# SYMPOSIUM ON

# CROP WEATHER RELATIONSHIP WITH REFERENCE TO RAINFED AGRICULTURE

*Chairman* : Dr. D.G. Bhapkar,
Director of Research,
Mahatma Phule Agricultural University,
Rahuri.

*Convener* : Shri P.N. Bhargava,
Head, Division of Statistical Research
(Crop Sciences),
I.A.S.R.I., New Delhi-12.

At the outset, the Chairman emphasised the need for carrying out intensive studies on crop weather relationship particularly in the areas where the crops are grown under rainfed conditions and in the areas which are drought prone. He also informed the group that in the country the major part of the cultivation is done under unirrigated conditions and as such there is a need for development of suitable cropping systems in these areas which have minimum risk to the vagaries of weather. The extended summaries of 23 papers received for the symposium are as follows :

**Agroclimatic Study of Productivity of Groundnut in India and Importance of Evolving Realistic Water Balance Models for Drought Monitoring and Crop Planning of Rainfed Cropped Area.**

By

A. Krishnan[1],

An international comparison of productivity of groundnut indicates that in spite of India being the country having the largest area under groundnut in the world its productivity is rather low. Analyses of the distribution of groundnut production, in India and the trend and stability of the area under groundnut, the production and productivity in different parts of India have been presented. Regions where groundnut is being inefficiently and regions where productivity is high but the coverage is low have been delineated. The relationships between the crop productivity and

1. National Scientist, University of Agricultural Sciences, Bangalore.

duration of drought free periods and periods with little or moderate water stress within the crop growing season have been studied. An illustration of determining the optimum sowing dates for the groundnut crop by use of system analysis approach and carrying out of risk analysis under different system of sowing has also been presented for Kolar and Bijapur districts of Karnataka state.

For rainfed croping system, evolving of realistic water budgeting model for monitoring of soil moisture as well as occurrence of droughts during the growing season is extremely important. The same will also be usefull in crop planning as well as estimation of surplus water available for water harvesting in a region. Such an analysis for assessment of feasibility or double cropping system and estimation of water harvesting potential in respect of semi-arid region of Bangalore has been illustrated. Importance of evolving of general crop weather models for different crops has been stressed.

**Crop Weather Relationship with Reference to Rainfed Agriculture**

BY

R.P. SINGH[2]

Crop productivity is weather-dependent. In rainfed agriculture, more than the quantum of rainfall, it is the distribution of rainfall which govern the yield. Crop environment plays a very vital role in crop growth, development and productivity. 'Epigenstic' factors often superimpose themselves on the genetically prescribed reactions which the plants perform in a given environment. Micrometeorology is a much neglected science in India. There is a need to carry out in-depth studies on the micro-climates and their related influence on crop growth and productivity. Available soil moisture and micro-climate which in turn, is governed by crop geometry and population dynamics, prescribe the threshold values of productivity in rainfed agriculture. A multi-disciplinary approach involving the disciplines of Meteorology, Agronomy, Soil Science, plant Physiology and Agricultural Statistics, will go a long way in understanding the micro-climate and its influence on crop productivity. The inter-disciplinary approach will also help in crop planning and forecasting of epidemics of diseases and pests.

There is a need to work out the probability of occurrence of drought of varying durations and intensities at different growth

2. Project Director, All India Coordinated Research Project for Dryland Agriculture, Hyderabad-500 659.

stages of crop plants grown in different agro-climatic regions. The probability of getting adequate runoff for water harvesting, its storage and recycling has also to be worked out for different regions. Micro-climatic studies in soils and intercrop systems have to be pursued. Influence of wind breaks on crop performance in relation to micro-climate created on the lee-ward side has to be studied. The incidences of diseases and pests in relation to temperature and humidity obtainable in the crop canopy has to be studied. The effect of weather and climate on crop growth, development and productivity of rainfed crops supplied with variable inputs has to be taken up in a co-ordinated manner. Based on these studies, a scientific crop planning could be done. Strategies for mitigating aberrant weather situations, called 'strategic planning' could also be done.

## System Analysis Approach for Crop Planning in Rainfed Agriculture

BY

P.N. BHARGAVA[3] AND ASHA SAKSENA[4]

The vagaries of weather in the areas where the cultivation is done under rainfed conditions have been mainly responsible for the variation in yield/productivity of the crop. In such areas, the strategy for farming would involve avoiding of important farming operations during periods of crop season associated with high level of risk. System analysis approach would therefore be an extremely important tool for this type of problems. This would enable to identify the suitable crop season, optimum sowing time, periods of moisture deficiency and surplus and the crop suitable for the region. In the present paper, three approaches to crop planning based on the empirical studies on the pattern of occurrence of weather parameters during various stages of crop growth have been delineated. The first approach utilises the information on pattern of moist and humid days, second on the probability distribution of dry and wet spells and the third on the actual evapotranspiration models. To illustrate the use of first two system analysis approaches for crop planning, data from Jalgaon district for jowar crop has been utilised whereas for the third approach, data from Jamnagar in respect of groundnut, jowar and bajra has been utilised.

3. Head, Division of Crop Sciences, IASRI New Delhi-110 012.
4. Scientist (S-1), IASRI, New Delhi-110 012.

To study the influence of moist and humid days, the number of moist and humid days for each year were worked out separately and thereafter, a linear regresion between yield and moist/humid days was fitted. It was found that the regression coefficients in both the regressions were highly significant. The minimum number of moist/humid days required to obtain the normal yield as obtained through graphical method, were 24 and 34 respectively. The effect of cessasion of humid days on the jowar yield was also studied. It was found that if the humid period terminates before 15th of Septem, berthere are chances of reduction in the yield of the jowar crop. If the humid period extends beyond this date, there ars chances of increment in the yield. The chances of getting the acquired number of moist/humid days are high if, the sowing of the crop is completed by the end of June or latest by first week of July.

Under the second procedure, for each year, each day of the season was first classified as wet or dry according to the available amount of rainfall in relation to PET (a day is classified as wet if $R \geqslant PET/2 \geqslant 3$mm., otherwise it is dry). This sequence of wet and dry days can be reckoned as outcome of Bernoulli trials. Utilising this sequence, a two-stage Markov chain model we fitted to find the probability of occurrence of such spells for obtaining the expected length of wet and dry spells during different crop phases (sowing, germination and seedling, vegetative growth, flowering and grain formation). This information was built up corresponding to different alternative dates of sowing. This distribution of expected length of dry and wet spells over the crop season was super-imposed over that of the ideal situation required to choose the most suitable period of sowing. The results indicated that if the sowing is done in the last week of June or in the first week of July, the number of wet and dry days available during the different phases of the crop growth coincide favourably with the ideal length of wet and dry spells corresponding to different crop growth phases.

Under the third approach, the study was made on the basis of the data available on rainfall, actual evapotranspiration (*AE*) and potential evapo-transpiration (*PE*). The weekly (*AE*) and (*PE*) were calculated for all the years for the standard weeks ranging from 23rd to 46th week (4th June to 18th November). The average *AE* and *PE* for each of the week was worked out, the corresponding *MAI* (moisture availability index) for each week was also obtained. For each year the very first week when *AE* was greater than *PE*/2 was considered as the sowing week. On the basis of the sowing week, cropping season for an year was classified as early (system 1) when it occurred from 23rd to 26th standard week (4th June to 20th June) ; normal (system 2) if it occurred between 26th to 28th standard week (25th June to 15th July) and late (system 3) 29th standared week or later (26th July or later). For each of these systems, the relative *AE* and *PE*/2 were obtained for the period of 18 weeks starting from 24th, 26th and 29th weeks. These cumulative models were examined for the existence of three types of pericde namely, drought free period (*AE* is less than or equal to *PE*/2), moderate drought period (AE is less than *PE*/2 but greater than *PE*/4) and severe drought period (when *AE* is less than *PE*/4). Under the system 1, a crop season of 15 weeks is available with drought of moderate intensity for two weeks in the beginning and two weeks in the end. Very good condition of soil moisture would also be available towards the end of the season. Under the system 2, a crop season of 13 weeks is available. Under this system, there are two weeks of moderate drought in the beginning and two weeks of moderate drought in the end and also severe drought of two to three weeks towards the end of the season. After 15th week, there is a likelihood of steep depletion of soil moisture. Under the system 3, a crop season of 12 to 13 weeks is available after that a period of continuous drought of 8 to 9 weeks exists towards the end. Under this system, a crop of about 70 days can safely be grown. It is, therefore, inferred that under system 1, groundnut can safely be grown. The system 2 is also suitable for groundnut but it is ideally suited to bajra and jowar particularly in view of the chances of crust formation in the soil towards the end of the season which may give rise to harvesting problems for groundnut. Under the system 3, a pulse or a fodder crop is suggested.

## Models for Studying Effects of Weather on Crop Yield

BY

RANJANA AGRAWAL,[5] R.C. JAIN[6] AND M.P. JHA[7]

Models for studying crop-weather relationship have been discussed. The suggested models have been used to study the effects of weather on rice yield for Raipur district.

5. Scientist (S2)
6. Scientist (S1) } I.A.S.R.I., New Delhi-110 012
7. Scientist (S3)

The results of individual effects of weather variables on rice yield indicated that the crop reacts differently to climatic variables during different stages of its growth. Above average maximum daily temperature had small beneficial effect during active vegetative phase and detrimental on other phases of the crop. This indicates that prevailing maximum temperature at Raipur is sufficient for rice crop except in active vegetative phase. Above average relative humidity (7 hrs.) had small beneficial effects during initial growth, lag vegetative and reproductive phases while small adverse effects were observed during active vegetative and ripening phases. Increase in relative humidity (14 hrs.) and number of rainy days had beneficial effects in general throughout the crop season. Effects were pronounced in later part of the reproductive phase. Increase in rainfall was beneficial throughout the crop season suggesting that crop production can be increased by supplying additional water.

Studies on joint effects of maximum temperature and relative humidity (14 hrs.) revealed that beneficial effects of above average maximum temperature on yield increased with rise in humidity while detrimental effects decreased. The effects of relative humidity increased with the increase in temperature. Joint effects of maximum temperature and rainfall showed that beneficial effects of above average maximum temperature on yield increased with increase in rainfall while adverse effects decreased in general. The increase in railfall with sufficient temperature was beneficial for the crop except towards the end of initial growth and ripening phases.

## Influence of Water Availability on Yield of Some Oilseed and Pulse Crops in the Arid Region

By

B.V. Ramana Rao[8] and Y.S. Rama Krishna[9]

The influence of water availability during different weeks of the growing season on the yield of castor, sesame, greengram and cowpea during the years 1972 to 1979 was studied. Experimental yields of the crops grown under rainfed conditions at CAZRI, Jodhpur were utilised. The ratio of actual evapotranspiration to potential evapotranspiration (*AE*/*PE*) values were computed weekwise using Thornthwaite and Mather's water balance procedure. Graphs

8, 9: Central Arid Zone Research Institute, Jodhpur

were drawn to represent the values of *AE/PE* during different weeks of the growing season in the years with good, average and poor yield for the different crops considered.

In case of castor, the yield was found to be considerably influenced by the water used from flowering to maturity period with a correlation coefficient of 0.97 and the relationship between ($Y_c$) in *q/ha* and water used in mm ($X_c$) from flowering to maturity period is

$$Y_c = -0.5027 + 0.3458\, X_c + 0.000245 X_c^2$$

The yield of cowpea ($Y$) was found to depend upon the mean *AE/PE*($X$) with a correlation coefficient of 0.98 and the relationship between crop yield in *q/ha* and mean *AE/PE* is

$$Y = -0.9988 + 1207X + 12.03X^2$$

The study clearly reveals that it is possible to quantify the influence of water availability on the yield of rainfed crops in the arid regions. The results are very much useful to determine the critical periods during which supplementary irrigation to the crops will be beneficial and the extent to which the yield of rainfed crops can be improved through proper management of rain water.

## Drought and Rainfed Rice Yield Some on-Farm Experiment and Farmer Evidence from West Bengal : Kharif 1982

BY

SUDHIN K. MUKHOPADHYAY[10]

The paper examines the following hypotheses in the light of the drought conditions of West Bengal during the Kharif Rice Season 1982 : (*i*) in the face of an adverse weather, a technology appropriate for one land type and level may not be appropriate for a different land type, even in the same agro-climatic region ; (*ii*) a technology recommendable from the point of view of yield and output maximisation may not be viable from the farmers' economic point of view. Data have been taken from the Rice-Based Farming Systems Research for Aman Rice for the district of Nadia where agronomic experiments have been carried out with various management packages using variety, fertilizer and insecticide as variable inputs.

10. Professor of Economics, University of Kalyani, West Bengal

The experiments conducted upon up, medium and lowland plots suggest that medium land farms suffered most as a result of the drought. This is true both for advanced technologies applied on farmers' plots and for farmers' technologies. Although experimental technologies performed uniformly better than former technology, the superiority was most marked on the lowland plots.

However, the technological superiority of the High Input Technology is practically wiped out when existing cost and price considerations are brought in. For up and medium land plots farmer technology seems to be able to provide positive, though marginal, rates of profit, whereas experimental technology is not found to be viable. It is only for the lowland plots that the experimental technology stands out viable from the point of view of both yield and economy.

Thus, it appears that in the present arsenal of the agricultural scientists, there is available technology appropriate for meeting droughts of the kind that occurred in 1982. To make it viable, however, appropriate extension and economic policies are called for.

## Crop-Weather Relationship for Pre-Harvest Forecasting of Production of Crops

BY

M.S. BHATIA[11]

The policy makers and planners need estimates of crop production in advance of harvest for formulation and execution of various farm policies related to production, prices, procurement, distribution, export, import etc. The present system of forecasting production of standing crops has some element of subjectivity as it is based on the visual observations and impressions of the land revenue and agricultural officials. To eliminate this subjectivity, there is need to develop an objective method of estimation of preharvest crop production based on scientific footing.

One of the important method of making preharvest forecaste is that based on crop-weather relationship. Weather includes factors like rainfall, temperature, humidity, evapotranspiration ratio etc. but

11. Directorate of Economics and Statistics, Ministry of Agriculture, Krishi Bhavan, New Delhi.

of these, rainfall is the most important factor affecting crop production in India as about three-fourths of the cropped area in the country is still rainfed. Technological development in the country are regarded as an expression of the desire to influence the various natural factors including weather and rainfall, as irrigational development to a large extent may mitigate the adverse impact of deficient or scanty rainfall. It is because of this relationship between weather and technological factors, the present study has considered both these factors simultaneously.

The present study, which is aimed to establish crop weather relationship for making short term forecasting, has been made for paddy in 13 major growing states in the country. The study is based on time series data for the period 1970-71 to 1981-82. The factors considered were area and yield per hectare of paddy as dependents and production weighted rainfall indices at the end of the months of June, July, August, September and October, percentage of irrigated area total area under paddy, distribution of rainfall as reflected by the number of weeks with normal or excess of the normal rainfall during South West Monsoon Season and time trend representing changes in technology as independents.

The forecasting equations based on crop weather relationship gave a very good fit as coefficients of multiple determinations of forecasting equations for area relationship were as high as 0.9588, 0.9556, 0.9292 and 0.9027 for Punjab, Orissa, Madhya Pradesh and Bihar respectively which indicate that 90 to 95 per cent variations in area under paddy were explained by the weather and other technological variables included in the forecasting equations. In case of Andhra Pradesh, Assam, Kerala, Maharashtra, and Uttar Pradesh ever 80 per cent of the variations in area under paddy were explained by the rainfall and technological factors. In case of yield forecasting equations 91 to 95 per cent of the variations in the yield per hectare was explained by the explainatory factors in the states of Kerala, Andhra Pradesh, Punjab and Maharashtra. In other states 50 to 80 per cent of the variations in the yield of rice have been explained by the factors included in the crop-weather relationship models.

Rainfall in June has shown positive and significant regression coefficients in area forecasting equations for the states of Assam, Bihar and West Bengal. June rainfall do not have any significant impact on area under paddy in the state of Andhra Pradesh Haryana, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Punjab, Tamil

Nadu and Uttar Pradesh. Rainfall index in the month of July has significant influence on area under paddy in the states of Bihar, Orissa and Tamil Nadu. Rainfall has not shown any significant influence on area under paddy in the states of Karnataka, Haryana and Punjab as these states have a very high proportion of area under irrigation. Time trend which represents changes in technology over time has shown positive and significant effect on area in the states of Assam, Bihar, Haryana, Madhya Pradesh, Maharashtra, Punjab and Uttar Pradesh.

If is further seen that rainfall in June has significant and positive impact on yield of paddy in the states of Andhra Pradesh, Karnataka, Madhya Pradesh and Orissa. This was because rains in June helps in timely raising of nursary and transplantation of paddy which in turn had positive effect on yield of crop. High rains in the month of August have shown generally negative impact on yield of paddy. Total rainfall in the South-West Monsoon period as reflected by the rainfall index at the end of September has shown positive and significant influence on yield in the states of Assam, Haryana, Orissa, Punjab and Tamil Nadu. Coefficients were also positive in the states of Kerala, Madhya Pradesh and Maharashtra. October rains have positive and significant coefficients in yield weather relationship equations in the states of Assam, Bihar, Kerala, Orissa and West Bengal.

Study also revealed that distribution of rainfall in the season has positive and significant impact on yield in the States of Andhra Pradesh, Madhya Pradesh, Maharashtra, Orissa and Uttar Pradesh. Technology has shown positive and significant coefficients for yield in the states of Andhra Pradesh, Haryana, Kerala, Maharashtra, Orissa, Punjab and West Bengal.

Based on the crop weather relationships developed on past time series data and taking weather and technology situation for the current year into consideration, forecasts for area, yield and production of paddy for 1982-83 for different states were made. According to these forecasts, while area under paddy may show only marginal decline of about one per cent, yield of paddy is expected to decline about 5 to 6 per cent in 1982-83 over 1981-82. The decline in yield in 1982-83 is expected to be more marked in the states of Andhra Pradesh, Karnataka, Madhya Pradesh, Maharashtra, Orissa, Tamil Nadu, Uttar Pradesh and West Bengal, which was mainly because of deficient or scanty rains in the months of September and October.

It is concluded that crop weather relationship models with production weighted rainfall index numbers alongwith irrigation and technology can be used for making preharvest forecasts of production with a reasonable degree of accuracy.

**Evaluation of different statistical models for pre-harvesting of groundnut Yield**

By

P.R. VAISHNAV[12] AND R.M. PATEL[13]

A small project was taken up to evaluate four different statistical models for pre-harvest forecasting of groundnut (*Arachis hypogaea,* Linn) yield in Kharif during the years 1980-81 and 1981-82 in Junagadh district of Saurashtra region, Gujarat State. The different yield contributing biometrical characters were recorded on the randomly selected plants during their life period. Moisture content in the soil at 0-15 cm and 15-30 cm depth of soil was also recorded at different stages of crop growth.

Correlations of yield with the number of branches and the number of immature pods were non significant in both the years, whereas the number of plants at harvest, the number of mature pods and the total number of pods per plant were significantly correlated with the final yield. The effect of moisture content in the soil at 0-15 cm depth at the time of pegging and pod development stages was significant.

The multiple regression technique was employed for the suggested four different statistical models. The models were as follows :

*Model-I* : $Y=\beta_0+\beta_1X_1+\beta_2X_2+\ldots\beta_kX_k+\varepsilon$

*Model-II* : $\text{Log } Y=\beta_0+\beta_1\text{Log}X_1+\beta_2\text{Log}X_2+\ldots+\beta_k\text{Log}X_k+\varepsilon$

*Model-III* : $\sqrt{Y}=\beta_0+\beta_1\sqrt{X_1}+\beta_2\sqrt{X_2}+\ldots+\beta_k\sqrt{X_k}+\varepsilon$

*Model-IV* : $\beta_0+\beta_1X_1^{-1}+\beta_2X_2^{-1}+\ldots\beta_kX_k^{-1}+\varepsilon$

The equations were fitted by considering the plant population and the number of mature pods per plant at 30 days and 15 days prior to actual harvesting of the crop. The testing of the partial

12,13 : Gujarat Agricultural University, Anand Campus, Gujarat, 388 110

regression coefficients of yield on the two variables for all the four models for 30 days prior to actual harvest revealed that partial regression coefficients of both the variables were significant in case of first three models, however in case of fourth model, only one of the two partial regression coefficients was significant. The te.t of significance of the multiple correlation coefficients suggested that all the coefficients were more or less at par. Similar trend was observed in case of data recorded at 15 days prior to actual harvest. The maximum variation accounted for was 35 per cent for Model—II.

In the second attempt, moisture per cent at a depth of 0-15 cm at 91 days after sowing (pod development stage) was included in the equations and data were reanalysed. The maximum variation accounted for model—I was 48 per cent and 44 per cent, in case of 30 days and 15 days prior to actual harvest of the crop respectively. However, the test of significance of the multiple correlation coefficients suggested that all the models were at par.

The equations for 30 days and 15 days prior to harvest of the crop are :

(*i*) $\hat{Y} = -314.702 + 8.348X_1 + 34.837X_2 + 18.664X_3$ and

(*ii*) $\hat{Y} = -312.243 + 10.117X_1 + 18.233X_2 + 16.865X_3$
respectively.

where, $\hat{Y} =$ Predicted yield of crop

$X_1 =$ Plant population per unit area.

$X_2 =$ Number of mature pods per plant

$X_3 =$ Moisture content in the soil at the depth of 0-15 cm after 91 days of sowing of the crop.

Thus Model—I which could be computed easily and which had accounted for the maximum amount of variation could be adopted for forecasting purpose, with the above mentioned variables, 30 days prior to harvest of the crop. However, such a model will have perhaps less utility on account of the comparatively lower amount of accounted variation ($R^2 = 0.48$). Such a model may be tested for smaller zones rather than a large region or a state to examine if there is any improvement in prediction.

## Crop-Weather Relationship with Reference To Rainfed Agriculture—A Brief Review of Work Done in Agricultural Meteorology Division, Pune

By

S J. Maske[14] and P.S. Nayar[15]

The success of Indian Agriculture depends mainly on monsoon rains. The farmer anxiously looks forward to timely commencement and proper distribution of rainfall during the season. However, commencement of rain may be much earlier or considerably delayed than the normal dates over all parts of India. The rain may terminate considerably earlier or persist longer than usual. Rainfall may unevenly distributed in space and time being excessive in one part of the country and in deficit in another or excessive during the part of the season and in deficit during another part. Because the vagaries of south-west monsoon, scientific approach to study rain, water availability for use is dryland agriculture is all the more a necessity. As such information on onset, withdrawl and variability of monsoon rain, water availability periods and probability of assured weekly rainfall for different parts of the country, was discussed in the paper.

A network of 36 Evapotranspiration stations located in different parts of the country has been found useful in estimating crop water requirements during different crop growth phases and it has helped to identify the periods of peak consumption. Agricultural Meteorology Division has undertaken collaborative studies with Agricultural Universities and Agricultural Research Institutes on pests and diseases like Paddy Stemborer, Jowar Shootfly, Cotton Bollworm, Pyrilla of sugarcane, Wheat Rusts and Downy Mildew of Bajra.

## Crop Yield Models Based on Weather Parameters

By

G.S. Sarwade[16]

In this paper, work done in India Meteorological Department on predicting rice and wheat yield in India from weather parameters and technology has been reviewed. Some salient features of the results have been summarised.

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14,15 : Indian Meteorological Department, Pune.

16, : Meteorological Office, Pune-5.

It was observed that the coefficient of variation in the yield ranged from 10 to 35% in case of kharif rice whereas in case of wheat it ranged from 10 to 60%. The percentage variations accounted by the models were between 75% to 96% for both rice and wheat. Technology was found to be largely responsible for the yield increase in recent years in wheat whereas for rice it is felt that technology has still much scope.

As regards to crop weather relationship, it was concluded that for kharif rice, dry spells of more than 8 days in July and August drastically diminish the yield. Temperature and other weather factors were not found to exert significant influence. In contrast, in case of wheat low minimum temperature during December to February was found helpful in increasing the yield. Also rainfall prior to the sowing period of the wheat crop which provides necessary soil moisture at the emergence and initial growth was found to exert profound influence.

The performance of the models have been discussed in the paper. Various suggestions have been offered to improve the models and increase its efficiency in yield forecasting.

**Intercropping : An Approach for Maximizing Production in Rainfed Agriculture**

BY

S.H. SHINDE[17], B.B. PATIL[18] AND S.V. MAHAJAN[19],

In Maharashtra nearly 88 per cent area is under rainfed cropping where rainfall is marginal with erractic distribution of rains. In such situation, it is essential to utilize the available rainfall to maximize the yeild. Intercropping provides insurance against risk and gives stable returns even under aberrent weather conditions. This is the reason why small farmers show preference for intercropping over sole crops. The intercropping can achieve greater stability by compensation of one competent crop when the other fails or grows poorly because of drought. Jodha (1979) has reported different advantages of intercropping system and one of them is "mixture involving drought resistant and drought sensitive crops; which reduces the risk of failure, of either of the crops".

17,18,19 : Mahatma Phule Agricultural Uni., Rahuri, Maharashtra-413 722.

Success of the intercropping system depends on selection of appropriate component crops such that they should be mutually cooperative in respect to their growth rhythms, canopy development rooting depths. Considering the growth rhythms, the best example of component crops is pearl millet and pegeon pea. Pearl millet complets the life cycle by 85 to 90 days which is the period of slow growth for pigeon pea. After the harvest of pearl millet, pigeon pea gets full scope for its growth upto harvest. Thus there is minimum competition period for component crops resulting in substantial increase in their yields.

In the intercropping system the soil environment is exploited by two different species having different root zones. A combination of cereals and pulses is, therefore, found to be beneficial. Inclusion of pulses in the intercropping system provides an additional benefit of nitrogen fixation. Some crop species are known to do better in diffused light and there fore inclusion of such crops in intercropping system is more advantageous e.g. spreading type of groundnut which requires low light intensity is found to be good intercrop.

Analysis of data collected for intercropping system faces some difficulties due to varying nature of marketable products and their market rates have large fluctuations with time and location. So stress may be given to evolve appropriate statistical procedure for analysis intercropping data.

## Simulation of Sorghum Yield Using Environmental Factors.

BY

A.K.S. HUDA[20], S.M. VIRMANI[21] AND J.G. SAKARAN[22]

To assess the contribution of environmental factors to sorghum growth and development, collaborative sorghum modeling experiments were conducted during 1979-1981 at 10 locations (11-31° N latitude). Data on crop growth, soil water at critical growth stages and daily climatic variables were collected. Regression models that included one or more of the independent variables namely soil water at planting (SW), rainfall, mean temperature, solar radiation, evapotranspiration (ET) for the whole growing season and for three

20. Agroclimatologist } Farming Systems Research Program
21. Program Leader } ICRISAT, Patancheru, A.P.—502 324
22. Computer Programmer }

growth stages were developed from 48 data sets. The three growth stages included emergence to panicle initiation (GSI), panicle initiation to anthesis (GS2) and anthesis to maturity (GS3). Stepwise regression technique was also utilized to develop models.

Results showed no single environmental factor explained sufficient variability in yield. Rainfall, mean temperature and their product for three growth stages together explained 67% yield variation. SW, rainfall, rainfall x ET in GS2 and GS3, rainfall x solar radiation in GS2 and the mean temperature x solar radiation in GS2 explained 76% yield variation. These two models when tested with 11 independent data sets explained only 50% yield variation.

The need for physiologically based climate and soil driven crop simulation models as research tool was demonstrated using sorghum simulation model (SORGF). This model simulates daily sorghum growth and development. Simulated grain yield using SORGF model was compared with actual yield data (correlation coefficient =0.87). Results on error analysis were disussed.

**Bajra Yield in Relation to Rainfall Distribution in Kutch (Gujarat).**

BY

J.H. PATHAK[23] AND R.M. PATEL[24]

Fisher (1924) opined to consider the distribution of rainfall to study its influence on crop. Alsberg and Griffing (1928) suggested much shorter than a month for this purpose. Accordingly efforts have been made to study the effect of weekly rainfall (consider ing standard meteorological weeks) during the growth period (23rd week to 38th week) of bajra in Kutch district of Gujarat State. On the basis of correlation between the weekly rainfall and the bajra yield certain variables (rainfall of 28th, 30th, 31st, 34th, 36th, 37th and 38th) were omitted from the analysis and the multiple regression equation was fitted to the data. Omitting the results of the abnormal year (1974-75) it was observed that the variables under study explained 49.75% of the total variation in crop yield. Inclusion of results of the abnormal year reduced it to 24.32% only.

23. Dy. Dircetor, Directorate of Agriculture Gujarat State, Ahemdabad.

24. Prof. of Agril. Stat., B.A. College of Agriculture, Gujarat Agri. University, Anand Campus, Anand.

**Role of Water use Efficiency in Crop Weather Analysis—A Case Study for Rice.**

BY

A.S.R.A.S. SASTRI[25] AND J.S. URKURKAR,[26]

In tropical countries like India water is the limiting factor for crop growth and development. For examining the relative crop performance for deciding suitable cropping patterns or crop rotations, a knowledge of water use efficieney gives a clear picture of the crop performance. The crop performance can better be judged with an analysis of the water use efficiency of not only grain yield but also the total biomass production in view of the economic importance of fodder production. The main objective of the study is to stress the role of water use efficiency in crop weather analysis as the water use efficiency analysis integrates more or less the weather based influence on crop growth and developed.

As a case study the water use efficiency of rice crop (Var-Asha) under 10 different dates of transplanting was studied with a 10 days interval under 10 different dates of transplanting starting with 1st June. The grain yield data as such indicated that the optimal period of transplanting is from 11th to 31st July whereas the water use efficiency pattern further filtered the spectrum as 11th to 21st July only.

This study thus determines the optimal dates of transplanting the rice crop. For continuing the same analysis for rainfed crop one has to consider the actual evapotranspiration rather than potential evapotranspiration. The actual evapotranspiration can either be measured by lysimeteres or can be estimated through any water budgeting technique. This type of analysis helps in comparing the relative performance of rainfed crops for examining the cropping pattern and crop rotation in any given erea.

**Crop Weather Relationship—A Study of Rainfed Agriculture in Marathwada.**

BY

P.R. WAGHMARE[27] AND S.R. KSHIRSAGAR[28]

Agrarian economy of the region is pre-dominantly a weather

25, 26 : Zonal Agricultural Research Station, (Rice Zone) Jawaharlal Nehru Krishi Vishwa Vidyalaya, Raipur, (M.P.)

27, 28 : Marathwada Agril. University, Parbhani, Maharashrta State.

controlled one. Ninety per cent of the gross cropped area of Marathwada region is rainfed. Hence, rainfall plays important role in agriculture. However, it is very difficult to obtain the relationship between yield and rainfall on aggregate basis. In the present paper to obtain the correlations between aggregate yield of region and rainfall, (the rainfall is pooled from all the centres), a suitable rainfall index is prepared to obtain the relationship. The relationship between the yield index and rainfall index is studied for the crops kharif jowar, rabi jowar, wheat, mung, groudnut, bajra and cotton crops.

**A Study on Effect of Rainfall on Bajri Yields in a Few Selected Tahsils From Scarcity Zone of Maharashtra State.**

BY

T.A. GHARPURE[29] AND E.D. BOROLE[30]

Considering the close association of rainfall and its distribution in scarcity zone, and its ultimate effect on the yield of the crop, an attempt has been made to find out suitable prediction equation to predict yield rate of a tahsil, on the basis of rainfall and its distribution.

Three tahsils *viz.* Sirur (Pune), Parner (Ahmednagar) and Karmala (Solapur) were selected for the study.

The tahsilwise average yield rates of unirrigated bajri and rainfall from 1964-65 to 1981-82 was utilised for the study.

Fourteen combination of number of rainy days and rainfall during each of the periods of (1) June (2) July (3) August (4) June + July (5) June + July + August (6) September (7) June to September were considered as independent variates. Selection of suitable variates was carried out in accordance with step down methods, as laid down by Suedecor and Cochren,

The prediction equations obtained for different tahsils are given below :

1) Sirur

$$y = -52.70 + 14.99^{**}\, x_3 + 0.52^{**}\, x_{10} \qquad (R^2 = 0.8032)$$

29, 30 : Department of Agriculture, Maharashtra state, Pune-1

(2) Parner

$$y = -43.78 + 0.87\, x_6 + 0.47\, x_{10} \qquad (R^2 = 0.3844)$$

(3) Karmala

$$y = 118.73 - 18.78\, x_1 + 2.09^{**}\, x_2 - 23.76^{*}\, x_5 + 0.93\, x_6 \qquad (R^2 = 0.7002)$$

where :

$y$ = Average yield rate of unirrigated bajri for the tahsil.

$x_1$ = Number of rainy days in June.

$x_2$ = Rainfall in June.

$x_3$ = Number of rainy days in July.

$x_5$ = Number of rainy days in August.

$x_6$ = Rainfall in August.

$x_{10}$ = Rainfall from 1st June to 31st August.

It is possible to predict-tahsil level yield rate on the basis of rainfall data available up to August end.

## Instability in Agricultural Productivity and Rainfall in Growth Context—A Case Study of Karnataka

BY

M.V. NADKARNI[31] AND R.S. DESHPANDE[32]

It is contended here that instability in agricultural productivity is not a purely climatic phenomenon and that rainfall plays but a limited role in explaining fluctuations in productivity over time. It is when we view instability in terms of an inter-district and inter-crop picture in a growth context that we begin to have more insights.

As distinct from the usual 'green revolution' model, Karnataka followed a strategy of extending the growth push to areas with unstable rainfall and to rainfed crops, incurring in the process the risk of increased instability. It succeeded because farmers in these regions took the necessary risks. It is argued that a state of affairs where benefits of such risk taking are cornered by one sector while the costs are borne by risk takers alone, cannot sustain agricultural growth in the long run.

31,32 : Institute for Social and Economic Change, Bangalore—560 072,

Another factor that could have increased overall instability in food-grains productivity is the changing crop composition. Crops whose yields were strongly and positively correlated became more prominent in the process of growth. This needs further attention.

### Study on Probability Distribution of Rainfall at Parbhani

BY

U.G. DESHMUKH,[33] B.S. KULKARNI[34] AND G. RAMAKRISHNA RAO[35]

An attempt has been made to fit normal distribution to daily rainfall data of 30 years recorded at Parbhani (Maharashtra) by using gamma transformation. The quantile estimates for each penteds were obtained. It is suggested from the analysis [that estimates corresponding to quantiles lying within 55 to 70 per cent can be considered to be reliable for forecasting. This information is very much useful for planning agricultural operations.

### Influence of Amount and Distribution of Rainfall on the Yield of Castor in Chalka Soils of Telengana

U.M. BHASKARA RAO[36] AND C.H. RAO[37]

Castor is an important crop of Telengana region of Andhra Pradesh. Only 67 per cent of variation can be explained by relating total rainfall during the crop growth period. The entire growing season is divided into five periods broadly coinciding with different physiological stages of crop. It was observed that about 90 per cent of the variation in yield is explained by the rainfall during the period 91-120 days. By considering the rainfalld uring the three periods, *viz.* 31-60, 61-90 and 91-120 days, 98 per cent yield variation is explainable. The regression equation using these three periods is most meaningful in view of the fact that the regression plane passes through origin. The rainfall during the period 1-30 days 121-150 days are not influencing the yield as the moisture requirements in those periods are less, Moreover the rainfall during earlier periods is much stable. The regression coefficient for 91-120 days ($P_4$) is about four times the regression coefficient for the period 31-60 days ($P_2$) and about five time the regression coefficient for 61-90 days ($P_3$) indicating the importance of ($P_4$). Similar trends were observed by using number of rainy days as the independent variable.

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33,34,35 : Marathwada Agricultural University, Parbhani—431 402.

36,37 : All India Coordinated Research Project for Dryland Agriculture, Hyderabad—500 659.

**Rainfall deficiency and recurrence time-drought prediction for Jhansi**

BY

D.P. HANDA[38] AND C.R. HAZRA[39]

The study indicates the weekly and monthly probability of deficient rains and recurrence time in Jhansi. The weekly drought has more relevance to crop growth. Rainfall breaks during mid June and cantinues upto mid September. About 93 per cent yearly rainfall occurs during monsoon season of which June accounts for 11% July 33% August 32% and September 17%. The rainy months (June to September) vary with respect to drought. September accounts for 54.6 per cent probability of such an occurence and July being the least with 26.5 per cent. Similarly, the probability of occurence of drought in first two weeks of June and last two weeks of September are more (58-73 per cent), indicating a proper crop planning in dryland condition to overcome these situations. The possibility of having drought in July and August is about once in every seven years whereas the chance for June and September being the drought once in every three years.

Sowing could not possibly be effected before mid June in dryland condition and also the major field crops particularly those which are sensitive to drought should synchromize their flowering and grain filling period till the moisture lasts. Late maturing crops beyond September should be avoided in light soils with low moisture holding capacity. Similarly, the double cropping and winter cropping is difficult in these areas because of the cessasion of rains by mid September. Only in heavy soils, some crops with low moisture requirements viz. safflower and mustard could be taken up provided the first crop is over by end of August preferably fodder crops.

The possibility of occurence of drought once in seven years in the months of July and August and once in three years chance for June and September. This calls for diversification of crops with respect to maturity, so that the risk from drought occurence of such a frequent nature once in three years in the month of September could be minimised particularly with short duration early maturing crops. Similarly, the sowing of crops will be possibly be delayed if the June being the drought once in every three years.

38 : Scientist, S—1 (Statistics), Division of Biometrics and Rural Economics, IGFRI, Jhansi.

39 : Scientist, S—2 (Soil Science), Division of Soil Science, IGFRI, Jhansi.

## Crop Weather Relationship With Reference to Rainfed Cultivation of Groundnut in Saurashtra Region of Gujarat State*

BY

T.J. KHATRI[40] AND R.M. PATEL[41]

The Saurashtra region of Gujarat is famous for its groundnut cultivation. Among various States in India, Gujarat and particularly Saurashtra region occupies the first position for groundnut cultivation both in respect of area as well as production. The crop is mostly grown as rainfed in a short duration of 100 to 120 days monsoon season. Attempts have been made to analyse crop weather data of 21 to 24 years for the five district of Saurashtra region. The yield production models have been worked out by selecting, rainfall variables through step-wise regression analysis. The selected variables proved very useful in recognizing the critical stages of crop growth and their relationship with yield. These critical stages will serve as guide lines in scheduling irrigation treatments for summer and Rabi cultivation of groundnut crop.

## Growth and Fluctuations in Crop output of Rainfed Crops in Anantapur District of Andhra Pradesh

BY

P. SATYA SEKHAR[42]

An attempt has been made to asses the growth performance in Area, Production and yield of rainfed crops—Jowar, Bajra and Ragi—in the Anantpur district of Andhra Pradesh. Trends in area, production and yield are analyzed with the help of piece-wise regression relationship. For the purpose of analysis, the study period 1956-80 is devided into three sub-periods, viz (*a*) Pre HYV period (1956-57 to 1965-66) (*b*) HYV period (1966-67 to 1975-76) and (*c*) Post HYV period (1976-77 to 1979-80). The piece-wise relationship also explaining the season specific effects of rainfall on crop area, production and yield.

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40. Associate Professor of Agricultural Statistics, N.M. College of Agriculture, Gujarat Agricultural University, Navsari, Gujarat, Pin-396 450.

41. Professor and Head, Department of Agricultural Statistics, Gujarat Agricultural University, Anand Campus, Anand, Gujarat, Pin-388 110.

42. Centre for Economic and Social Studies, Hyderabad-500 004

The growth rates of area, production and yield vary substantially across crops as well as over time periods. It can be observed that the yield rates have been constantly high for all the three crops. For Jowar and Bajra the growth in area has declined in all the three periods. However, for Ragi, a positive growth rate in the HYV period has been observed and in the post-HYV-period, growth rate in area and yield has declined due to shifts to other crops. The results have clearly indicated that in 50 per cent of the years of the sample period rainfall had favourable effects and in the remaining years unfavourable effects on crop area expansion, production and yield.