SECTION 3

The Effects on Crop Yields: A Simulation Approach

3.1. Introduction

In 1978 a simulation model of the water–plant–soil type was developed by researchers of the Brazilian Agricultural Research Enterprise (EMBRAPA), (Garagorry *et al.*, 1982). This model was the main element of a computerized system for analysis of agroclimatic data, used to meet the needs of researchers of the Center for Agricultural Research in the Semi-Arid Tropics (CPATSA, located in Petrolina, State of Pernambuco). These needs were related to:

(1) The determination of the optimal planting period for annual crops in NEB.
(2) The production of risk estimations associated with the several crops.
(3) The preparation of maps of agroclimatic zones.
(4) The appraisal of potential in different projects for the use of excess water in the soil.
(5) The development of proposals for improved agricultural systems at the farm level.

The outcome of previous experiments aimed at attaining the above results had been unsatisfactory, owing to the unavailability of a sufficiently large sample of years to provide the basis for estimations of the risks involved in determining the optimal time of the year for planting. On the other hand, computerized experiments with the above-mentioned model had been carried out for some time with beans (*Phaseolos*); cowpeas (*Vigna Unguiculata*) – a type of short-cycle bean (60–70 days), very resistant to moisture stress; corn and soybeans. The results of these experiments were considered satisfactory by CPATSA scientists (Garagorry *et al.*, 1982; Garagorry and Porto, 1983).

Two important aspects must be taken into consideration with respect to the use of a simulation model of the water–soil–plant type, rather than dealing simply with climatic data. Firstly, the monthly average or annual precipitation data used in the more traditional studies are of little use for ascertaining what

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really occurs at the farm level, due to the extreme variability of precipitation in NEB. The simulation model, for instance, may be able to explain why a certain crop had a lower yield in one year than another in spite of the fact that the total amount of rainfall in the former was larger. Several examples researched with the use of the model show that these types of situations can occur quite frequently.

Secondly, the five main objectives listed above are interrelated in one way or another. Generally speaking, it is extremely difficult to devise a model that is adequate for a range of different objectives unless these objectives are closely interrelated. This section focuses on the study of agricultural systems at the farm level, particularly with respect to the selection of optimal planting periods and optimal water management. The simulation model has clearly shown that the best planting period may vary significantly from one place to another, even on farms located in the same state (Garagorry *et al.*, 1982). In other words, NEB comprises several semi-arid tropic types, so an agroclimatic zonation is mandatory before any appropriate recommendations can be made to farmers.

To date, all studies of climatic zoning based solely on precipitation data have given unsatisfactory results. These results are very different from the ones obtained by the use of interrelated data from climate, soil and plants. An agroclimatic zonation will be one of the model's outputs for each crop. Moreover, the model takes into account the excess or deficit of water in the soil, which provides an estimation of the risk associated with these variables, and from this a probability distribution is obtained for a yield index for each crop.

In this section we use the modeling approach described above to estimate the impacts caused by climatic variations on productivity in NEB. With this end in mind, six municipalities representative of the semi-arid tropic zone of NEB were selected for study, based upon historical meteorological and yield data for these locations.

Although the scenarios suggested in Section 2 of this case study were used as far as possible, it should be noted that:

(1) While the year 1983 has been characterized as a year of meteorological drought, it was not necessarily a year of extensive agricultural drought. Although drought was meteorologically extreme and affected the entire NEB, in some localities the distribution of rainfall allowed for the maintenance of significant agricultural activity. That, for example, was the case for Petrolina (where CPATSA is located), which is included in the present study.

(2) While some drought scenarios have been selected from the post-1979 period, much of the climatic and yield data that were suitable for the model were available only up to the year 1978.

Because of these constraints, and some specific characteristics of the model (to be discussed later), other similar scenarios were substituted, using criteria based on the analysis of empirical data related to the agricultural years, which do not always coincide with the calendar year.