

Original Research Article

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## Identification of Most Important Weeks on Minimum Temperature for Wheat Crop

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### ABSTRACT

#### Keywords

Percent deviation, Wheat crop, Temperature and coefficient of determination (R<sup>2</sup>).

#### Article Info

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In the present study attempts have been made to identify a most important weeks for wheat yield at district level. Weekly data of 18 meteorological weeks on (47<sup>th</sup> to 52<sup>nd</sup> weeks on first year and 1<sup>st</sup> to 12<sup>th</sup> Standard Meteorological Weeks, SMW for 2<sup>nd</sup> year) on minimum temperature over a span of 20 year (1995 to 2015) has been used along with the annual wheat production data (used as detrended yield for fitting of model) for Faizabad district of eastern U.P. Distribution of temperature has been recorded for wheat crop. Yield of wheat crop was recorded yearly for the study. Percent deviation has been calculated for the every week. The effect of temperature has been calculated for every week and joint effect of all weeks. The effect of temperature for every week has been calculated as correlation coefficient and regression coefficient (R<sup>2</sup>) on wheat yield. The model for every week has been developed and testing through F-test. The pattern of temperature has also been depicted through graph. The first week of crop period has been found as most important week i.e. 61% followed by last week 60% (in terms of Coefficient of determination, R<sup>2</sup>).

### Introduction

Agriculture in the entire world mostly depends on the persisting weather conditions. The alternation in global warming has dramatically affected agriculture and its productivity. The increase in temperature has significantly led to change in the agricultural zones and shift in the growing seasons. Among these changes, the change in rainfall pattern is the serious threat to the agriculture, which in turn affects the country's economy and food security. The delayed or inadequate monsoon also cause influence on the sale of agriculture inputs such as fertilizers,

agrochemicals etc. Some of the areas in India receive more rainfall than normal while some receive below the normal. The various studies showed the overall loss in the crop production in the country in the last few years was due to the anticipated rise in the temperature. Kumar *et al.*, (2016) has suggested model which require small number of parameters to be estimated while taking care of distribution pattern of weather over the crop season and Crop yield forecasting of paddy and sugarcane through modified Hendrick and Scholl technique for south Gujarat.

Wheat is one of the most important food grains for cultivation in Rabi season and consumption as well in eastern Uttar Pradesh. In eastern U.P. region of India wheat is generally sown from second week of November.

The meteorological statistics and yield data from the phenological period in which weather elements illustrate significant correlation with crop yield by using multiple linear regressions. As climatic patterns change, so also the spatial distribution of agro ecological zones, habitats, dissemination of plant diseases and pest and ocean circulation patterns changes that cause serious impact on agriculture and food production. Models based on weather parameters can provide reliable forecast of crop yield in advance of harvest (Agrawal and Mehta, 2007). Abnormal changes in climate and resulting increase in frequency and intensity of drought have long-term implications for the viability of these ecosystems. Some forecasting equations have also been developed so for forecasting of rice yield, for estimation of sugarcane yield and for wheat yield (Agarwal *et al*, 2012) have been proved their importance.

The Pre-harvest forecast of crop yield is very useful for Government and Planners in taking various policy decisions relating to procurement, storage, distribution, marketing, price, export-import, etc. A lot of work has been done by different scientist in this direction in different part of the country, but no work has been done by someone in this region in this direction. First time the effect and pattern of minimum temperature consider for study for this region.

### **Materials and Methods**

The study has been conducted for Faizabad district of Eastern Uttar Pradesh, which is

situated between 26° 47' N latitude and 82° 12' E longitudes. It lies in the Eastern Plain Zone of Uttar Pradesh. The annual rainfall of study area about 1002 mm and is liberally sourced by the Sarju (Ghaghra) river and its tributaries. Soils are deep alluvial, medium to fine textured but are easily ploughable. The favorable climate, soil and the availability of ample irrigation facilities make rice and wheat is suitable crops for that area. Wheat crop is generally cultivated during the Rabi season because during this period crop receives a better temperature along with other weather variables.

Time series data on yield for wheat crop pertaining to Faizabad district of Uttar Pradesh for 20 years (1995- 2015) have been procured from Directorate of Agricultural Statistics and Crop Insurance, Government of Uttar Pradesh.

Weekly weather (minimum temperature) data for similar period of Faizabad district of Uttar Pradesh during the crop growth period have been obtained from the department of Agrometeorology, N.D. University of Agriculture and Technology Kumarganj, Faizabad. The data on minimum temperature has been collected for 18 weeks (47<sup>th</sup> week to 52<sup>nd</sup> from 1<sup>st</sup> year and 1<sup>st</sup> week to 12<sup>th</sup> week from 2<sup>nd</sup> year) (Table 2).

### **Effect of minimum temperature**

In order to study the effect of individual weather variable, two new variables from each weather variable are generated as following Pandey *et al.*, (2016):

Let  $X_{1w}$  be the value of 1<sup>st</sup> weather variable at w<sup>th</sup> weeks ( $w = 1, 2, \dots, 18$ ) in this study  $n$  is 18.

$$Z_{10} = \sum_{w=1}^{18} X_{1w} / 18$$

Let  $r_{1w}$  be the simple correlation coefficient between weather variable  $X_i$  at  $W$ -th week and detrended crop yield over a period of  $K$  years and  $r_{1w}X_{1w}$  is the product moment. The generated weighted variables

$$Z_{11} = \frac{\sum_{w=1}^{18} r_{1w} X_{1w}}{\sum_{w=1}^{18} r_{1w}}$$

for each year. The following model is then fitted to study the joint effect of all 18 weeks on minimum temperature

$$Y = a_0 + a_1 z_{10} + a_2 z_{11} + cT + \varepsilon$$

$$\text{Percent deviation} = \frac{(\text{Actual yield} - \text{Forecasted yield})}{(\text{Actual yield})} \times 100$$

### Pattern of Minimum temperature

The pattern of weather variables have been worked out in crop period and depicted through graphs.

### Results and Discussion

#### Effect of minimum temperature

The multiple regression equation obtained is

$$Y = 2560.68 + 22.96 Z_{10} - 32.97 Z_{11} + 18.01 T$$

The results from table 1 indicates that weighted weather variable ( $Z_{11}$ ) found positive and significant at 1% level, time trend  $T$  found positive and significant at 1% level and unweighted weather variable was significant at 10% level. The value of  $R^2$  was 80.60% which is significant at 1% level of significance. Nain *et al.*, (2004) also reported that the differences between observed and predicted wheat yield were, on an average, 4.72% by using weather variables for Indo-Gangetic plains. Likewise, yield of groundnut

Where  $Y$  is detrended 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  $\varepsilon$  is error term supposed to follow normal distribution with mean zero and variance  $\sigma^2$ .

### Percent Deviation

This measures the deviation (in percentage) of forecast from the actual yield data. The formula for calculating the percent deviation of forecast is given below

was significantly correlated with growing season rainfall in southern India Gadgil *et al.*, (2002).

### Pattern and Role of weekly Minimum Temperature

First Standard Meteorological Week (47th) of wheat sown crop period plays most important role in terms of multiple  $R^2$  i.e. 62%, followed by last week (12th) with 60%  $R^2$ . Correlation Coefficient between yield and average weekly temperature during the crop period found negative and maximum in first week followed by last week i.e. -.62 and -0.60. In terms of significance only first and last week found significant at 1% level. After that 6th week (i.e. flowering stage) plays an important role. The  $R^2$  value for the 6<sup>th</sup> week is 42% which is significant at 10% level. The correlation coefficient between yield and 6<sup>th</sup> week of minimum temperature is 0.42.

Lal *et al.* (1999) also observed that maximum temperature, minimum temperature and moisture stress were crucial weather variables affecting soybean yield.

**Table.1** Effect of minimum temperature

Variable	Regression coefficient (standard error)	P value	R <sup>2</sup>	95% confidence interval	
				Lower	Upper
Intercept	2560.68		80.60*	1220.91	3900.46
Z10	22.96(72.29)	0.75		-130.29	176.22
Z11	-32.97(14.75)	0.04		-64.23	-1.71
T	18.01(7.57)	0.03		1.96	34.05

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

**Table.2** Role of different weeks in crop yield forecasting

S.No	SMW(Standard Meteorological Weeks)	Correlation Coefficient	R	Significance of the model	Predicted Yield at n <sup>th</sup> week
1.	47	-0.62		0.001	2686.31
2.	48	-0.31		0.18	2618.58
3.	49	0.04		0.86	2611.42
4.	50	-0.10		0.69	2616.01
5.	51	-0.28		0.23	2563.44
6.	52	0.09		0.70	2613.60
7.	1	-0.08		0.74	2615.70
8.	2	-0.02		0.92	2616.12
9.	3	-0.16		0.49	2593.90
10.	4	-0.14		0.56	2567.52
11.	5	-0.02		0.94	2610.06
12.	6	0.42		0.06	2670.77
13.	7	-0.07		0.78	2620.89
14.	8	0.10		0.68	2609.12
15.	9	0.36		0.12	2696.28
16.	10	0.15		0.53	2593.26
17.	11	-0.26		0.28	2692.15
18.	12	-0.60		0.005	2593.99

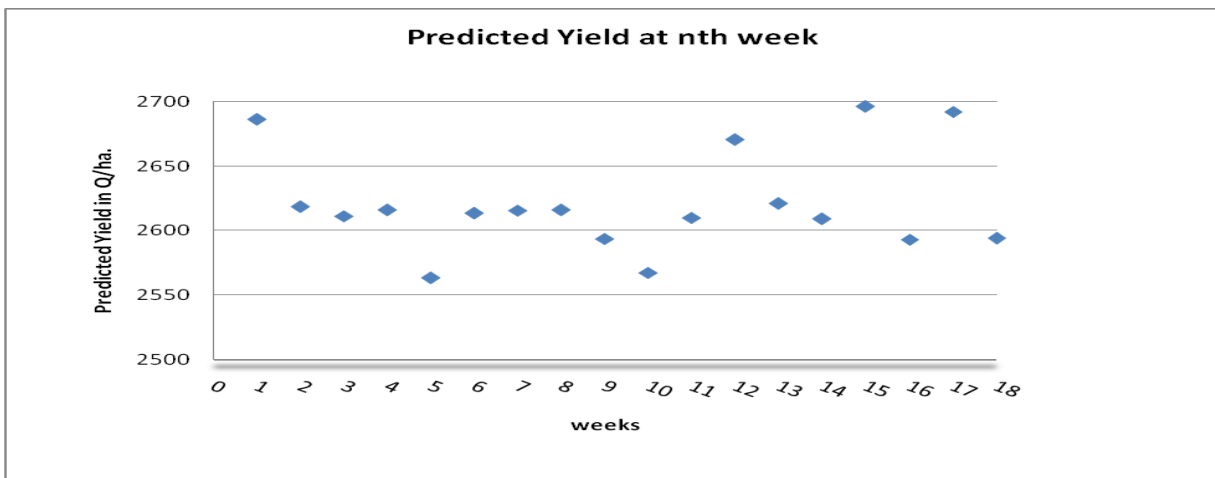
**Table.3** Validation of model

years	Actual yield	Predicted yield	Percent Deviation
<b>19</b>	2976	2989.688	-0.45994
<b>20</b>	2896	2802.799	3.218272

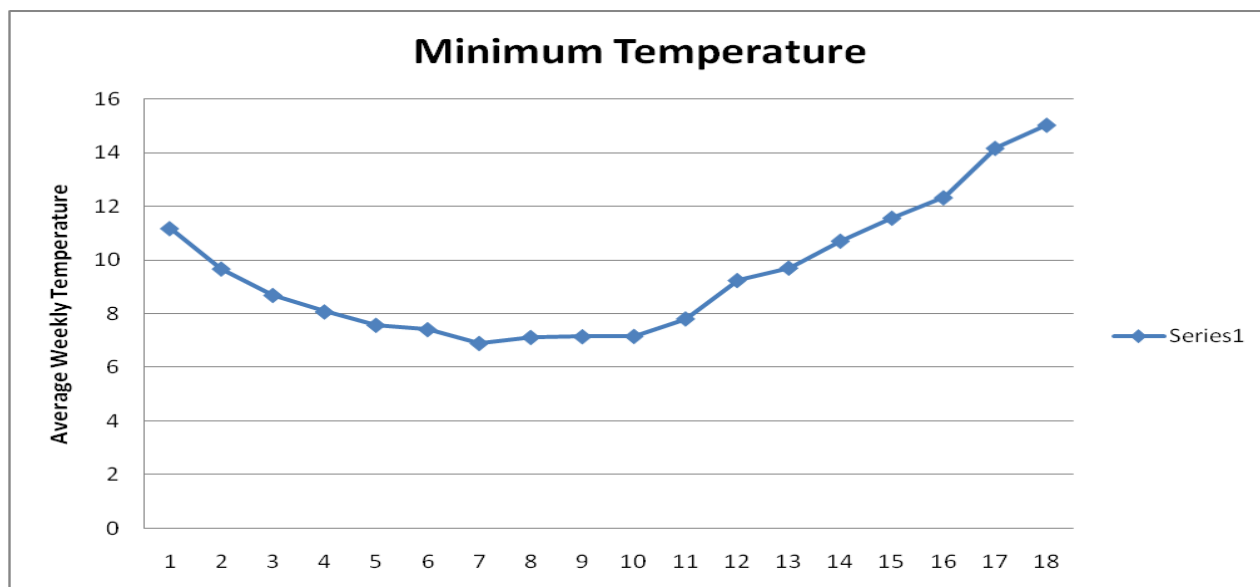
**Table.4** Percent deviation from predicted value

S.No.	Observed Value	Predicted Value of nth week	Percent Deviation
1	2530	2686.31	-6.17826
2	2502	2618.58	-4.65947
3	2676	2611.42	2.413303
4	2397	2616.01	-9.13684
5	2230	2563.44	-14.9525
6	2626	2613.60	0.472201
7	2357	2615.70	-10.9758
8	2392	2616.12	-9.36957
9	2179	2593.90	-19.0408
10	2637	2567.52	2.634812
11	2377	2610.06	-9.8048
12	2607	2670.77	-2.44611
13	2683	2620.89	2.314946
14	2758	2609.12	5.398115
15	2819	2696.28	4.353317
16	2790	2593.26	7.051613
17	2810	2692.15	4.19395
18	3013	2593.99	13.90674

**Fig.1** Predicted value at nth week



**Fig.2** Trend of Minimum temperature over the Crop period



A combination of temperature and radiation was a better predictor of wheat grain yield. Temperature, rainfall and relative humidity were found significantly correlated with sugarcane yield Srivastava *et al.*,(2007).

Our results are in line with Kumar *et.al.* (2014) multiple regression models were developed for yield forecasting of paddy, sugarcane and wheat for two districts of Gujarat (Navsari and Bharuch) on the basis of generated weather variables. Significant weather variables are obtained on the basis of highest  $R^2$  and significant P-value Pandey *et.al.* (2014). Similar study done for Forecasting Model developed on weather parameters for faizabad district of Eastern U.P Pandey *et al.*, (2016).

Almost similar results, as observed in this study, have also been reported by Kandiannan *et al.*, (2002) for Coimbatore in Tamil Nadu, where temperature, rainfall and radiation entered significantly in a stepwise prediction equation of rice yield. In Andhra Pradesh also, rainfall and temperature have been reported to affect rice yield significantly (Barnwal and Kotani, 2010).

In conclusion, the study revealed that the wheat crop requires balanced weather parameters during all growth phase. Early growth phase require decreasing temperature, second stage requires constant temperature. However, at the maturity stage increasing temperature plays very important role. According to predicted model  $R^2$  is 81% effect on wheat yield. Percent deviation of predicted model has been very less i.e. -0.46 for I year and 3.22 for II year. Weekly predicted yield data have been calculated. It seems from the graph that technological development of minimum temperature is mixed up. However graph shows the proper pattern. This is the study of effect of change of yield due to variation of minimum temperature during wheat crop season (Table 3 and 4).

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