Bangladesh J. Agric. Econs. XVI, 1 (June 1993) : 37-47

Research Note

RICE YIELD FORECASTING IN RANGPUR DISTRICT AN EARLY WARNING

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ABSTRACT

This study is an endeavor to determine the relationship of some of the selected climatic variables and a non-climatic variable with Aman rice yield estimation. The study is also intended to forecast the yield of the Aman crop and to determine the difference between the forecast and actual yield estimation by varieties at different stages of the crop of Rangpur district in Bangladesh. On the basis of forecast estimate pertinent authority could take appropriate actions such that the sufferings of the rural people are minimized. Data were collected from district meteorological offices and district fertilizer sales office of Rangpur district. Data were collected from 1968 to 1988 in the weekly form Forecasting equations were formulated where predictor variables showed significant effect at different stages (i.e. vegetative reproductive, grain filling and maturation stages) for Aman rice crop on weekly basis. Simple and multiple linear regression analysis were used for analytical purposes. F-test, T-test and test of lack of fit were used to test the validity of the models. Statistical analysis which showed retrodictive results (20 years average) very close to actual estimate of Rangpur district were IIYV Aman at Vegetative and at reproductive stages whereas for LV Aman at Vegetative, reproductive, grain filling and maturation stage. Recommendations were made for inclusion of more non weather variables and to use the models for other districts for forecasting.

1. INTRODUCTION

Forecasting of foodgrain production estimate, provides reliable, comprehensive and timely information on the food situation and similar assessments of the prospects that may contribute to the formulation, adjustment and implementation of government policies. Forecasting Or Early Warning on foodgrains is interpreted not only in the narrow sense of giving advance notice of emergencies, but it also refers to regular monitoring and reporting on the food situation, whether exceptional conditions are expected or not, particularly on foodgrains production, prices and outlook.

Prediction of this sort which involves explaining events that will occur at some future time is called forecast and the process of arriving at such explanation is called forecasting (Freund 1981).

It must he realized that mathematical treatment of data does not in itself solve all problems. Common sense, experience, ingenuity and good judgment of 7n investigator are necessary for good forecasting. Farmers, agriculturists, and government officials desire good short and long-range weather forecasts, and warning of expected climatic Changes far in advance (Steyaert 1981).

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There is a need to forecast the estimation of total food requirement of the country as a planning and budgetary device, namely, the effective demand for and supply of foodgrain. This refers to what a household is able to buy, as distinct from what, in an objective sense, its basic needs. The demand for food is important for various reasons: it is the long term aim of government policy to reduce poverty and create a situation in which all families generate the income necessary to purchase, at least, their food requirements.

Factors influencing the growth of rice yield, and knowledge about the different growth phases of the rice plant, are helpful in developing yield forecasting models using climatic and non-climatic variables. Particular emphasis in this study was given to the impact of climatic variables and a non- climatic variable i.e. fertilizer.

Statement of the problem:

Government is sometimes unable to get the exact situation of the standing crops on the fields, which compounds the food problem of the country. Government estimates the production target of all the food grain crops at the beginning of the fiscal year and than budget its import. Standing crops which received poor rainfall, less sunshine hours during flowering stage and such other factors may yield poor harvest which Government may not know ahead of time in the absence of an adequate forecasting technique.

Objectives of the study:

1. To forecast the yield of Aman crop by varieties using climatic and a non-climatic variable at different stages of the crop production;
2. To determine the relationship between the forecast yield and the actual yield of Aman crop at different stages;
3. To determine the feasibility of formulating models to relate yield variations by climatic and non-climatic variables during the growing seasons and
4. To provide information to higher authorities for policy formulation regarding the standing crops of the district for taking appropriate actions so that foodgrain is available to all people at all times.

Significance of the study:

Rice crops could not be harvested as expected due to abundant rainfall, drought, less sunshine hours during flowering stages, flood, cyclone and such other natural hazards. Consequently, a decrease in rice yield occurs. These brings mass famine throughout the country, the innocent victims of which are the rural poor. As such, a forecasting model is necessary as an effective tool to determine the food situation of the country ahead of time and for the government to act accordingly so that the suffering of the rural poor are reduced.

Finding of this study will serve as a basis for making decisions by higher authorities in the procurement of foodgrains internally whenever harvest is good. Also, it will allow them to maintain a stable price by distribution of foodgrain from its store or import from other countries if prospect of poor harvest is likely to occur.

Scope and limitation of the study:

The study was carried out in one purposively selected district of Bangladesh, namely Rangpur. Rangpur is the largest agricultural district of the country situated in the northwest. Furthermore, the study was limited to some climatic factors and a non-climatic factor (fertilizer) as the independent variables. Yield at the different stages of the crop was considered a; the dependent variable. Aman was the only crop under this study. Methodology is discussed in the following section. Results of the study are presented in section III. Some recommendations are made in the last section.

II. METHODOLOGY OF THE STUDY

The conceptual framework of this study was based on Augus's "Forecasting Rice yields in the Murrumbridge and Murray valley: A feasibility Study". The Study was designed to assess the feasibility of using a simulation model to relate the yield variation to weather during the growing season. The present study was designed to forecast the yield estimate of Aman rice crop by varieties. The stages of the crops were classified as vegetative, reproductive, Drain filling and maturation stages.

Climatic parameters that affect crop yield and ultimately production are rainfall, daylengtlt, optimal evapotranspiration, diurnal range of temperature, cloudiness ratio, moisture deficit, deviation from optimum temperature, interaction of net solar radiation and hours of bright sunshine. Non-climatic factors like fertilizer, irrigation, seeds, price of foodgrains, etc. also affect yields. Demographic and economic factors may also contribute to yield. The climatic and non-climatic variables which were considered in this study are shown in Figure 1.

In Bangladesh, less then 20 percent of the crop areas are under irrigation. Consequently, it can be inferred that yield of crops depends mostly on weather variables. Normally the life cycle of rice crop varies from 90 to 180 days. For this study varieties of 120-130 days were considered. Data for this study were collected from Rangpur District on IIYV Aman Local Varieties. Secondary data were collected from Bangladesh Meteorological Department (BMD), Bantyladesh Bureau of Statistics (BBS) and Ministry of Agriculture for the period 1968 to 1988.

Equations were formulated on weekly basis. January 1 to 7 was taken as week number one while December 25-31 was considered as the 52nd week of a year. Aman is mainly transplanted between July and August i.e. between week number 27 and 35 of a year. Week number 27 is the first week of July. In this study data for the vegetative stage was taken at the 33rd week which indicated that transplant was done four weeks earlier. Similarly, for reproductive, -rain filling and maturation stages, data were taken for the 36th, 39th and 42nd weeks respectively.

Independent Variables	Dependent Variable
<u>Climatic Factors</u>	
Maximum Temperature (X_1)	
Minimum Temperature (X_2)	
precipitation/Rainfall (X_3)	
Hours of Bright Sunshine (X_4)	
Average Temperature (X_5)	
Diurnal Temperature (X_6)	
Cumulative Precipitation (X_7)	
Net Solar Radiation (X_8)	
Equilibrium Evapotranspiration (X_9)	YIELD
Moisture Deficit (X_{10})	
Interaction of NSOL and DVOPT (X_{11})	
Deviation From Optimum Temperature (X_{12})	
Soil Moisture (X_{13})	
Non-Climatic Factor	
Fertilizer (X_{14})	

Figure 1. Conceptual paradigm showing the relationship between the Independent Variables and Dependent Variable.

III. RESULTS:

Forecast of HYV Aman yield Estimates

Vegetative Stage

The effect of independent Variables on yield of HYV Aman during the vegetative stage of production was estimated by a simple linear regression. The result of the statistical analysis indicated X_{11} to the most significant predictor variable for the week under the study(t-Statistic =-2.433. p=<.01). It means that there exists a negative relationship between the interaction of net solar radiation and deviation from optimum temperature. Youshida (1978) stated that solar radiation during the vegetative stage has an extremely small overall effect on grain yield. The-co-efficient of determination was 0.73 indicating that about 73% of the variance on yield was contributed by the single factor. Remaining all the variables had contributory effects on yield estimation.

To test the adequacy of the model, test of lack of fit was done. The lack of fit was not significant (0.211) which means the data were fit for the model. The following equation was applied to get the yield estimate of HYV Aman during the vegetative stage.

Y_{33}= 29. 9875 - 0. 1965 *X_{11}.

Y_{33}= Yield prediction of HYV Aman during the 33rd week

Y_{11}= Interaction of net solar radiation and deviation from optimum temperature.

F=statistic was equal to 5. 96 which was highly significant at. 01 level of significance.

The model was tested by backcasting the yield for the last 20 years. This implies that by using the above model, estimate for past years i.e. from 1968 to 1988 was done and compared with the BBS estimate as shown in Table 1. The average actual yield by BBS of HYV Aman for the last twenty years was 2.432 tons/ha while the average forecast yield estimated during the same period was 4% less than that of actual estimate (Table 1).

Reproductive Stage

During the reproductive stage of the crop, the variable which appeared to be significant is deviation from optimum temperature (X_{12}). It was determined by using simple regression analysis. The regression co-efficient (-0.4564) of X_{12} had significant relation (t-Statistic=-2.292, p=<.01) to yield estimation. The co-efficient of determination was 0.5804 which indicated that 58% of the variances on yield was contributed by X_{12}.

Yoshida (1976) stated that during the reproductive stage, the number of Spikelet per plant decreases as growth advances from vegetative to reproductive stage during temperature range of 22^0 C to 31^0 - C. This conforms with the present study. During this period and onwards temperature starts decreasing. Positive indication of the co-efficient indicates higher temperature at the latter stages.

Test of lack of fit of the model was not significant (2.10) indicating fitness of the data in the model. Regression equation which was fitted to get the yield estimate for HYV Aman of the district during the reproductive stage is shown below:

Y_{33} = 30. 1936 - 0. 4564* X_{12}

Where Y_{33} = yield estimation of the Aman crop during the 36th X_{12} = deviation from optimum temperature.

The model for the week was tested by estimating yield of Aman HYV for the last 20 years. Actual average yield estimate during the reproductive stage 2.432 tons/ha. Average forecast yield estimate during the reproductive stage was accurate by more than 90% than the estimate by BBS. (Table 1).

During the grain filling and maturation stages no variable was found to have significant effect on yield estimation but all the variables and contributory effect.

Table : 1 BBS Estimate and Forecast Yield Estimate of HYV Aman of Rangpur district during 1969 to 1988.

(tons/ha)

YEAR	BBS	WEEK NO.33 (Vegetative Stage)	WEEK NO 36 (Reproductive Stage)
1969	4.155	2.566	1.900
1970	2.999	1.537	2.053
1971	2.985	3.658	2.324
1972	1.870	2.470	2.165
1973	2.670	0.267	2.324
1974	2.370	2.759	2.549
1975	2.466	2.380	2.591
1976	2.291	2.765	2.779
1977	2.470	2.378	2.200
1978	2.268	1.833	2.433
1979	2.305	2.552	2.324
1980	2.321	2.219	1.878
1981	2.321	1.415	2.491
1982	2.198	1.732	2.276
1983	2.258	2.404	2.484
1984	2.333	2.006	2.284
1985	2.158	2.020	2.209
1986	2.131	2.490	1.696
1987	2.085	1.079	0.705
1988	1.994	2.762	2.743
Average	2.432	2.213	2.237

BBS-Bangladesh Bureau of Statistics

INFLUENCE OF PREDICTOR VARIABLES AT DIFFERENT STAGES OF AMAN LOCAL VARIETIES FOR YIELD ESTIMATION

Vegetative stage

During the vegetative stage of the Aman LV, the significant predictor variables for yield estimation were interaction of net solar radiation and deviation from optimum temperature (X_{11}) and fertilizer (X_{14}).

The regression co-efficient of X_{11} (-0.1232) and X_{14} (0.0062) had significant relation (t-statistic = 2.748. p=<.05) and (t-Statistic = 2.741. p=<.01) respectively to yield estimation. Co-efficient of determination is equal to 0.42 which indicates that 42% of the variance on yield was contributed by the two predictor variables. It may be mentioned that fertilizer was also found as the most important predictor variable in the Aman LV equation at the vegetative stage. This indicates that application of fertilizer at the vegetative stage could increase the productivity of the crop.

Test of lack of fit was not significant (1.2 and 1.11) indicating that the data fits the model. The regression equation fitted to estimate the yield is shown below:

$Y_{33} = 11324 - 1232*X_{11} + 0.0062*X_{14}$

Where Y_{33} = yield estimation of the Aman LV during the 33rd week

X_{11} = Interaction of net solar radiation and deviation from optimum temperature.

X_{14} = Fertilizer

The model was tested by backcasting the yield estimation of the last 20 years by the above equation. The average of the forecast yield estimate was accurate by more than 95%. (Table 2).

Reproductive Stage

Regression analysis was done to select the significant predictor variable required to forecast yield estimation of Aman LV in Rangpur district during the reproductive stage. Interaction of net solar radiation and deviation from optimum temperature appeared to be the most significant predictor variables for forecasting yield estimation. Its regression co-efficient (-0 .1631) showed a negative but highly significant relation. (t-statistic = – 2.401, p<.05) to yield estimation.

This means that a decrease of X_{11} by one unit can effect an increase in yield by 0.1631 ton/ha. During reproductive stage spikelet number per plant increases as the temperature drops. Thus, the optimum temperature appears to shift from high to low as plant growth advances from the vegetative to the reproductive stage (De Datta 1981). Grain yield is mostly affected by solar radiation at the reproductive stage Yoshiad 1980). To forecast yield estimate, a regression equation was made and is shown below:

$Y_{36} + 17.44 - 0.1631*X_{11}$

Where Y_{36} = yield forecast of Aman during the 36th week

X_{11} = Interaction of NSOL and DVOPT

The above model was tested by yield estimation for the last 20 years. The average forecast yield estimate for the last 20 years was one percent less than the actual estimate by BBS, which was 1.262 tons/ha. Backcast for the last 20 years can be seen at Table 2.

Grain Filling Stage

Week 39 is the grain filling stage. Regression analysis was done to remove the variables which do no significantly influence forecast yield estimate. Fertilizer offtake during the week appeared to be the most significant predictor variable in yield prediction, while the remaining variables had contributor effect.

The regression co-efficient (0.0056) had significant relation (t-statistic= 2.145, $p < .05$) to yield estimation. The co-efficient of determination was 0.87. This revealed that 87 percent of variance of yield estimate of the crop was contributed by fertilizer.

Lack of fit of the model was not significant (1.93) which means that the data fit the model. Regression equation for Aman local variety in Rangpur district during the grain filling stage is shown below:

$Y_{39} = 7.4985 + .0056 * X_{14}$

Where Y_{39} = yield forecast of Aman during the 39th week

X_{14} = Fertilizer.

The model was tested by estimating yield for the last 20 years. The model gave a deviation of six percent less than the actual average estimate. The actual average estimate was 1.262 tons/ha (Table 2)

Maturation Stage

A simple regression was used to forecast productivity of Aman LV during the maturation stage. The regression analysis indicated X_4 as the only predictor variable. The correlation co-efficient (-1.77) showed highly significant relationship (t-statistic = 2.515, $p<.05$) with the yield estimate. This means that a decrease of X_4 by one hour per week increases yield by 1. 773 tons/ha. correlated with yield in his study. Stensel (1957) suggested that the rice plant's most critical period of solar energy requirement is from panicle initiation until about 10 days before maturity.

The co-efficient of determination (R^2) is equal to 0.64 implying that 64 percent of the variance of yield was contributed by X_4. During the maturation stage higher X_4 reduced grain yield considerably because of a decrease in the percentage of filled spikelets. The test of lack of fit was not significant (1.99) making the data fit in the model.

The equation used for Aman LV in Rangpur district during the grain filling stage is shown below:

$Y_{42} = 27.03 - 1.7756 * X_4$

Where Y_{42} = yield estimation of Aman during the 42nd week

X_4 = hours of bright sunshine.

The model was tested by estimating yield for the last 20 years. The model gave a deviation of 6 percent less then the actual estimate. Average 20 years estimate of BBS was 1.262 tons/ha.

Retrodictive result of the equations are shown in Table 2. Prediction during the reproductive stage was very near to estimate given by BBS.

Table 2. BBS Estimate and Forecast Yield Estimate of LV Aman of Rangpur district during 1969 to 1988.

(tons/ha)

YEAR	BBS	WEEK NO.33 (Vegetative Stage)	WEEK NO.36 (Vegetative Stage)	WEEK NO.39 (Grain filling Stage)	WEEK NO.42 (Mauration Stage)
1969	1.409	0.819	1.055	0.933	1.067
1970	1.338	1.452	1.231	0.911	1.084
1971	1.135	1.347	1.126	0.760	1.084
1972	1.201	1.144	1.427	0.855	0.871
1973	1.230	1.509	1.514	0.868	1.215
1974	1.203	1.296	1.552	0.973	1.215
1975	1.250	1.512	1.606	0.982	1.804
1976	1.316	1.295	1.315	1.181	0.937
1977	1.383	0.988	1.432	1.183	1.477
1978	1.378	1.392	1.279	1.042	0.871
1979	1.409	1.205	0.971	1.324	1.886
1980	1.283	0.753	1.449	1.272	0.839
1981	1.410	0.931	1.272	1.385	0.986
1982	1.456	1.310	1.496	1.478	0.888
1983	1.530	1.085	1.484	1.681	1.199
1984	1.551	1.093	1.124	1.618	1.477
1985	1.418	1.358	1.077	1.633	1.690
1986	1.406	0.368	0.284	1.475	1.575
1987	1.521	1.511	1.580	1.577	1.624
Average	1.262	1.199	1.249	1.186	1.185

BBS-Bangladesh Bureau of Statistics

IV. RECOMMENDATIONS

Based on the findings it is recommended that government should use the models which gave accurate prediction of productivity by more than ninety percent of the above mentioned crop. This would enable the authority to have sufficient time in its planning and distribution system. In the surplus area the pertinent authority could procure foodgrains in order to maintain the price stability and plan its distribution pattern during the pre-harvest period in areas where low productivity was anticipated.

As mentioned earlier government receives the final estimate of any crop production, from BBS two or three months after the crop is harvested. The marginal and poor farmers of the country normally do have a reserve of foodgrains for one or two months after the crop is harvested. For them a delay of a few weeks in receiving foodgrains through different channels of Public Foodgrain Distribution System (PFDS) would enable them to starve. The relevant suthority should also give emphasis on the distribution of fertilizer at the vegetative stage of Aman LV and change the transplanting dates based on prepared plantings. The above mentioned equations may be used for other districts also.

The research experience suggests the following areas for further research: inclusion of more non-climatic variables, study of other crops and close monitoring of crops conditions and formulation of equations for all the weeks from transplanting to harvesting.

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