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RICE YIELD MODELLING: A CASE STUDY OF NORTH KONKAN REGION OF MAHARASHTRA

Dr. Chandrashekhar M. Nikam, Associate Professor, M. S. G. College, Malegaon-Camp, District: Nashik

Abstract

Maharashtra has 3.6% of the total rice area and 3% production of the country. The average yield is 1559 kg/ha, which is below the national average of 1921 kg/ha. Wide disparities in rice area and yield are also noted in three main rice-growing regions within the state viz., the Coastal, Upland and Inland areas. This paper charts to growth trends of rice grown during the kharif season by fitting a semi-log trend equation to the area and yield series of 86 talukas for the period 1967-68 to 1993-94. Regression coefficients were tested for significance by 'T" statistics. The analysis revealed that I) the growth of rice at the macro State level is mainly yield-led due to the development and spread of high yielding rice production technology. II) High rates of vertical growth of rice production in the Coastal region are seen in areas with low crop concentration III) Deep black soils of river valleys in the Upland and Inland rice regions showed both area-led as well as yield-led growth trends for areas receiving high annual rainfall (1800 mm) and low annual rainfall (1500 mm) respectively.

Keywords: Regression coefficients, productivity, yield modelling.

Introduction

Climate-agriculture relationship fall into two sets of nested models: climate impact models and climate interaction models. They both assume a direct cause and effect relation between a climatic event and a response within the system under study (such as decrease/increase of yield). Such an approach commonly used regression models to infer statistics relations between climatic variability and potential changes in crop production. There are other environmental factors like soil, pest attack u managerial factors like tillage, weeding, seed variety, irrigation, zation and pest control which also determine the yield of a crop. This paper deals with the regression models for evaluation of climate impact and technology (managerial) impact on rice yield.

Methodology

Numerical interpretation of weather data has many uses in operational and scientific agriculture like landuse planning, management strategy and forecasting crop development, maturity, yield and production. In fact, for any agricultural enterprise wherein weather is thought to influence the final results, a numerical model will provide a more rational an objective interpretation of weather influence than mere subjective guesses and considerations. WMO (1983) has presented three types of models:

- Empirical - statistical models
- Physico - statistical models crop
- Dynamic models tors Inciede

Crop weather modelling involves the consideration of two processes in the life cycle of the crop a) influence of weather on crop growth i.e. accumulation of photosynthates and b) influence of weather on crop development is, the progress of crop through various phonological stages during its life cycle from seeding or primordial initiation to maturity (Robertson, 1982). Most models particularly those of the dynamic type consider these two processes simultaneously by calculating net photosynthesis during various development stages (Malet, 1980). Dynamic models are required for continuous crop condition surveillance systems.

Empirical-regression models using simple weather data are required for many problems in landuse and crop zonation planning and climatic impact evaluation. This kind of analysis tries to scan the strength and pattern of relations between meteorological variables, which are expected on a prior grounds to affect yield, is valuable especially when there is not well-formulated hypothesis on the precise nature of the relationship. Fisher (1924) and Abhay (1949) have done the pioneering work in the field of developing empirical-statistical relationships for calculating yields and made wide use of multiple regression analysis for this purpose. A linear regression of yield on the values of selected meteorological variables during selected 'sensitive periods is the simplest method. Procedure involves screening the relation between specific period weather variable and yield, and choosing those that gave statistically significant correlation coefficients. The linear multiple regression are developed as

Y = a + bx, + cX, + dX...

Where Y is the rice yield in kg ha, b, c, d are regression coefficients and X, X, X, are independent variables for most sensitive crop growth periods. These factors include meteorological conditions averaged over phonological stages or calendar periods; certain crop conditions such as height, density, leaf area and so forth; information on soil characteristics and in some models information on management such as application of fertilizers and disease control. Crop management and soil conditions do not readily lend themselves to quantitative evaluation and, therefore, cannot always be included as discrete factors in the model. Thus the relationships are frequently localized. It is axiomatic that regression models should not be extended outside the data set and location for which they were developed. A special problem with multiple regression techniques is the possible high correlation among the independent variables (multicolinearity), which can result in misleading variable selection with statistical methods. Before estimating any regression, simple correlation coefficients between the explanatory variables are computed to check for multicollinearity, if any, among these variables. Linear relationships among the variables finally included in the model are worked out. If the T statistics of correlation between them proves insignificant then only those variables are accepted as predictors.

In the present study, at first all the weather elements according to growth stages of rice crop are linearly correlated with the yield. Those stages that give high correlation for the particular weather element called 'sensitive period' are selected for the further analysis. Yield is assumed to be lonely related to the weather elements. The linear correlation among the selected variables were critically scrutinized to ensure that the effect of weather elements on paddy yield in each period is independent of the effect of weather elements in another time period. Different weather elements for different periods are subjected to stepwise multiple regression analysis with yield as dependent and weather element as independent variables. With a view to have prediction sufficiently in advance of the harvest, selection of the highly correlated stagewise weather variables for modelling is restricted up to the flowering stage of rice crop, Numerous combinations and permutations of variables are tried through backward and forward ranking of the variables. That combination which gave high multiple correlation coefficient and which computed yield figures close to most of the reported ones is selected as the final equation for evaluation of climate impact on rice yield.

Results and Discussion

Coastal Region: Dahanu

Table 1:- Parameters of climate impact model

Station	a	RF-II	RHn-III	SSH-I	F	MCC	R^2 (%)
Dahanu	-1227.4	1.994	29.336	68.841	8.79**	0.75	55.7
'T' Values		(2.77*)	(-1.82)	(-1.72)			

Significant at 95%

Significant at 99%

Analysis has brought out very strong positive contribution of rainfall of the II stage (vegetative), sunshine duration of the I stage (establishment) and afternoon relative humidity of the III stage (flowering). It is important to note that all the three predictors have significant correlation with rice yield. The ANOVA statistics of the regression analysis ('F' value) is significant at 99% level.

Observed and calculated yields derived from the model departure (%) of calculated yield from the observed one and technology trend are illustrated in the Figure 5.1-A. Negative departure indicates the overestimation while, the positive departure shows underestimation of rice yield by the model. The predicted yields appear to follow the actual yields closely denoted by the deviation within 20% for most of the years. However, during the years 1972 and 1986 the departure is large exceeding 40%. Rainfall received during the crop season of these years is only 57% and 49% respectively. The rainfall of stage II (predictor in the model) in 1972 and 1986 were just 23% and 50% of the normal for the stage. The crop season, as a whole, of 1986 experienced deficit of the order of 60%. As a consequence of deficit rainfall, the other meteorological conditions also become anomalous, which the model could not explain.

Thus the regression model provides reasonably accurate forecast when the predictors are within a certain range from their normal and the variables that are not included in the model are also normal. If the model is to be used for operational gold forecast, the probability of the occurrence of aberrations in concerned weather elements have to be considered. Information on persistence and sequence of occurrence of extremely dry and wet years need to be wed and accordingly forecast yield be modified for operational use. With this equation, the model has explained 55.7% variation in the rice field; which shows that 56% yield events can be accurately predicted by the climate variables like rain, relative humidity and sunshine well in advance by the end of the flowering stage to the last week of July Regression models though have limitations in prediction of yield, they do help to understand the climate impact on yield formulation and indicate the scope of its manipulations development and production. For the prediction of unexplained yield events other factors like technology (HYV seeds-fertilizers-pesticides and irrigation), soil management, agronomic practices (tillage, weeding field geometry, and plant population) and incidence of pest and diseases should be taken into consideration. The above analysis reveals that contribution of such technology and management factors to rice productivity at Dahanu is fairly high (469). to suit it for sustainable crop Against this backdrop, perusal of technology parameter becomes important. Linear correlation coefficient between technology variable and rice yield at Dahanu is 0.49, which is significant at 95% level. Regression coefficient is also significant (T-2.89, DF-26). Trendline is indicating an upward rise in yield through time (Fig. 5.1.A) With this observation we included technology variable in the carrier prediction model however, the improvement obtained in the explained variance of yield series by inclusion of technology is marginal less than 1%. The partial regression coefficient in a combination model for technology variable is not statistically significant. The only significant variable in the model is rainfall of stage IN This points out that the high linear bivariate correlation between technology and yield is not truthful site is a spurious or pseudo correlation. Soil properties and soil and crop management, which are often less prioritized aspects by the farmers, play significant role in controlling rice yield. Since these aspects lie outside the scope of this study, we cannot further improve the prediction procedure.

Coastal Region: Karjat

The components of regression model developed for prediction of commonly grown early rice varieties in Karjat Taluka are indicated in the Table 2.

Table 2: Parameters of climate impact model.

Station	A	RF-II	RHn-III	SSH-I	F	MCC	R^2 (%)
Karjat	-1227.4	1.994	29.336	68.841	8.79**	0.75	55.7
'T' Values		(2.77*)	(-1.82)	(-1.72)			

Significant at 95%

Minimum temperature, sunshine duration and afternoon relative humidity during the establishment stage, rainfall during vegetative stage and morning humidity during flowering stage are reported to be the major weather elements in formation of rice yield at Karjat. None of the regression coefficients in the model is significant. However, the ANOVA derived test statistics - 'F value is significant at 95% level, so model is fairly acceptable. Yields-actual and calculated obtained from the model appear to follow each other closely, which is also noted by less deviation (+ 20%) between them in most of the cases, except for the years 1972 and 1986 when departure is 40%. In the year 1972 crop season rainfall was less by 33% of the normal, which resulted into water stress (>60%) in the vegetative and reproductive crop stages; on the other hand, in the year 1986 the initial two stages i.n. establishment and vegetative growth received about 25% more rainfall than the normal, whereas the grain formation stage experienced 80% deficit. Variability in the yield of rice explained by the model is only 51.6%. ate impact on rice productivity at Karjat is thus only 50%, which acts that other production factors are of equal concern. The unexplained variance needs to be accounted for by considering other environmental and management variables. Linear correlation coefficient between technology variable and rice yield is 0.63. Regression equation fitted to technology trend explains 39.3% variation in rice yield; the regression coefficient is also significant at 99% level (T=4.10.

DF=-26). It is therefore, important to examine the prediction model including technology element along with the weather variables. A slight improvement of 4% is noted in the explained variance by technology. Weather driven model over the weather driven model.

Conclusion

This paper evaluates contribution of weather to modelling the rice yield which in turn indicated the scope for improving productivity of rice through climate modification. Examination of technology trend in the yield series highlighted the sensitivity of a region for adoption of modern methods of rice cultivation. This was conducted by application of weather and technology variables in the prediction of rice yields using the stepwise multiple regression analysis. Influence of weather on the rice yield is more pronounced in the North Konkan. The most dominating weather variables are rainfall in the vegetative stage, afternoon humidity and sunshine duration in the establishment and flowering stages. It is important to note that the impact of technology in rice agriculture is increasing from north to south in the Coastal rice growing region as indicated by the increasing explained variance from 25 to 60%. The weather-technology combination model could predict 5 to 6 yield events out of 10 correctly.

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