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EFFECT OF WEATHER VARIABLES ON RICE CROP IN EASTERN UTTAR PRADESH, INDIA

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Abstract

Rice is the major crop of Uttar Pradesh, which covers about 36.5 per cent area of total gross-cropped area in Uttar Pradesh. The present study mainly deals with the effect on weather variables. The study has been undertaken for rice crop in the district of Faizabad, Uttar Pradesh, India. The present study is formulated to determine the individual and joint effect of weather variables on rice yield. On the basis of R^2, we found that individually sun shine (hr) is more important with 67.57 followed by wind velocity and rainfall with 48.63 and 46.74, respectively. The joint effect of weather variables is also playing an important role in case of rice crop. According to R^2 more important combination is rainfall & wind velocity with 82% followed by rainfall & sunshine hr and wind velocity & sun shine hr 63% and 53.8, respectively.

Key words : Weather variables, step wise regression, rice crop, R^2, wind velocity, crop yield.

Introduction

Weather is one of the most important factors influencing crop growth. It may influence production directly through affecting the growth structural characteristics of crop such as plant population, number of tillers leaf area etc. and indirectly through its effect on incidence of pests and diseases. The effect of weather parameters at different stages of growth of crop may help in understanding their response in term of final yield and also provide a forecast of crop yields in advance before the harvest. The extent of weather influence on crop yields depends not only on magnitude of weather parameters, but also on their frequency distribution. Therefore, the knowledge of the frequency distribution of weather parameter is also essential while developing the pre-harvest model.

Several studies have been carried out in past both in India and abroad on the crop weather relationship. This approach is based on the understanding that weather parameters have been recorded for a number of years and data on rice yield are available for the same period.

A lot of work has been done by IASRI, New Delhi in this direction in different locations of the country. The discriminant function has also been used to forecast pre-harvest yield of rice by Agrawal (2002) using weather variables. Environment plays an important role in crop production. The eastern U.P. has different environment and ecology as compared to other parts of the state and country. The study has been undertaken for rice crop in the district of Faizabad, Uttar Pradesh, India.

Materials and Methods

The study has been conducted for Faizabad district of Eastern Uttar Pradesh, which is situated between 26^0 47' N latitude and 82^0 12' E longitudes. It lies in the Eastern Plain Zone (EPZ) of Uttar Pradesh. It has an annual rainfall of about 1002 mm and is liberally sourced by the Sarju (Ghaghra) river and its tributaries. Soils are deep alluvial, medium to medium heavy textured, but are easily ploughable. The favorable climate, soil and the availability of ample irrigation facilities make growing of rice and wheat a natural choice for the area. Rice crop is generally cultivated during the *Kharif* season because during this period, it provides a better environment for the cultivation of the rice crop.

Time series data on yield for rice crop, fertilizer consumption (NPK in kg/ha) and per cent irrigated area under rice of Faizabad district of Uttar Pradesh for 21 years (1989-90 – 2009-10) have been collected from Directorate of Agricultural Statistics and Crop Insurance, Govt. of Uttar Pradesh.

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Weekly weather data (1989-90 – 2009-10) on the weather variables of Faizabad district of Uttar Pradesh during the different growth phases of rice crop have been obtained from the Department of Agro meteorology, N.D. University of Agriculture & Technology, Kumarganj, Faizabad (U.P.), India. The data have been collected up to the first 19 weeks of the crop cultivation, which includes 23rd standard meteorological week (SMW) to 42th SMW. The data on three weather variables *viz*. rainfall, wind-velocity and sunshine hours have been used in the study.

In Faizabad district, rice is generally sown from the second week of June, when average daily temperature falls around 41^{0}C. Sowing of rice when temperature is lower results in poor germination, reduced tillering and early onset of flowering and thereby exposing the floral parts to the hot damage. All these factors depress the crop yield. The different crop growth phases are discussed below.

Fisher (1924) suggested another approach to this problem. He assumed that the effect of change in weather variable in successive weeks would not be an abrupt or erratic change, but an orderly one that follows some mathematical law. He assumed that these effects are composed of the term of the term of a polynomial function of time. Further, the value of weather variables in w^{th} week, X_w was also expressed in term of orthogonal function of time substituting these in usual regression equation

$$Y = A_0 + A_1X_1 + A_2X_2 + ... + A_nX_n$$

Utilizing the properties of orthogonal and normalized functions.

Hendricks and School (1943) have modified Fisher's technique. They divided the crop season into 'n' weekly number should be sufficiently flexible to mathematically express the relationship, it can be expressed as

$$A_w = a_0 + a_1w + a_2w^2 \qquad (W = 1, 2, ..., n)$$

This model was extended for two weather variables to study joint effects. Further, since the data for such studies extended over a long period of years, an additional variate T representing the year was included to make allowance for time trend.

Individual effect of weather variables

In order to study, the effect of individual weather variable, two new variables from each weather variable are generated as follows:

Let X_{iw} be the value of i^{th} (i = 1, 2, …, p) weather variable at w^{th} weeks (w = 1, 2,..., n). In this study, n is 19.

Let, r_{iw} be the simple correlation coefficient between weather variable X_i at W-th week and detrended crop yield over a period of K years. The generated variables are then given by

$$Z_{ij} = \sum_{w=1}^{n} r_{iw}^{j} x_{iw} \Big/ \sum_{w=1}^{n} r_{iw}^{j}\ ;\ j = 0, 1$$

For j = 0, we have un-weighted generated variable

$$Z_{i0} = \sum_{w=1}^{n} X_{iw} \big/ n$$

and weighted generated variables

$$Z_{i1} = \sum_{w=1}^{n} r_{iw} X_{iw} \Big/ \sum_{w=1}^{n} r_{iw}$$

For each year.

The following model is then fitted to study the effect of individual weather variable

$$Y = a_0 + a_1z_{i0} + a_2z_{i1} + cT + \varepsilon; \qquad i = 1, 2, ..., p.$$

Where, Y is untrended yield. T is variable expressing time effect, a_0, a_1, a_2 and c are parameters of the model to be evaluated for the effect of variables and ε is error term supposed to follow normal distribution with mean zero and variance σ^2.

Joint effect of weather variables on crop yield

For studying the joint effect of two weather variables on crop-yield, the model has been extended by including interaction terms in the model as follows:

$$Q_{ii',j} = \sum_{w=1}^{n} r_{ii',w}^{j} X_{iw} X_{i'w} \Big/ \sum_{w=1}^{n} r_{ii',w}^{j}\ ;\ j = 0, 1$$

Where, $r_{ii',w}$ is the correlation coefficient between crop yield (detrended) Y and product of weather variables X_{iw} and $X_{i'w}$. Clearly, we have two generated variables (interaction term)

$$Q_{ii,0} = \sum_{w=1}^{n} X_{iw} X_{i'w} \big/ n,$$

the un-weighted one

and

$$Q_{ii,1} = \sum_{w=1}^{n} r_{ii',w}^{j} X_{iw} X_{i'w} \Big/ \sum_{w=1}^{n} r_{ii',w}$$

the weighted one.

Including these two interaction term is the given in model. We have a new model to study the effect of joint weather variables as

$$Y = a + \sum_{i=1}^{2}\sum_{j=0}^{1} b_{ij} Z_{ij} + \sum_{j=0}^{1} b_{ii',j} Q_{ii'j} + cT + \varepsilon$$

Where b_{ij} and $b_{ii',j}$ are parameters (regression coefficients) of the model, and other terms have already been explained previous model .Step wise regression method has been used to fit the model with the data.

Results and Discussion

1. Individual effect of weather variable on rice crop

1.1 Rainfall

The multiple regression equation obtained is

$$Y = 20.4230 + 0.0077Z_{40} - 0.007Z_{41} + 0.0886T$$

The results from table 1 indicates that weighted & un-weighted weather variable with T was significant. Weighted weather variable found negatively significant at 1% level, un-weighted weather variable was significant at 10% level and time trend T was also significant at 5% level. The value of R^2 was 46.74, which is significant at 5% level of significance.

1.2 Wind velocity

The multiple regression equation obtained is

$$Y = 18.864 + 1.5775_{50} - 1.7730Z_{51} + 0.1152T$$

The result from table 2 is an important weather variable for rice crop, which have 48.63% (R^2) effect on rice. Un-weighted weather variable found negatively significant at 5% level, weighted variable was significantly affected on crop at 1% level and time trend was positively and significantly affected at 5% level for the crop yield.

1.3 Sunshine (hr)

The multiple regression equation obtained is

$$Y = 18.844 - 0.7183_{70} + 0.9811Z_{71} + 0.0700T$$

The result from table 3 is also an important weather variable for rice crop, which have 67.57% (R^2) effect on rice. Unweighted weather variable found negatively significant at 10% level, weighted variable was significantly affected on crop at 1% level and time trend was positively and significantly affected at 5% level for the crop yield.

2. Joint effect of weather variable on rice crop

2.1 Rainfall and wind velocity

The stepwise multiple regression equation obtained is

$$Y = 23.257 + 0.028Z_{40} - 0.014Q_{451} + 0.063T$$

The result from table 4 indicates that un-weighted rainfall found significant at 5%, no individual effect of wind velocity. The interaction effect of weighted weather variable was found negatively significant at 1% level and the time trend was positively and significantly affected at 5% level for the crop yield. But the overall effect of rainfall and wind velocity was 82.0% (R^2) on rice.

2.2 Rainfall and Sunshine (hr)

The stepwise multiple regression equation obtained is

Table 1 : Individual effect of rainfall.

Variable	Regression coefficient (standard error)	P value	R^2	95% confidence interval	
				Lower	Upper
Constant	20.4230 (0.9309)		46.74^*	18.4589	22.3870
Z_{40}	0.0077 (0.0179)	0.6724		-0.0302	0.0456
Z_{41}	-0.007 (0.0022)	0.0066		-0.0118	-0.0022
T	0.0886 (0.0478)	0.0814		-0.0123	0.1896

Table 2 : Individual effect of wind velocity.

Variable	Regression coefficient (standard error)	P value	R^2	95% confidence interval	
				Lower	Upper
Constant	18.8626 (1.9339)		48.63^*	14.7822	22.9430
Z_{50}	-1.5775 (0.9034)	0.0988		-3.4836	0.3284
Z_{51}	1.7730 (0.6016)	0.0090		0.5036	3.0423
T	0.1152 (0.0500)	0.0341		0.0096	0.220

Table 3 : Individual effect of Sunshine (hr).

Variable	Regression coefficient (standard error)	P value	R^2	95% confidence interval	
				Lower	Upper
Constant	18.844 (1.967)		67.57^*	14.693	22.995
Z_{70}	-0.7183 (0.492)	0.1627		-1.7570	0.3202
Z_{71}	0.9811 (0.228)	0.00049		0.4989	1.4633
T	0.0700 (0.0391)	0.0914		-0.0125	0.1526

Table 4 : Joint effect of rainfall and wind velocity.

Variable	Regression coefficient (standard error)	P value	R^2	95% confidence interval	
				Lower	Upper
Constant	23.257 (0.639)		82.0*	21.909	24.605
Z_{40}	0.028 (0.011)	0.021		0.005	0.051
Q_{451}	-0.014* (0.002)	0.0001		-0.018	-0.010
T	0.063 (0.028)	0.039		0.004	0.122

Table 5 : Joint effect of rainfall and sunshine (hr).

Variable	Regression coefficient (standard error)	P value	R^2	95% confidence interval	
				Lower	Upper
Constant	16.276 (0.906)		63.5*	14.373	18.178
Z71	0.721** (0.147)	0.0001		0.411	1.030
T	0.088* (0.034)	0.034		0.007	0.168

Table 6 : Joint effect of wind velocity and Sunshine (hr).

Variable	Regression coefficient (standard error)	P value	R^2	95% confidence interval	
				Lower	Upper
Constant	17.481 (0.165)		53.8*	15.755	19.208
Z_{71}	0.642* (0.041)	0.0002		0.337	0.946
Q_{571}	0.011* (0.003)	0.0057		0.0010	0.0221

Table 7 : Individual effect of weather variable on rice crop.

Variable	Significance level	R^2
Rainfall	1%	46.74*
Wind velocity	1%	48.63*
Sunshine (hr)	1%	67.57*
Rainfall & wind velocity	1%	82.0*
Rainfall & sunshine (hr)	1%	63.5*
Wind velocity & sunshine (hr)	1%	58.3*

**P< 0.05, **P<0.01, +P<0.1

$$Y = 16.276 + 0.721Z_{71} + 0.088T$$

The result from table 5 is also an important interaction of weather variables for rice crop, which have 63.5% (R^2) effect on crop yield. The interaction effect have no significant effect on crop. The weighted sunshine variable was significantly affected on crop at 5% level and time trend was positively and significantly affected at 5% level for the crop yield.

2.3 Wind velocity and Sunshine (hr)

The stepwise multiple regression equation obtained is

$$Y = 17.481 + 0.642Z_{71} + 0.011Q_{571}$$

The result from table 6 indicates that weighted sunshine found significant at 5%, no individual effect of wind velocity. The interaction effect of weighted weather variable was found positively significant at 1% level. But the overall effect of rainfall and wind velocity was 53.8.0% (R^2) on rice, which was significant at 1% level.

Conclusion

As far as is concerned with the individual effect of weather variables, it has been found that all the weather variables have made significant impact on rice yield. However, in case of minimum temperature and relative humidity, it shows negative effect indicating thereby that fall in minimum temperature affects the rice yield positively, while increase in relative humidity beyond a level would affect rice yield adversely.

In case of joint effect of pairs of weather variables (individual and interaction effect), it has been found that the individual effects of rainfall and wind velocity have been found significant. Besides these weather variables sun shine (hrs) has also been found to exhibit their individual and interaction effect. Therefore, it can be concluded that from the results of the table 7 that the individual effect of wind velocity, sunshine (hrs) and rainfall and interaction effects of wind velocity and rainfall is relatively more important for rice yield. It can however, be added that the effect of weather variable is variant with the different stage of rice production, which could have revealed the effects of weather variables in a better way, but this aspect has not been considered in the present investigation.

References

Agrawal, R., R. C. Jain and M. P. Jha (1980). Forecasting of rice yield using climatic variables. *Ind J. Agric. Sci.*, **50(9)** : 680-684.

Agrawal, R., R. C. Jain and M. P. Jha (1983). Joint effects of weather variables on rice yields. *Mausam*, **32(2)** : 177-81.

Kaustav, A. (2008). Forecasting of crop yield using discriminant function technique, *M.Sc., PG School, IARI*, New Delhi.

Kumar, N., R. R. Pisal, S. P. Shukla and K. K. Pandey (2014). Crop yield forecasting of paddy, sugarcane and wheat through linear regression technique for south Gujarat. *Mausam*, **65(3)** : 361-364.

Mehta, S. C., R. Agrawal and V. P. N. Singh (2000). Strategies for composite forecast. *Jr Indian Soc. Ag. Stat*., **53(3)** : 262-72.

Pandey, K. K., R. P. Kaushal, A. N. Mishra and V. N. Rai (2009). A study o Impact of Weather Variables with Different Distributions. *Ind. J. Agricult. Stat. Sci*., **5(1)** : 139-53.

Pandey, K. K., V. N. Rai and B. V. S. Sisodia (2014). Weather Variables Based Rice Yield Forecasting Models For Faizabad District Of Eastern U.P. *Int. J. Agricult. Stat. Sci*., **10(2)** : 381-385.

Rai, T. and Chandrahas (2000). Use of discriminant function of weather parameters for developing forecast model of rice crop. (*IASRI Publication*).

Ramasubramanian, V. and R. C. Jain (1999). Use of growth indices in Markov chain model for crop yield forecasting. *Biometrical Journal*, **41(1)** : 99-109.

Robertson, G. W. (1974). Wheat yields for 50 years at Swift Current Saskatchewan in relation to weather. *J. Plant Sci*., **54** : 625-50.

Saksena, A., R. C. Jain and R. L. Yadav (2001). Development of early warning and yield assessment models for rainfed crops based on agro-meteorological indices. (*IASRI Publication*).

Srivastava, A. K., P. K. Bajpai, R. L. Yadav and S. S. Hasan (2007). Weather Based Sugarcane Yield Prediction Model for the State of Uttar Pradesh. *Journal of Indian Society of Agricultural Statistics*, **61(3)** : 313-327.

Varshneya, M. C., S. S. Chinchorkar, V. B. Vaidya and V. Pandey (2010). Forecasting model for seasonal rainfall for different regions of Gujarat. *J. Agrometeorology*, **12(2)** : 202-207.