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Effect of weather variables on the yield of wheat crop in District Jaunpur, Eastern Uttar Pradesh, India

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Abstract
India is an important centre of wheat cultivation. The wheat is cultivated on the largest areas in India. wheat is the major crop of Uttar Pradesh, which covers about 32.5 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 wheat crop in the district Jaunpur, Eastern Uttar Pradesh, India. The present study is formulated to determine the individual effect of weather variables on wheat yield. On the basis of R^2, we found that individually Maximum Temperature is more important with 62.7 followed by sunshine (hr.), rainfall, wind velocity and Minimum Temperature with 61.3, 52.0, 30.4 and 27.9 respectively.

Keywords: Weather variables, significant Correlation & Regression, Yield, wheat crop, R^2.

Introduction
In India, wheat crop is grown mainly in the northern states, with Uttar Pradesh being the top-most contributor of wheat with a total production of 25.22 million tonnes, followed by Punjab (15.78 MT) and Madhya Pradesh (14.18 MT). It is interesting to know that despite being the highest producer of wheat and having the largest land under wheat cultivation in India (9.85 million hectares), Uttar Pradesh productivity (2561 kg/ hectare) is still less than the national average. But Punjab with 4491 kg/ hectare beats every other state in terms of productivity!
Wheat crop is usually sown from months of September to December in various states of India depending upon the suitable climate, and the harvesting is done from February to May depending upon the climate as well as the time it is seeded. The temperature required for sowing ideally should be the winter temperature of 10°C-15°C and summer temperature of 21°C-26°C. The temperature at sowing needs to be low while at the harvesting time, higher temperatures are necessary for the proper ripening of Wheat.
Being a plant, pests and diseases have always been a problem, although, with the use of pest and disease resistant varieties and pesticides, the yield has increased phenomenally. Some common pests that affect the wheat cultivation are Stripe Rust /Yellow Rust, Powdery Mildew, Aphids, Head Scabs, Army Worm, Termites etc. Most of them can be taken care of with some added vigil and judicious use of pesticides.
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 wheat crop in the district of Jaunpur, Uttar Pradesh, India. The district of Jaunpur is situated in the North-West part of Varanasi Division. The rivers Gomti and Basuhi divide the district into nearly four equal landmasses. The soils are mainly sandy, loamy and clayey. Jaunpur district is often affected by the disaster of floods that is why there is a paucity of minerals. Excavations at some places yield to some rocks which are burnt to make lime. The lime obtained from sand and gravel is used in buildings construction work. The economic development of the district is mainly dependent on agriculture.

Material and Methods
The time series data on yield for wheat crop of Jaunpur district of eastern Uttar Pradesh pertaining for the period from 2000-01 to 2017-18 have been procured from the website.
http://updes.up.nic.in/spatrika/spatrika.htm by Economics and Statistics Division, Planning Department, Government of Uttar Pradesh.
Weekly weather variables wheat crop in the district of Jaunpur, Eastern Uttar Pradesh have

been obtained from the National Data Centre, India Meteorological Department, Pune for the study period 2000-01 to 2017-18. The data for wheat crop have been collected up to the first 16 weeks of the crop cultivation which include 44th Standard Meteorological Week (SMW) to 7th SMW of a next year. The data on five weather variables viz. Maximum Temperature, Minimum Temperature, Rainfall, wind-velocity and Sun-shine hours have been used in the study.

Individual Effect of Weather Variables

The statistical models have been proposed by expressing effect of changes in weather variables on yield in w[th] week as a linear function of respective correlation coefficients between detrended wheat yield and weekly weather data (Agrawal *et al*., 1986) [2]. Trend effect on yield is also removed from yield while calculating correlation coefficients of yield with weather variables to be used as weights.

De-trend Yield

$$Y = a + bt$$

Where; Y, a, b and t is observed yield, constant, regression coefficient and time trend respectively.

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 16.

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

$Y = a_0 + a_1 Z_{i0} + a_2 Z_{i1} + cT + \varepsilon$; $i = 1, 2,..., p$.

Where, Y is untrended wheat 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.

Result and Discussion

1. Effect of weather variables on the yield of wheat crop by Correlation Analysis

Persual of the table 1, we found that unweighted maximum temperature (Z_{10}), unweighted minimum temperature (Z_{20}) and unweighted sunshine hour (Z_{50}) are positively correlated as 0.48, 0.20 and 0.49 respectively with detrended yield of wheat crop at 5% level of significance while unweighted rainfall (Z_{30}) and unweighted wind velocity (Z_{40}) found to be negatively correlated with detrended yield of rice crop.

Table 1: Correlation Coefficient between Detrend yield and generated Weather variables.

Variables	Correlation Coefficient	Variables	Correlation Coefficient
Z10	0.48*	Z11	0.69**
Z20	0.20	Z21	0.72**
Z30	-0.68**	Z31	-0.75**
Z40	-0.33*	Z41	-0.01
Z50	0.49*	Z51	0.72**

Weighted maximum temperature (Z_{11}), weighted minimum temperature (Z_{21}) and sunshine hour (Z_{51}) shows positive while weighted rainfall (Z_{31}) weighted wind velocity (Z_{41}) and shows negative correlation with the yield of wheat crop.

2. Individual effect of weather variable on wheat crop with Regression Coefficient and R^2

2.1 Maximum Temperature

The multiple regression equation obtained is

$$Y = 50.416 - 1.336Z_{10} + 0.469\,Z_{11} - 0.091T$$

Table 2.1.1: Individual effect of Maximum Temperature

Variable	Regression Coefficient (standard Error)	P value	R^2	95% Confidence interval	
				Lower	Upper
Constant	50.416 (18.520)		62.7%	10.694	90.138
Z_{10}	-1.336* (0.742)	0.093		-2.928	0.256
Z_{11}	0.469*** (0.103)	0.001		0.248	0.690
T	-0.091 (0.115)	0.444		-0.338	0.156

From the persual of table 2.1.1 maximum temperature weather variable for wheat crop. The results indicates that un-weighted maximum temperature regression coefficients were found to be statistically significant at 10% & weighted maximum temperature regression coefficients were found to be negatively statistically significant at 1% level of significant and time trend T was found negatively non-significant. The value of R^2 (%) is 62.7

2.2 Minimum Temperature

The multiple regression equation obtained is

$$Y = 23.671 - 1.426Z_{20} + 1.30Z_{21} - 0.052\,T$$

Table 2.2.1: Individual effect of Minimum Temperature

Variable	Regression Coefficient (Standard Error)	P value	R^2	95% Confidence Interval	
				Lower	Upper
Constant	23.671 (10.581)		27.9%	977	46.364
Z_{20}	-1.426 (1.282)	0.285		-4.177	1.325
Z_{21}	1.300** (0.581)	0.042		0.054	2.546
T	-.052 (0.153)	0.740		-0.380	0.277

From the persual of table 2.2.1 minimum temperature weather variable for wheat crop. The results indicates that un-weighted regression coefficients were found to be non-significant & weighted minimum temperature found significant at 5% level of significance and time trend T was also found negatively non-significant. The value of R^2 (%) is 27.9

2.3 Rainfall

The multiple regression equation obtained is

$$Y = 26.404 - 0.945\, Z_{30} - 0.343\, Z_{31} - 0.121\, T$$

Table 2.3.1: Individual effect of Rainfall

Variable	Regression Coefficient (Standard Error)	P value	R^2	95% Confidence Interval	
				Lower	Upper
Constant	26.404 (1.677)		52.0%	22.808	30.001
Z_{30}	-0.945** (0.374)	0.024		-1.748	-0.143
Z_{31}	-0.343*** (0.101)	0.004		-0.561	-0.126
T	-0.121 (0.120)	0.333		-0.379	0.138

From the persual of table 2.3.1Rainfall weather variable for wheat crop. The results indicates that un-weighted rainfall regression coefficients & weighted rainfall regression coefficients were found to be significant at 5% & 1% level of significant and time trend T was found negatively non-significant. The value of R^2 (%) is 52.4

2.4 Wind velocity

The multiple regression equation obtained is

$$Y = 28.163 - 2.477\, Z_{40} + 1.326\, Z_{41} + 0.029\, T$$

Table 2.4.1: Individual effect of Wind velocity

Variable	Regression Coefficient (Standard Error)	P value	R^2	95% Confidence Interval	
				Lower	Upper
Constant	28.163 (5.872)		30.4%	15.568	40.757
Z_{40}	-2.477 (1.526)	0.127		-5.751	0.797
Z_{41}	1.326* (0.568)	0.035		0.107	2.544
T	0.029 (0.159)	0.861		-0.314	0.371

From the persual of table 2.4.1Wind velocity weather variable for wheat crop. The results indicates that un-weighted regression coefficients were found to be non-significant & weighted Wind velocity regression coefficients were found to be significant at 5% level of significance and time trend T was also found non-significant. The value of R^2 (%) is 30.4

2.5 Sunshine (Hr.)

The multiple regression equation obtained is

$$Y = 17.642 - 1.171\, Z_{50} + 2.044\, Z_{51} + 0.103\, T$$

Table 2.5.1: Individual effect of Sunshine (Hr.)

Variable	Regression Coefficient (Standard Error)	P value	R^2	95% Confidence Interval	
				Lower	Upper
Constant	17.642 (2.402)		61.3%	12.491	22.792
Z_{50}	-1.171 (0.740)	0.136		-2.758	0.416
Z_{51}	2.044*** (0.577)	0.003		0.808	3.281
T	0.103 (0.116)	0.391		-0.146	0.351

From the persual of table 2.5.1sunshine (Hr.) weather variable for wheat crop. The results indicates that un-weighted sunshine (Hr.) regression coefficients were found to be negatively non-significant & weighted sunshine (Hr.) regression coefficients were found to be significant at 1% level of significant and time trend T was found non-significant. The value of R^2 (%) is 61.3

Conclusion

All the weather variables which are used in this study is found to be important for the yield of wheat crop in district Jaunpur, Eastern Uttar Pradesh, India. Correlation and regression analysis shows that among all these variables two variables viz., sunshine (hr.) and minimum temperature effects positively to the yield of the rice crop while all the rest variables affected negatively.

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