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AN ANALYSIS SCHEME FOR MODELING THE FUNCTIONING OF A TOMATO CANOPY

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Abstract

An analysis scheme of the functioning of a tomato canopy is presented. It is the basis of the framework of a plant row model (Bussières, 1990). This scheme indicates the variables and the factors which have been taken into account and those which are interrelated. Differents levels are considered: canopy, plant, fruit. Some considerations are presented on the prospects for developing of such a model for research and the crop management of the processing tomato.

1. Introduction

It is important to make a model of the tomato field in order to forecast its functional operation based on the factors on which it depends and to soundly decide upon the crop management techniques. Bussières (1990) has built a framework of a plant row model to simulate it from day to day from seeding to harvest, and pointing out the variability inside the row. Such a model requires a detailed analysis of the functioning at any moment t. At a first level of research, such an analysis consists in listing the various variables and factors involved and in determining those which are interrelated. We present a scheme of the accomplished analysis and some points for consideration concerning the prospects for improvement and utilization.

The aim of this presentation is to show the direction in which knowledge and decision making possibilities for processing tomato crop management will probably evolve besides the evolution of tecnical operations (Dumas, 1991, same issue). Processing tomato crop should indeed be the subject of modeling efforts, already undertaken (Wilson et al., 1987, for instance), as is the tomato grown under shelter and also many other open field crops.

2. Methods

2.1. Analysis scheme

The study was undertaken using a "system approach". Some definitions and principles about this type of approach have been given by Gras (1990). A system is mainly considered as a group of mutually interrelated units. Studying such a system consists, on the one hand, in identifying its elements and, on the other hand, in determining those which are strongly interrelated. According to Osty (cited in Gras, 1990), such a system approach means "to first

Acta Horticulturae 301, 1992
Processing Tomatoes

consider the whole before studying the parts which can be successfully studied in depth". This approach reduces the risk of overlooking the relationships which exist between the subsets, which could occur if they are studied too soon.

During the first stage of such an approach, one could limit oneself to simply noticing the important relationships which exist between the elements. A chart can then suffice.

The chart in Figure 1 gives the variables and their interrelationships at the time t in the plant row. Only the most important ones in the structure of the row plant have been considered here. These variables take place at different levels :

- the plant row itself,
- the medium,
- the canopy,
- within the latter, the plant,
- then the fruiting truss,
- and the bud.

Many variables are considered through :

- their state at the time t,
- their variation rate during an interval dt following t.

2.2. Experimental data

The experimental data used in this study came from an experimental design which includes various plots cropped according to various ways of management techniques on the same calcareous clay soil during three successive years (Table 1). A more complete description was provided by Dumas et al. (1983).

Table 1 - Short description of the studied fields.

	fields				
	B	C	F	H	K
soil type	clayey-calcareous				
previous crops	maize	spinach	spinach	maize	spinach
years	A1	A1	A2	A2	A3
cultivar	Earlymech				
sowing time (calendar days)	99	113	127	109	130
seed density (seeds/ha)	272000	134000	279000	293000	310000
seed depth (mm)	20	15	25	30	30
irrigation	sprinkling managed in order to consume soil reserves				
harvesting time	246/259	268/272	256	257	282

3. Discussion and conclusion

The scheme transposed into a quantitative model has allowed fairly satisfactory simulations of tomato crop rows (Bussières, 1990).

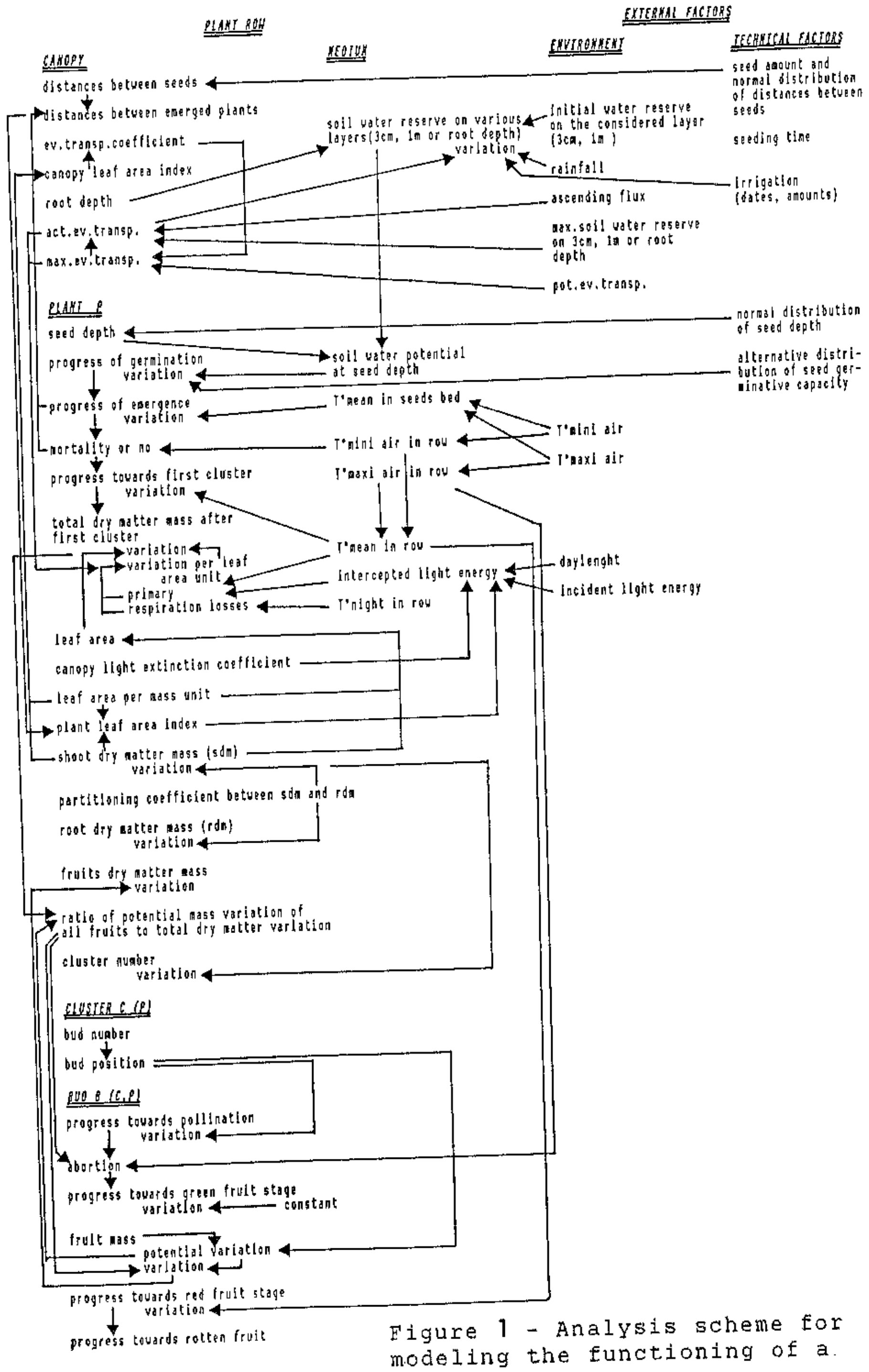

Figure 1 - Analysis scheme for modeling the functioning of a tomato canopy

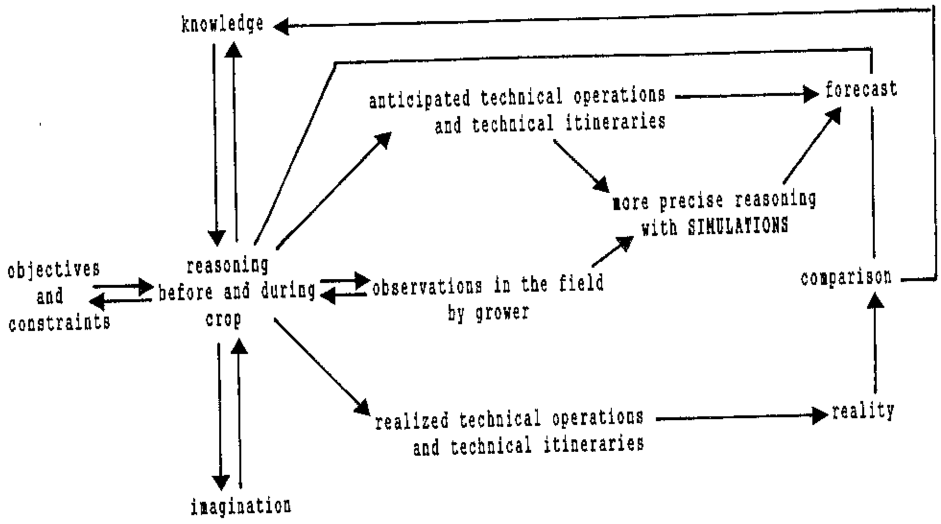

Figure 2 - Diagram showing the elaboration of technical itinerary and the position of simulation

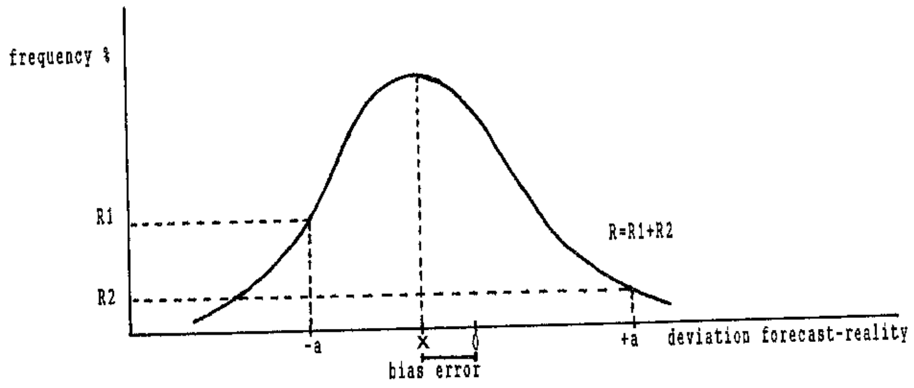

Figure 3 - Supposed distribution curve of deviation between forecast and reality for field yield

In this first stage, however, many factors and variables have not yet been taken into account. The analysis must, therefore, be completed and studied in greater depth, for instance, by introducing the nitrogen nutrition concerns, for which submodels exist. These submodels are relative to nitrogen availability in the soil and are likely to be usable once they undergo the adaptations enabled by the analysis scheme, or they are relative to the nitrogen effects on tomato (Suniaga Quijada and Dumas, 1991, same issue).

Such a scheme constitutes an integration of the knowledge which exists at various levels and it expresses the variability within space and time which appears in each of them. It shows that the explanation of a given level does not only depends on the lower levels.

It should, therefore, help to know better and model the functioning of the field, by identifying the lacks of knowledge and further necessary research and by helping to organise and conduct such research. Indeed, in particular, by considering the various levels and their variability within space and time, one should enhance the possibility:

- of control in open field and thus of confrontation between simulated and observed values,
- of modeling by using more empirical knowledge where local or momentary conditions at the field level make them acceptable when no knowledge of greater depth exists.

Concurrently, this way should be of use to imagine, perfect and real time pilot crop management schedules which are adapted to given objectives and constraints. Indeed, tecnical choices result from successive confrontations which are made by the grower between his objectives and constraints and the forecasts of the effects of the considered tecnical operations (Figure 2). The improvement of these forecasts depends on the increase of their accuracy (decrease of bias error) and on the reduction of the risk R for them to be different from the reality by a value greater than a given threshold a (Figure 3). For instance, one can assume that an expert will forecast the yield average of 100 tomato fields at 10 $t.ha^{-1}$, but that in 20 cases the achieved yield will diverge from the forecasted one by more than 30 $t.ha^{-1}$. Consequently, with the present knowledge which could allow a mean yield satisfactory for the demand, the most interesting improvement for the growers - but also for the canning industry in terms of harvesting date, for example - to reason crop management in given conditions is the reduction of the risk R. It should result from the amelioration of the capacity to take into account a great number of factors and mecanisms, even if it is approximative for each of them. In particular, it is obvious that over and above the average value of the factors, their very pinpoint or transitory variations (e.g. appearance of a pest localized in the field or transient climatic event) can be decisive in the functioning of the field and must be considered. The present type of scheme and the resulting model should help to take these variables into account. However, the difficulties will probably depend on the knowledge of the variability of these input factors. Even if these values can be fairly well known for the environment (soil variations, etc...) the variations of the technical factors will probably be more difficult to know (irrigation or seeding heterogeneities, etc...). This will require research of reference data of these variation factors and also more precise observation methods by the growers.

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