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Effect of Climatic Variable on Wheat at Its Different Stages with the Help of Regression Analysis

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ABSTRACT

This study examines the effect of climatic factor e.g. Temperature (Maximum and Minimum), Relative humidity (Morning and Evening), Evaporation and Rainfall variation on the yield of different stages of wheat in Samastipur district of Bihar by using regression analysis statistical method. The data of wheat yield of 29 Years (1984-2013) was taken from Department of Agricultural Economics, RAU, Pusa and Weather Variables (1984-2013) was taken from Agro-metrology Unit, RAU, Pusa. regression model approaches will have used to estimate the impact of climate variables on the stages of wheat yield. The whole crop season was divided into eight stages and at each stage the contribution of each weather variable was assessed using regression model. Model VII was used to study effects of weather variables on the crop yield at different growth stages. It can be concluded that per unit increase in the magnitude of most of the weather variables has made adverse effect on the yield during the entire crop season except during certain phases of crop growth. For example, the beneficial effect on the yield has been generally obtained during boot stage due to unit increase in minimum temperature.

Key words: *Climate change, Wheat yield, weather variable, Regression model.*

INTRODUCTION

Evidently climate change is being realized in every walk of our life. Palpable impact is seen on growth and development, water use and productivity of major crops including wheat. Wheat (*Triticum aestivum* L.) is the third most important cereal in terms of total cereal cultivated area at 20 percent. The impact of climate change on wheat yields in India[5]. It is desirable that the minimum and maximum temperature during the wheat growing period should be 300C to 320C and the mean daily temperature for optimum growth is between 200 C and 250 C[3]. The effect of climate change scenario of different periods can be positive or negative depending upon the magnitude of change in CO_2 and temperature[1]. The impact of temperature rise based on scenarios and general circulation model on the increase in the development rate and thus reduce the wheat growth season[4]. In the hotter region increasing temperature is useful for wheat while it is largely harmful in the colder region.

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Wheat yield is robust against variation in the temperature and is found to cause the risk through a change in yield variability. However, wheat yield and its variability are largely robust against the level as well as the variance of rainfall. Recently much attention has been given to the effects of climate change on agricultural output, because of the relevance of agriculture to the world economy, and the sensitivity of crop yields to climate conditions. Historically, much of the work on climate change impacts has focused on US outcomes, but recent work has increasingly studied developing countries, following predictions that the greatest short-term consequences of climate change may exist in the developing world. Climate change impacts on India can have far-reaching consequences, as well; India is the world's second largest producer of agricultural outputs, and any changes in production due to climate change could materially impact global agricultural imports and exports. Agriculture is the most vulnerable sector to climate change. Agriculture productivity is being affected by a number of factors of climatic change including rainfall pattern, temperature, relative humidity, evaporation, changes in sowing and harvesting dates, water availability, and evapo-transpiration and land suitability. The IPCC[6] predicted that 0 increases in global mean temperature (1-3 C) after 1990 would produce beneficial impacts in some regions and harmful ones in others. In India, studies by several authors shown that during last century there is observed increasing trend in surface temperature[9,10], no significant trend in rainfall on all India basis[8], and decreasing/ increasing trends in rainfall in regional basis[7,9]. All these can have tremendous impact on agricultural production.

MATERIALS AND METHODS

The study was carried out in Samastipur district of Bihar in India. This is situated in Agro- climatic zone I (Northern West). The traditional agricultural practice is prevalent in this district. Then latitude and longitude is 25° 51′47.48″ N and 85° 46′48.04 0″ E respectively. It is situated at an elevation of about 52 m above mean sea level. The climate of the site is characterized by hot and humid summers and cold winters with an average rainfall of 1200 mm, 70 percent (941 mm) of which occurs during July -September and average temperature is maximum 36.6°C and minimum temperature is 7.7°C. Frequent droughts and floods are common in the region. Wheat productivity data is collected from Dept. of Agricultural Economics, RAU, Pusa, Samastipur, Bihar. We take data of wheat productivity and climatic variable from 1984-2014. We consider the average amount of wheat productivity in tonnes/hectare. The direct impact of climatic variables on wheat yield. The data regarding the climatic variables is collected data source from the Agro-meteorology Unit, RAU, Pusa, Samastipur Bihar.Following are the climatic factor and their units which are taken in this research: Maximum temperature (°C), Minimum Temperature (°C), Relative Humidity (morning) (%), Relative Humidity (evening) (%), Rainfall (mm), Evaporation (mm/m^2). Now we can also analysis the wheat production after the effect of climate change on each stages of wheat. Generally, we take eight stages of wheat. Sowing time of wheat is mid of November i.e. 15thNov-20thNov and harvesting time is start from first week of April.Following are the name and time of each stage which is mention below

1. Seedling emergence (20th Nov – 26th Nov).
2. Tillering (27th Nov- 15th Dec).
3. Node stage (16th Dec- 5th Jan).
4. Boot stage (6th Jan-30th Jan).
5. Ear head emergence (31st Jan – 20th Feb).
6. Milk stage (21stFeb – 5th March).
7. Dough stage (6th March – 15th March).
8. Maturity stage (16th March- 31st march).

Regression Model Approach

Effect of changes in weather variables on yield at different stages as a linear function of correlation coefficient between yield and weather variables. In all we have considered eight models.

Model I: The first model due to Agrawal et al[2]. (1986) is

$$Y = a + b_0 \sum_{s=1}^{n} X_s + b_1 \sum_{s=1}^{n} r_{xy(s)} X_s + b_2 \sum_{s=1}^{n} r^2_{xy(s)} X_s + cT + e$$

$$= a + b_0 Z_0 + b_1 Z_1 + b_2 Z_2 + cT + e$$

Where Y is un-trended wheat yield (t/ha); a, b_s (S=1, 2...8) and c are model parameters; s is stages identifications; n is number of stages; X_s is the value of weather variable in Sth stage; rxy(s) is correlation coefficient between yield and weather variable in Sth stage. T is trend variable (Time index) and e is error terms assumed to follow independently normal distribution with mean zero and constant variance σ^2.

Model VI: This is obtained by deleting the quadratic terms and in model v, and the model becomes:

$$Y = a + b_0 Z_0 + b_1 Z_1 + b_{00} Z_{00} + b_{11} Z_{11} + cT + e$$

Model VII & VIII: The Models are same as models V and VI, respectively except that correlation coefficients are obtained using adjusted yields for trend effect. Data on relative humidity have been transformed into arc-sine root proportion as they were in percentage.

Stepwise regression was used to develop models for studying relationship between yield and weather variables. Effect of weather variables on wheat yield at its different stages as a linear function of correlation coefficient between yield and weather variable. The impact of weather variables on the yield of wheat has been assessed using two approaches: Regression model and Regression Tree approach.

RESULTS AND DISCUSSION

Regression Models

Eight models, as described in Material and Methods section, have been studied to explore the best possible relationship between crop yield and various weather variables. Table 1 shows the summary of fitted models in terms of the values of the coefficient of determination (R^2). It is observed that i) models using correlations based on yield adjusted for trend effect outperformed those based on simple correlations and ii) inclusion of quadratic terms of weather variables as well as second power of correlation coefficient did not improve the model in general. The performance of models VII and VIII are observed to be similar and hence model VII has been finally chosen to study effects of weather variables on the crop yield at different growth stages. The effects of one-unit increase in weather variables over the average yield at different growth stages of the crop have been assessed by differentiating the models with respect to X_s.

Model II: In fact, the models II is deduced from the model I by deleting the term b_2Z_2.

The model becomes as follows.

$$Y = a + b_0 Z_0 + b_1 Z_1 + cT + e$$

Model III & IV: The models are same as Models I & II respectively except that rxy(s) is obtained using yield adjusted for trend effect.

Model V: This is obtained by including quadratic terms of weather variable in model I, as such model becomes

$$Y = a + b_0 \sum_{s=1}^{n} X_s + b_1 \sum_{s=1}^{n} r_{xy(s)} X_s + b_2 r^2_{xy(s)} + b_{00} \sum_{s=1}^{n} X_s^2 + b_{11} \sum_{s=1}^{n} r_{x^2y(s)} X_s^2 + b_{22} \sum_{s-1}^{n} r^2_{x^2y(s)} X_s^2 + cT + e$$

$$= a + b_0 Z_0 + b_1 Z_1 + b_2 Z_2 + b_{00} Z_{00} + b_{11} Z_{11} + b_{22} Z_{22} + cT + e$$

Regression Model Approach

Effect of climate variables on stages of wheat yield

The effects of one-unit increase in weather variables over the average yield at different growth stages of the crop have been discussed in this section. The effects as a result of multiple regression models are given in table 2.

Effect of Minimum Temperature

The multiple regression equation obtained for Minimum Temperature is

$$Y = 8.245 + 0.518\, Z_1 + 0.254\, T \quad (R^2 = 0.72)$$

The effects are computed as

$$\frac{\partial Y}{\partial X_{(xy)s}} = 0.518 r_{xy(s)}$$

It can be observed from the table-2 that the effect of 1°C above the average has been found to be detrimental in general except at Dough Stage (1.54) and Boot stage (0.48). There was remarkable negative impact during Tillering (-2.53) and Ear head emergence (-1.64).

However, in the remaining stages, the effects were fluctuating.

Effect of maximum temperature

The multiple regression equation obtained for Maximum Temperature is

$$Y = 12.742 - 0.0647 Z_0 + 0.501 Z_1 + 0.412 T \quad (R^2 = 0.69)$$

The effects are computed as

$$\frac{\partial Y}{\partial X_{xy(s)}} = -0.0647 + 0.501 r_{xy(s)}$$

It can be observed from the table-2 that during seedling emergence (20th Nov – 26thNov), tillering (27th Nov- 15th Dec), node stage (16thDec- 5th Jan), Boot stage (6th Jan-30 Jan), Ear head emergence (31st Jan – 20th Feb), Milk stage (21stFeb – 5th March), Dough stage (6th march – 15th march) & Maturity stage (16th March- 31st march), the effect of 1°c above the average has been found to be detrimental. The effects have been found to be beneficial during Node Stage (2.45). There was pronounced negative effects during ear head emergence (-2.11). However, in the remaining stages, the effects were fluctuating.

Effect of relative humidity (morning)

The multiple regression equation obtained for Relative Humidity (morning) is

$$Y = 2.451 + 0.425 Z_{11} + 0.252 T \quad (R^2 = 0.75)$$

The effects are computed as

$$\frac{\partial Y}{\partial X_{xy(w)}} = 0.012 \times 2 X_w r_{x^2 y(w)}$$

The effects were in general beneficial on the wheat yield throughout the crop growth period except in dough stage & maturity stage. Pronounced beneficial effects were observed during boot (1.35) and Ear head emergence (1.45).

Effect of relative humidity (evening)

The multiple regression equation obtained for Relative Humidity (evening) is

$$Y = 5.324 + 0.004 Z_{11} + 0.218 T \quad (R^2 = 0.65)$$

The effects are computed as

$$\frac{\partial Y}{\partial X_{xy(w)}} = 0.004 \times 2 X_w r_{x^2 y(w)}$$

The effects of relative humidity (evening) were in general harmful on the wheat yield throughout the crop growth period except in node stage and boot stage. Pronounced beneficial effects were observed during node stage (2.04). Pronounced negative effects were observed during seedling emergence stage (-2.2) and milk stage (-2.12).

Effect of total rainfall

The multiple regression equation obtained for Total Rainfall is

$$Y = -0.378 + 0.019 Z_{11} + 0.224 T \quad (R^2 = 0.60)$$

The effects are computed as

$$\frac{\partial Y}{\partial X_{xy(w)}} = 0.019 \times 2 X_w r_{x^2 y(w)}$$

The effects of rainfall were in general beneficial on the wheat yield throughout the crop growth period except in milk stage, maturity stage& boot stage. Pronounced beneficial effects were observed during ear head emergence stage (3.31) and dough stage (1.87). Pronounced negative effects were observed during milk stage (-2.56) and maturity stage (-2.44).

Effect of evaporation

The multiple regression equation obtained for Evaporation is

$$Y = -0.314 + 0.234 Z_1 + 0.412 T \quad (R^2 = 0.73)$$

The effects are computed as

$$\frac{\partial Y}{\partial X_{(xy)s}} = 0.234 r_{xy(s)}$$

The effects of evaporation were in general harmful on the wheat yield throughout the crop growth period except in dough stage & maturity stage. Pronounced beneficial effects were observed during dough stage (20.62) and maturity stage (0.84). Pronounced negative effects were observed during in general.

CONCLUSION

Multiple linear regression models estimated the effects of different weather variables on wheat yield. Interaction term between some of the weather variables which are expected to have impact on yield on account of synergistic effects between them were included in the model. The main effects of all the variables were observed to have statistically non-significant contribution towards changing crop yield except relative humidity (morning).

However, the interaction of relative humidity with other weather variables was estimated to have statistically significant contribution towards yield variability. It indicates that the role of an individual weather variable may not assess the actual impact on yield; however, its variation as a function of another weather variable may indicate change in the wheat yield as obtained from the regression results. The whole crop season was divided into eight stages and at each stage the contribution of each weather variable was assessed using regression model. Model VII was used to study effects of weather variables on the crop yield at different growth stages. It can be concluded that per unit increase in the magnitude of most of the weather variables has made adverse effect on the yield during the entire crop season except during certain phases of crop growth.

REFERENCES

1. Aggarwal, P.K., Impact of climate change on Indian agriculture. *Journal of Plant,* **30(2):** 189-198 (2003).
2. Agrawal, R., Jain, R.C. and Jha, M.P., Models for studying rice crop weather relationship. *Mausam*, **37(1):** 67-70 (1986).
3. Briggle, L.W., Origin and Botany of Wheat. In E. Hafliger (ed.) Wheat Documenta, Ciba- Geigy, Basel, Switzerland, Pp 6-13 (1980).
4. Challinor, A.J., Wheeler, T.R., Craufurd, P.Q., Ferro, C.A.T. and Stephenson, D.B., Adaptation of crops to climate change through genotypic responses to mean and extreme temperatures agriculture. *Ecosystems and Environment*, **119:** 190-204 (2007).
5. Gupta, R., Somanathan, E. and Dey, S., The impact of climate change on wheat yields in India. pdf. (2014).
6. IPCC: Climate Change 2007- Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Parry, M.L., Canziani, O.F., Palutikof, J.P., Van der Linden P.J. and Hanson, C.E. (eds), Cambr idge University Press, Cambridge (2007).
7. Kripalani R.H., Kulkarni, A., Sabade, S.S. and Khandekar, M.L., Indian monsoon variability in a global warming scenarios', *Natural Hazards,* **29(2):** 189- 206 (2003).
8. Pant, G.B., Kumar, R. and Borgaonkar, K., *Climate and its long-term variability over the western Himalaya during the past two centuries. The Himalayan Environment (Eds. S. K. Dash and J. Bahadur),* New Age International Limited, Publishers, Delhi. Pp. 172-184 (1999).
9. Singh, N. and Sontakke, N.A., On climatic fluctuations and environmental Changes of the Indo-Gangetic plains, India. *Climatic Change,* **52:** 287-313 (2002).
10. Singh, R.S., Narain, P. and Sharma, K.D., Climate changes in Luni river basin of arid western Rajasthan (India). *Vayu Mandal*, **31(1–4):** 103-106 (2001).