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AN APPROACH TO MODELLING OF ENVIRONMENTAL FACTORS AND GENOTYPE INTERACTION : A CASE STUDY OF MILLET (*Pennisetum glaucum* (Leeke) R. Br.)

Introduction

In the dry regions of Africa, millet production is generally low and varies with time and space. An understanding of the interaction between genotypes and environment is necessary to improve its production. Production depends on a combination of physiological and agroclimatical factors like temperature, potential evapotranspiration, soil water availability and satisfactory water consumption (SWC). With a dynamic modelling approach, we aim to enhance knowledge on the behaviour of millet under drought conditions so as to improve its productivity in these regions.

Materials and Methods

The data base was obtained from field experiments carried out in 1996 and 1997 at CERAAS Bambey in Senegal. Studies were conducted on a millet variety, Souna 3, with a growth cycle of 90 days. The plants were subjected to three water regimes : well watered throughout the growth (T0), water deficit during vegetative and flowering-grain filling (T1) and during flowering/grain filling stages (T2). Algorithms for the model were derived from the relationship between above-ground biomass accumulation of the different organs, leaf senescence, leaf area index (LAI) cumulated daily temperature-degree days (T_{cum}) and daily satisfactory water consumption (SWC). The AraBHy model which simulates water balance of peanut was adapted to allow the simulation of SWC.

2a

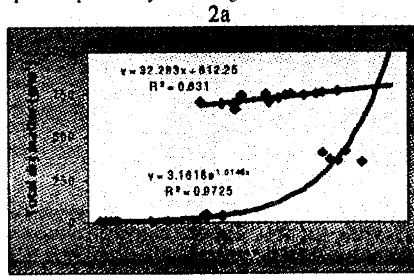
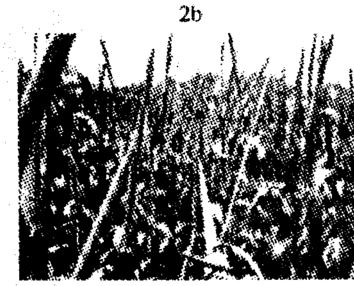


Figure 2. Relationship between total dry matter and leaf area index before and after senescense

2b



Millet cultivated in the experimental field of CERAAS (flowering-grain filling stage.

Millet behaviour under maximal evapotranspiration (MET) could k expressed by (1)

$$(1)\quad \begin{cases} \text{If } T_{cum} \le T_{senes.}\text{ then : } B_{MET}(T_{cum}) = \dfrac{B_{max}}{1 + b.e^{-cT_{cum}}} \\ \text{If } T_{cum} > T_{senes.}\text{ then : } B_{MET}(T_{cum}) = B_{MET}(T_{senes.}) - a(T_{cum} - T_{senes.}) \end{cases}$$

$T_{senes.}$: T_{cum} at senescence, B_{MET} : function of the development of millet, B_{max} : total maximal biomass.

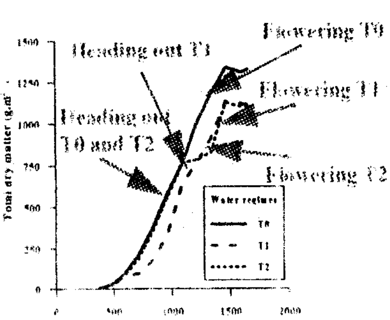


Figure 1. Biomass production as a function of cumulated degree days.

B_{MET} may be also estimated from LAI : equations 2a and 2b (Fig. 2). The effect of water deficit on B_{MET} depends on the intensity and the stage at which it occurred. It could k modelled by calculating the difference in phases between well irrigated plants and those subjected tc water deficit. At each phenological stage (i) corresponds therefore tc a value (Ti, MET) of T_{cum} for the plants at MET and a value (T_i, STR) of T_{cum} for the plants subjected tc water deficit. Tk phenological delay at a stage (i) could k defined by the functions (3) and (4) :

$$(3)\ R\varphi_i = T_{i,MET} - T_{i,STR} \qquad (4)\ R\varphi(T_{cum}) = g(T_{cum})$$

For any water regime, total biomass production is considered as the sum of a function of production under MET : $B_{MET}(T_{cum})$ and a function of stress (5) :

$$(5)\ B_{STR}(T_{cum}) = B_{MET}(T_{cum}) - s(SWC_{cumMET}(T_{cum}) - SWC_{cumSTR}(T_{cum}))$$

From this, the biomass of plants subjected to water deficit and those at MET could be compared at the different physiological stages. This is the reason why tk stress function is established from the same phenological stages obtained from the function of phenological delay (6) :

$$(6)\ B_{STR}(T_{cum}) = B_{MET}(T_{cum} - R\varphi(T_{cum})) - s(SWC_{cumMET}(T_{cum} - R\varphi(T_{cum})) - SWC_{cumSTR}(T_{cum}))$$

At harvest, grain yield could k obtained from the above-ground biomass through a harvest index.

Results

During the vegetative phase, a severe water deficit delayed heading out by 140 degree days and reduced biomass production (Fig. 1). Based on these results, a model which simulates biomass production as a function of the SWC of the crop and T_{cum} received was developed.

Conclusion

These results provide a basis for tk establishment of tools which could k used for predicting millet production. Simulated data. associated tc field data can k integrated into a geographical information system (GIS) in order tc assess drought, develop production area mapping and breeding programme planning in arid regions.Cond

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