model and to study the environmental factors affecting the range of variability of the parameters in the model.

In crop modelling, the three most important variables which have to be considered as they may limit plant growth and development are solar radiation, moisture, and temperature (DeWit et al., 1970; Reetz and Hollinger, 1980). Moreover for sunflower crop we propose to investigate the relationship between the model parameters and "ECG", an ecophysiological index including the effects of solar radiation, leaf area index, air temperature and soil water availability on crop growth (Coelho and Dale, 1980).

## MATERIALS AND METHODS

The trial was carried out on a very shallow (0.60 m) clay (43 %) soil, well drained due to a fissured rocky subsoil with 73 mm total available water. During 4 years (1980, 1981, 1985, 1988), characterized by the typical Mediterranean climate of Southern Italy (Rutigliano - Bari, latitude: 41° 01' N, longitude: 14° E, altitude: 122 m) 4 sunflower hybrids (6 plants $m^{-2}$) were grown (Cerflor: early; Romsun HS 90: mid-early; Viki: intermediate; Stromboli: late) under limited irrigation water supply (1000 $m^3$ $ha^{-1}$ of water applied twice: at budding and seed-setting stages), corresponding to 50% of calculated maximum evapotranspiration.

From emergence to physiological maturity, once a ten days sunflower was harvested, the leaf area measured and total biomass dried and weighted.

The observed data and wheather data, recorded near the trial field, were utilized to perform the retained model.

## RESULTS AND DISCUSSION

In *figure 1 dry matter evolution in the four years is reported* as a function of time. We remark that:

- the different hybrids produced only a low influence on the model parameters; on the other hand, the most of the variability is due to the different climatic patterns in the four years. For this reason, the results of each year are here presented as the average of the four hybrids;

- all the variability is contained within two limits which could be fixed by the model parameters. $\mu$ influences the curve slope and $\gamma$ the final dry matter.

Any model have to take into account all the climatic variability and this is a crucial point when a model is fitted to field data collected in Mediterranean areas. In practice, the use of a model is limited by exact informations about the parameters: what do they mean? how large their variability ranges are? which values do they take? In Mediterranean environment, in particular, model users have to know which values the model parameters take under different environmental conditions.

Concerning the proposed equation for calculating daily dry matter increasing, our experimental data let us to give some answers for the sunflower grown under the Mediterranean climate.

$W_o$ is the initial dry weight at time = 0; in other words it is the weight of the aerial sunflower dry matter at emergence. It is affected by the "climatic history" that precedes the emergence. Its range of variation is included between 0.005 and 0.05 g $m^{-2}$.

$\mu$ is the *specific growth rate of above - grownd dry matter*, more precisely $\mu$ represents the growth rate per unit of leaf dry weight. It gives an idea of the velocity of the sunflower to attend the maximum value. Mathematically is the parameter which determines *the shape of growth curve*. Many regression were performed between $\mu$ and agrometeorological parameters (air temperature, solar radiation, soil water availability) and the best correlation was found between $\mu$ and the sum of thermal units (treshold value = 12 °C). As shown in Figure 2, $\mu$ differs between 0.18 and

0.1 g $g^{-1}$ $d^{-1}$, over the climatic patterns of the seasons.

$\gamma$ it is a senescence factor related to leaf abscission. The agroclimatic patterns and occurance of water stress in the soil do affect $\gamma$ values ($0.0009 \leq \gamma \leq 0.002$). To less favourable climatic trends for sunflower growth correspond higher $\gamma$ values. It is clear that $\gamma$ could not be simply related to a single agrometeorological factor, then the research of a correlation between $\gamma$ and agrometeorological factors required an ecophysiological index which includes the effects of temperature, soil moisture and solar radiation: ECG (Fig. 3). ECG was defined by Coelho and Dale (1980) as "energy-crop growth" (Castrignanò et al., 1988).

A good relation was also found between ECG and dry matter. In Figure 4 ECG index was plotted against the total dry matter of 4 sunflower hybrids. The linear regression is fitting very well to observed harvest data; this result confirms that ECG could predict the sequential harvest data if the average accumulation of dry matter per unit of ECG (the slope of the linear regression) is known experimentally.

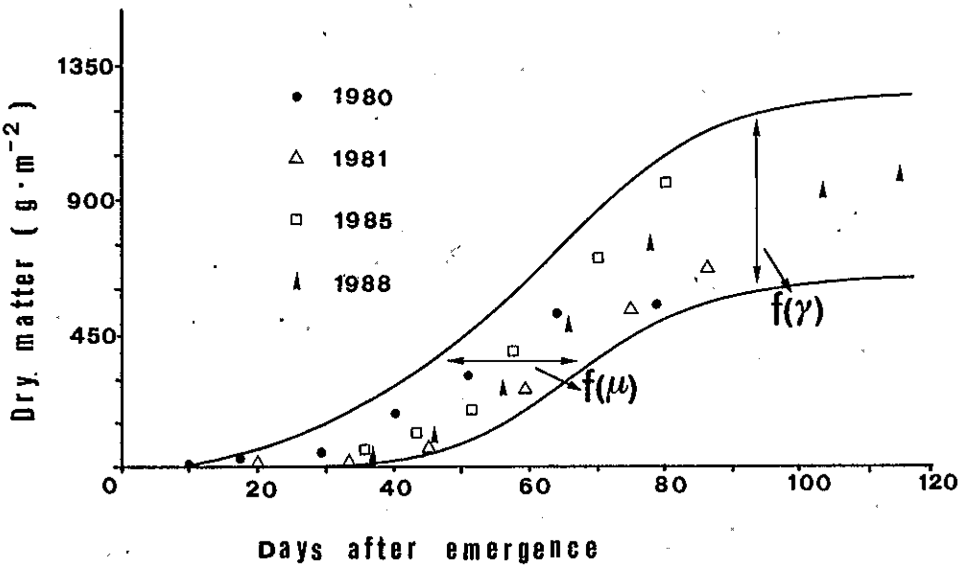


Figure 1 - Dry matter evolution as a function of time.

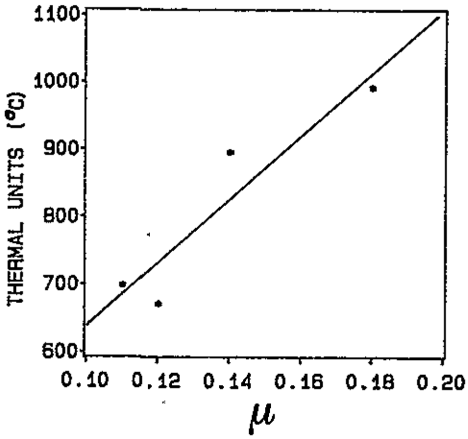


Figure 2 - μ values vs. sum of thermal units.

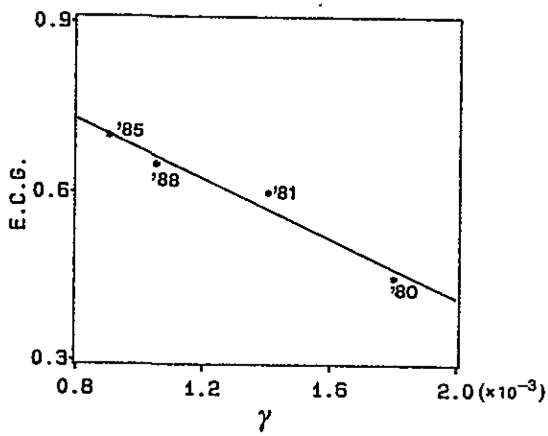


Figure 3 - γ values vs. energy-crop growth index.

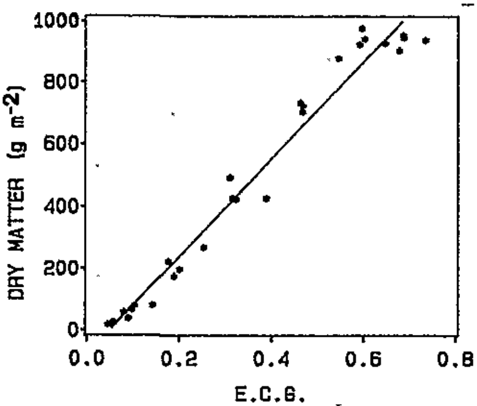


Figure 4 - Total dry matter as a function of ECG index.

## CONCLUSIONS

The advantage of employing the proposed adapted logistic function to predict sunflower dry matter are:

- each parameter has a biological meaning;
- the magnitude of varibility is known in semi-arid environment;
- the value of each parameter could be determined by some agro-meteorological factors.

A very high correlation exists between the ECG index (that is considering the effects of temperature, soil moisture and solar radiation) and sunflower dry matter accumulation.

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