PROPOSED AREAS OF RESEARCH IN THE FIELD OF AGROCLIMATOLOGY AS RELEVANT TO CPATSA/ EMBRAPA.

S.JEEVANANDA REDDY
Consultant (Agroclimatology)
CPATSA/EMBRAPA/IICA.
Petrolina - PE - 18.11.82.

BACKGROUND

Agroclimatology is an applied science that is concerned with the relationships between weather and agricultural production. Of the two sets of factors connected in the word agroclimatology, one set, the meteorological, in every bit is as variable as the other, the agronomic. The variables in the two fields are also similar in that they exist on all scales of space and time. i.e., micro, local, regional and global. Application of agroclimatology becomes more useful for understanding the dynamics of agricultural production as a function of weather and climate are better understood.

To achieve this objective, efforts will have to be made in the disciplines of agriculture as well as in that of meteorology. In the first case, one can analyse the actual agricultural process and identify limiting factors in the production cycle. In the second case, one can analyse the meteorological conditions of a region and calculate the potential productivity. A synthesis of these two systems should strive to define the agricultural system that realises this production potential as much as possible.

In the past the main emphasis was placed on agriculture and there by the progress to date in agroclimatology is little. Also, the past studies in the agroclimatology were mainly based on long term averages of monthly or annual values. In relation to short cycle of dryland crops month is too long a period. Hence, the attributes derived from average monthly, seasonal and annual rainfall are of little practical applicability in the agricultural production studies. They give only a broad outline but not the production level and the associated risks.

To understand the productivity and the associated risks, the studies must be based on at least weekly data sets (if not daily); and for at least 25 years to get meaningful statistics. Eventhough much of this data has been collected for a number of locations it has not been effectively utilized. There is one major limitation in the use of data sets. That is, considerable variation in number and daily timing of observations on one hand and on the other hand no uniform standard procedure was adopted in the processing of the data. Both in terms of method of recording and processing of data, they differ from

Internationally accepted procedure* as well as among themselves. Therefore, it is important, first, to bring all this data to one common standard from (i.e., International standard as stipulated by WMO), before it is used actually in the analysis.

Keeping these in view, the following five broad areas of research in the field of agroclimatology were identified:

1) Agrometeorological data collection;
2) Agroclimatological data collection;
3) Agroclimatic Classification studies;
4) Soil-Water balance modelling studies; and
5) Crop-Weather modelling studies.

While 1 & 2 deals with the standardization and computarization of both agrometeorological and agroclimatological data which are basic inputs for the other three studies. The 3rd deals with the classification of the semi-arid tropics into agronomically relevant homogeneous zones for the transfer of location-specific dryland technology. The 4th deals with the verification of soil water balance models as applicable to northeast Brazilian stuation and characterization of the homogeneous zones identified in the 3rd study. The 5th item presents the verification of crop-weather models as applicable to northeast Brazilian Crops and simulation for the identification of areas suitable for optimum production of different crops--crop specific models. Majority of these studies are computer based simulations.

In addition to these there are several other areas that need to be collaborated with agricultural scientists as and when required.

---

*The standard procedure of recording temperature and relative humidity are to keep the four thermometers (maximum, minimum, wet & dry bulb) in a single "Stevenson's Screen" and thermograph & hair hygrograph in a double Stevenson's Screen (here double means twice the width of single Stevenson's Screen). However, at CPATSA Center, these six instruments along with Piche evaporimeter (which should be kept in a separate screen) were housed in one big screen and inturn this screen is housed inside an another big screen. There by, the temperature and relative humidity do not represent the true air temperature and relative humidity. Few more such observations can be made with reference to non-recording raingauge, pyranometer etc.

1. PROJECT TITLE: Agrometeorological data collection (Agcl. 1)

2. EXECUTING INSTITUTE: CPATSA

3a. SUMMARY:

Standardization of agrometeorological data and provide this information to all the agricultural scientists. This will also help in the standardization of agroclimatological data. Suitable ways and means will be evolved to fill the data gaps.

3b. BACKGROUND:

Of the different environmental factors that affect plant growth and development, meteorological, ones which man has little control, are very important. Crop scientists require a record of day-to-day weather changes on the experimental area during the crop growing season for the proper interpretation of interactions of weather with different species of plants and insects, pests, and diseases. Records of daily weather observations are also essential i) in building up suitable crop yield weather models; ii) to monitor changes in the soil moisture & irrigation scheduling requirements etc. The weather observatory, therefore, is an integral part of any biological research station. Eventhough over the northeast Brazil there are a good number of meteorological observatories, only a very few are situated in the proximity of the biological research stations.

There is an extensive data set collected over years for northeast Brazil. However, they not only differ from international standards but among themselves (Reis, 1978) in terms of:

- number and daily timing of observations:
- instrumentation procedures; and
- data standardization procedures.

Since the validity of agroclimatological research will depend on the quality and standardization of information, it is suggested that prior to their use it is important to bring all this information to a common standard level. For this purpose the agrometeorological observatories serve the best, where simultaneous observations can be made under different systems and establish their relationships.

The most important parameters that need immediate attention are:

- precipitation;
- temperature (maximum & minimum);
- pan evaporation; and
- global solar radiation.

4. RESEARCH AREAS: Agrometeorological-Observatory.

5. OBJECTIVES:

   1. To establish agrometeorological observatories at different research centres over northeast Brazil.
   2. To investigate the relationships between meteorological obsevations recorded by a variety of instruments currently being used in northeast Brazil.
   3. To develop suitable standardization procedures for agrometeorological and agroclimatological data.
   4. To suggest suitable methods for data gap filling.
   5. To compile the agrometeorological data in an appropriate form.

6. METHODOLOGY:

   1. Visit different agrometeorological centres(in northeast Brazil) and agroclimatological data bank centers to assertain the basic differences of standardization procedures etc.
   2. Based on the above information simultaneous observations can be proposed under different standardization procedures at least at 5-6 agrometeorological observatories over different seasons. Also based on the requirement more agrometeorological observatories can be set up at research centers that are of interest to CPATSA.
   3. From this data set interrelationships among different standardization procedures can be established.
   4. Based on these relationships, first, the agrometeorological data of all the centres can be converted into one standard form.
   5. Also, the standardized information can be compiled into an appropriate form, by filling the data gaps with appropriate procedures (using computers).

References:

1. Reis, A.C.S. 1978. Climatological features of the semi-arid tropics: meteorological network and studies in northeast Brazil. Proc. Agrometeorological Research needs of the semi-arid tropics, ICRISAT Patancheru P.O., A.P., India, pp. 23-36.

8. SCIENTISTS:

9. LOCATIONS: CAPTSA Center

10. SIGNATURE:

1. PROJECT TITLE: Agroclimatological data collection (Agcl. 2)

2. EXECUTING INSTITUTE: CPATSA

3a. SUMMARY:

A data bank will be set up to provide the basic agroclimatological data, particularly precipitation, potential evapotranspiration or open pan evaporation, global solar radiation and temperature (both maximum and minimum) for the study of agroclimatic and Bio-agroclimatic classification of the semi-arid northeast Brazil into agronomically relevant homogeneous zones and for their characterization. Wherever measured data are not available particularly in the case of potential evapotranspiration, global solar radiation and temperature suitable methods will be developed to estimate these parameters for as many locations as there are precipitation data.

3b. BACKGROUND:

In the past majority of the agricultural scientists used to fall back on the simple meteorological elements like temperature and rainfall and often in terms of monthly totals and averages because these are readily available. Crops, of course, are react to actual weather sequences and not to mean values. Accordingly, progress in relating biological and meteorological events was slow. Bourke (1968) states that "the sad truth is that in these days it is normally easier to get financial sanction for complex and impressive instrumentation which are of little practical applicability and are of mainly academic interest than for the tedious and unspectacular drag of reducing and interpreting the data". Eventhough plenty of valuable data were collected over years with enormous efforts they are not properly utilized. With the advent of modern computers it is essential to bring all this information into standardized and easily accessable form. Once this goal is achieved it is easy for a scientist to implement his ideas in solving the important agricultural problems for which these data were and are being collected.

4. RESEARCH AREAS: Agroclimatology-data bank

5. OBJECTIVES:

1. To collect and standardize the daily or weekly precipitation records for as many locations as possible in the northeast Brazil, at least for a period of 25 - years for each location.

2. To develop suitable procedures and generate potential evapotranspiration or pan evaporation, global solar radiation and temperature for as many locations as the precipitation net work.

6. METHODOLOGY:

1. Visit appropriate centers and acquire the agroclimatic data of as many locations as possible on individual years basis, for the northeast Brazil.

2. Based on the procedures developed in Project 1, the agroclimatological data need to be standardized.

3. Using the open pan evaporation as the basis potential evapotranspiration or pan evaporation data for the entire northeast Brazil need to be derived.

4. Identification of suitable method and computation of global solar radiation for the entire northeast Brazil need to be carriedout.

5. Using the existing net works data (after standardization) by extrapolating through simple regression, temperature data need to be derived for the entire northeast Brazil.

References:

1. Bourke, P.M.A. 1968. Introduction: the aims of agrometeorology. In Proc. Reading symp. on agrometeorological methods, Natural Resources Res. Nº 7, UNESCO, pp. 11-16.

8. SCIENTISTS:

9. LOCATIONS: CPATSA Center.

10. SIGNATURE:

1. PROJECT TITLE: Agroclimatic classification studies (Agcl: 3)

2. EXECUTING INSTITUTE: CPATSA

3a. SUMMARY:

Using the modified Thornthwaites approach first the semi-arid tropics will be demarcated. Using some of the procedures developed by Reddy, the agroclimatic attributes will be derived using the data collected in Project 2 -- minor modifications will be made if needed to suit the northeast Brazilian situation. Using numerical classification procedures along with these attributes the northeast Brazil will be sub-divided into agronomically relevant homogenous zones. These results will be compared with similar situations in India, Australia and West Africa for understanding the feasibility of transfer of dryland technology.

3b. BACKGROUND:

The traditional crops, varieties and cropping systems often do not make full and efficient use of available soil and water resources. To improve this situation, new techniques for resource management which more effectively conserve and utilize the rainfall and the soil, and the new crop production systems which increase the productivity and minimize the instability are to be developed. By fitting certain agricultural operations to particular environments yields can be increased substantially.

The research results of any given station are relevant not only to the neighbouring areas, but to widely dispersed regions in the world having similar physical environment. This involves the establishment of guiding parameters for the transfer of location - specific technology to other regions with the least risk. Much of the environmental information is an integral part of the system where careful analysis can yield valuable information about important hazards and constraints (Nix, 1981). A logical step in this direction, is therefore, to understand the climates of different regions and to classify them into agronomically relevant homogenous zones.

Within the rather wide range of atmospheric conditions, an infinite variety of combinations can appear. It is, therefore, natural to attempt grouping of kindred climates to obtain a classification that will permit the establishment of regional boundaries between areas of uniform climatic conditions. To build up climatic categories is by no means an easy task. The best that can be achieved is a classification of climate for specific purposes rather than a climatic taxonomy comparable with that of plants. In each case, another set of limiting conditions will govern and hence the climatic classification of a place will change with the objective towards which the classification is directed, the solution of specific problems of productivity demands the formulation of specific criterion for each case (IRRI, 1974).

The thought of deliniating climatological regions originated almost simultaneosly with that of determining biological regions. The need for a holistic and systematic approach to problems of very complex systems such as crop production systems has long been recognised. But, until recently conceptual and computational tools needed were not developed (Nix, 1981). Nix (1968, 1979) has suggested three different, but not mutually exclusive, approaches to predict the success of the transfer of site - specific dryland technology (Swindale, 1979). Among these the analogue transfer approach is a better approach in the absence of systematic crop-weather data sets. In this approach areas analogous to the experimental site are identified by soil and or/ climatic classification. Although the analogue approach does not require any detailed understanding of functional relationships between selected site attributes and crop response, greater the understanding and more relevant the attributes, the better will be the classification.

4. RESEARCH AREAS: Agroclimatology-Classification

5. OBJECTIVES:

1. To demarcate the semi-arid tropics; and
2. To sub-divide the semi-arid tropics (SAT) into agronomically relevant homogeneous zones for the transfer of location - specific dryland agricultural technology.

6. METHODOLOGY:

1. After reviewing different climatic classification approaches Reddy, found modified Thornthwaite's approach as quite appropriate procedure for the demarcation of the SAT. Hence, using this approach along with the data of as close network as possible, the SAT boundary will be demarcated.
2. After reviewing different agroclimatic approaches, Reddy developed a method of computing agroclimatic attributes that define the climatic

limitations for the dryland agriculture. Using these derived attributes, following numerical classification procedures the SAT can be subdivided into agronomically relevant homogenous zones. These zones can also be compared with the similar zones in India, West-Africa and Australia to see the feasibility of transferring the proven dryland agricultural technology.

3. A survey need to be conducted to collect agricultural production data to interpret these zones.

References:

1. IRRI. 1974. An agroclimatic classification for evaluating cropping systems potentials in sutheast Asia rice growing regions. IRRI, Los Bonos, pp. 10.

2. Nix, H.A. 1968. The assessment of biological productivity. In land evaluation, (Ed.) G.A. Stewart, Melbourne: MacMillon, pp. 77-87.

3. Nix, H.A. 1979. Agroclimatic analogues in transfer of technology. In Proc. Intern. Symp. on development and transfer of technology for rainfed agriculture for the SAT farmer, ICRISAT Patancheru, P.O., A.P., India, pp. 83-88.

4. Nix, H.A. 1981. Simplified simulation models based on specified minimum data sets: the CROPEVAL Concept. In application of Remote Sensing for agricultural procuction forecasting, A. Berg, (Ed.), A.A. Balkema/ Rotterdam, pp. 151-169.

5. Swindale, L.D. 1979. Problems and Concepts of agrotechnology transfer within the tropics. In proc. on the development of transfer of technology for rainfed agriculture and the SAT farmer, ICRISAT Patancheru, P.O., A.P., India, pp. 73-82.

8. SCIENTISTS:

9. LOCATIONS: CPATSA Center

10. SIGNATURE:

1. PROJECT TITLE: Soil-Water balance modelling studies (Agcl. 4)

2. EXECUTING INSTITUTE: CPATSA

3a. SUMMARY:

Stage 1: Soil-water balance models will be verified using the data collected over a few locations under fallow, weeds and different crops/ cropping patterns.

Stage 2: Using appropriate soil-water balance models and weather records of longer period collected under project 2 computer simulations will be carriedout to assess the optimum time for land preparation, cultivation & sowing; identification of crops/cropping pattern; and feasibility study of an on farm tanks & supplemental irrigation strategies for increasing the procuctivity.

3a. BACKGROUND:

The major constraint for dryland agriculture in the semi-arid tropics is water. Due to the vagaries of climates, rainfall distribution is erratic and dry spells and droughts of varying duration are frequent. In addition, most of the precipitation occurs as high intensity storms, so that a high proportion may runoff or percolate beyond the roat zone. High evaporative demand and, in many areas, shallow soils with limited water holding capacities amplify the problems of dryland agriculture. The size and distribution of both water surplus and water deficit are of great importance in evaluating alternative water and land management systems for better crop production.

Water balance models provide a basis for evaluation of alternative water and land management systems through accounting of water surplus and deficits. Estimates of soil water balance are useful in several ways for solving agricultural problems. For example (i) in the development of agroclimatic models for establishing the length of crop growing season. This allows a more predictive approach to land management problems by adjusting crops to climates, and, at a given site, permits assessment of different fallow-crop strategies, optimum time of sowing etc., (ii) in the development of yield forecasting models which can help in the interpretation of the considerable variability of crop yields between seasons and regions; and (iii) the monitoring of supplemental irrigation requirements and runoff modelling. All of these aspects may be important for efficient management of agricultural production at a particular site.

Reddy (1982) reviewed the literature and has developed a simple model (ICSWAB) that has been found to work well over diverse climatic, soil and crop conditions. It computes evapotranspiration as a function of time using the easily measurable meteorological parameters such as rainfall and pan evaporation. The growth stage of a crop is represented by coefficients that are based on leaf area index (LAI) and percent light interception (LI). This permits the model to accout for the available water at different stages of crop growth. However, before actually adopting this model to the northeast Brazilian situation; it is essential to test and compute appropriate crop growth stage coefficients for the crops/cropping patterns of this region.

4. RESEARCH AREAS: Soil-Water balance-characterization.

5. OBJECTIVES:

1. To verify the soil-water balance models with reference to the northeast Brazil.

2. To characterize the semi-arid tropical climates of northeast Brazil:

   a) to identify optimum time for land preparation, cultivation and sowing;

   b) to identify suitable crops/cropping patterns; and

   c) to study the economic feasibility of on farm tanks.

6. METHODOLOGY:

1. Soil-Water balance measurements -

   depths - 0-10, 10-20, 20-30, 30-45, 45-60, 60-90, 90-120, 120-150, 150-180 cms

   crop conditions - fallow - daily upto 25 days

   weeds - daily upto 25 days

   crops/cropping patterns - weekly or at ten-day intervals from sowing to harvest

   seasons - Three to four

2. Crop measurements -

   leaf area index (LAI) } weekly or at ten-day intervals

   light interception (LI) } from germination to harvest dry matter and grain yields

3. Verification of the existing models with this information to use under fallow, weeds and different crop/cropping patterns.

4. Characterization of the northeast Brazil through computer simulations using the long period agroclimatic data collected in project 2.

References:

1. Reddy, S.J. 1982. A simple method of estimating the soil water balance. Agric. Meteorol., 27:

8. SCIENTISTS:

9. LOCATIONS: CPATSA Center,

10. SIGNATURE:

1. PROJECT TITLE: Crop-Weather modelling studies (Agcl. 5)

2. EXECUTING INSTITUTE: CPATSA

3a. SUMMARY:

Through collaboration with agronomists and physiologists or breeders at different centers in the northeast Brazil, basic agronomic data on growth and development of different crops will be collected; and will be utilized to verify or modify the existing crop-weather models. Using appropriate models through computer simulations using the long period agroclimatic data suitable for different crops will be identified. This is a multi-disciplinary collaborative study.

3b. BACKGROUND:

Crop-weather modelling attempts to develop, combine and utilize the physical laws that govern biological processes, and inherently they should be the most efficient methods for overcoming the high site factor constraints. Knowledge of how the weather at a particular site affects crop performance during different seasons is important for two main reasons first it helps plant breeders to choose cultivars suited for a given climate and second, it allows agronomists and crop physiologists to understand how weather parameters affect crop growth, development and yield so that they can suggest appropriate cropping patterns and related management practices. Despite intensive research on individual components and processes, our understanding of the whole crop production system is still quite limited (Nix, 1981).

Majority of the existing models are either region - specific or crop-specific/ and or season - specific. Hence, their applicability under diverse soil-climate-crop conditions is quite limited. For example, SORGF (A dynamic sorghum growth and development) model of Arkin et al. (1976) developed under sub-humid, extra-tropical conditions found to be not valid without major modifications under semi-arid conditions. This is found still more complicated by the divergent behaviour of different genotypes of the same crop to weather (Reddy et al., 1982). Therefore, unless mechanisms of crop-weather interaction is understood clearly, the empirical equations built on few experimental results may not yield good dividends. However, a great many partial models of important components and sub-systems have been developed.

The lack of adequate knowledge of crop-weather interactions, and the complexity of models immediately emphasize the need for interdisciplinary team-work, since knowledge and insight gained from biological, physical, social and economic disciplines are required.

The progress in this direction will help in the verification or modification of the existing partial models and to synthesize these partial models to a system that can be applied to northeast Brazilian situation to identify most suitable areas for different crops/cropping pantterns.

4. RESERACH AREAS: Bio-agroclimatology-classification.

5. OBJECTIVES:

1. To verify or modify the existing crop-weather models as applicable to crops of the northeast Brazil.
2. To assess the potentiality of different crops/cropping patterns in the semi-arid northeast Brazil using crop-weather model simulations.

6. METHODOLOGY:

1. Stage 1: It is valuable to convene a meeting of scientists from different disciplines and institutions to discuss the feasibility of multidisciplinary team-work.

2. Stage 2: Verification or modification of the crop-weather models - most of the crop-weather models comprises of three parts, namely:

   - phynological development vs temperature index;
   - yield (both dry matter & grain) vs global solar radiation index; and .
   - stess vs moisture index.

   All these information are needed under different crops/cropping patterns of importance to the northeast Brazil.

3. Once these models are finalized, simulation study can be carried out using the long period climatological data by developing appropriate computer programs.

References:

1. Arkin, G.F., Vanderlip, R.L. & Ritchie, J.T. 1976. A dynamic grain sorghum growth model. Trans. ASAE, 19:622-630.

2. Nix, H.A. 1981. Simplified simulation models based on specified minimum data sets: the CROPEVAL concept. In application of remote sensing for agricultural production forecasting, A. Berg, (Ed.), A.A. Balkema/Rotterdam, pp. 151-169.

3. Reddy, S.J., Maite, R.K. & Seetarama, N. 1982. An iterative regression approach to the phenology in the semi-arid tropics. Exp. Agric. (under comm.).

8. SCIENTISTS:

9. LOCATIONS: CPATSA Center,

10. SIGNATURE: