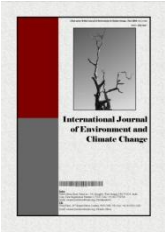

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Use of Statistical Models in Yield Forecasting of Wheat, Mustard and Potato Crop in Western Districts of Uttar Pradesh, India

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Twenty five year (1992 to 2017) of weather data of wheat, mustard and potato crop for 11 districts Aligarh, Baghpat, Barielly, Bijnor, Bulandshahar, Gaziabad, Meerut, Muzaffarnagar, Rampur, Saharnpur and Sahjahnpur of Western Uttar Pradesh were used to develop pre harvest yield prediction model. Every year Agromet Field Unit (AMFU) Modipuram generate district level yield forecasting model for major crops (wheat, mustard and poatato) pre-harvest stage (F3) for the seasons i.e. *rabi*. Considering the importance of wheat, mustard and potato crop a attempt was made to develop pre harvest yield forecasting models, in the selected 11 districts of western Uttar Pradesh. The models were validated with 2015 and 2016 data set. The results revealed that per harvest for forecasting model had F3 stage R^2 values between 0.44 to 0.96 per cent for wheat crop , 0.57 to 0.87 per cent for mustard crop to and 0.54 and 0.99 per cent for Potato crop in the different districts of western Uttar-Pradesh. During both the years of validation the observed yields were in good agreement with forecasted yield for wheat, mustard as well as potato crop.

Keywords: Forecast; statistical model; wheat crop; mustard crop; potato crop.

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1. INTRODUCTION

Climate is a primary determinant of agricultural production and changes in climate would likely to have devastating effect on agriculture. Food security of India depends on agricultural production of the country. Yearly seasonal and geographical crop yield availability depended on space and timely rainfall distribution. Therefore for effective planning and policy it is very important to know regional impact of weather parameter on crop yield. Wheat is major food grain crop, mustard is major crop oil seed crop and potato is major case crop in India. Statistical analyses ply a key role in current research studies on food security where yield time series analysis is used to estimate past yield trends and to predict future yield trends. Various types of statistical models have been used for the analysis of yield time series [1].

Reliable and timely forecasts are essential for agriculture policy making and also for crop production, marketing, storage and transportation decision [2-6]. This helps in managing risk associated with these activities [7]. Crop yield in different years are affected due to technological change, system productivity and climatic variability. Individual effects of weather parameters on crop yields were studied and yield forecasting models based on weather factors were given by Agrawal et al., [8] and Munu et al., [9]. Agrometeorological crop yield forecasting methods provide a quantitative estimate of the expected crop yield over a given area, in advance of the harvest provided no extreme conditions occur [10,2]. These are based on the common-sense assumption that weather conditions are the main factor behind the inter-annual (short- term) variations of de-trended crop yield series [3]. Hendrick and Scholl [4] have suggested models which require small number of parameters to be used while taking care of distribution pattern of weather over the crop season. Forecasting models were developed based on modified Hendrick and Scholl technique for sugarcane crops by using past years yield and weather data.

Considering the importance of wheat, mustard and potato crop a attempt was made to develop pre harvest yield forecasting statistical model in the at selected 11 districts of Western Uttar Pradesh.

2. MATERIALS AND METHODS

The models were first fitted to the time series included in our data sets and their qualities of fit were compared. The accuracy of the yield predications obtained with the models was then assessed by cross- validation. The long period (1992-2016) actual yield data of wheat, mustard and potato crop were collected from website of Directorate of Economics and Statistics, Department of Agricultural and cooperation, Ministry of Agriculture, Govt. of India [11]. The standard meteorological week (SMW) wise weather data from 40^{th} to 11^{th} were used to for wheat crop, from 40^{th} to 7^{th} SMW data were used to mustard crop and 41^{th} to 7^{th} SMW data were used to potato crop were used to develop regression model for 11 districts. The variables used in the study were weekly rainfall (mm), maximum and minimum temperature (^{0}C), RHI i.e. morning relative humidity(%) and RHII i.e. afternoon relative humidity (%). Different weather indices were generated using weekly values of weather parameters and their weighted values using correlation coefficient (Table-1). Similar work for Western Uttar Pradesh and eastern Uttar Pradesh has been reported by [12,13].

3. RESULTS AND DISSUSSION

3.1 Wheat Yield Forecasting

Using the statistical model yield forecasting was generated the coefficient of determination R^2 ranged between 0.44 to 0.96, F ranged between 11.5 to 56.9 and std. error ranged between 111.7 to 199.9. The wheat yield predication statistical model developed for 11 districts of western Uttar Pradesh (Table-2 & Fig -1). Show that Rainfall and Maximum temperature is the most important parameters common in all the models for wheat crop in most of the 11 districts under study of western Uttar Pradesh.

3.2 Mustard Yield Forecasting

The models developed for yield forecasting of mustard in 11 districts of western Uttar Pradesh (Table 3 & Fig. 2) show that R^2 value ranged between 0.57 to 0.87, F value ranged between 10.3 to 32.7 and Std. error ranged between 83.3 to 182.4. The Maximum temperature is the most important parameters common in all the models for Mustard crop in most of the 11 districts under study of western Uttar Pradesh.

3.3 Potato Yield Forecasting

The potato crop yield forecasting model developed for 11 districts of western Uttar Pradesh show that Maximum temperature is the

Table 1. Weather indices used in model is using composite weather variables

Weather	Simple weather indices					Weighted weather indices				
Parameter	**T max**	**T min**	**R/F**	**RH (I)**	**RH (II)**	**T max**	**T min**	**R/F**	**RH (I)**	**RH (II)**
T max	Z 10					Z 11				
T min	Z20	Z20				Z21	Z21			
R/F	Z30	Z30	Z30			Z31	Z31	Z31		
RH (I)	Z40	Z40	Z40	Z40		Z41	Z41	Z41	Z41	
RH (II)	Z50	Z50	Z50	Z50	Z50	Z51	Z51	Z51	Z51	Z51

Table 2. Pre-harvest yield forecasting statistical model (f3 stage) of wheat crop for different districts of Western Uttar Pradesh

S.No.	District	yield 2017-18	Equation	R^2	F	Std. error
1	Aligarh	3064	Y=2959.8+(25.0*Z51)+(-.05*Z150)+(.38*Z351)+(-.8*Z131)	0.72	11.5	188.6
2	Baghpat	4141	y=2228.5+(.04*Z341)+(37.0*time)+(.15*Z151)	0.85	37.4	148.2
3	Bareily	2895	Y=2681.7+(.11*Z351)+(.31*Z241)+(1.1*Z10)	0.87	26.9	136.4
4	Bijnor	2852	Y=1944.8+(.19*Z131)+(28.22*Z21)	0.76	32.2	111.7
5	Bulandshar	3821	Y=1293.8+(12.9*Z51)+(.07*Z351)+(4.9*Z41)	0.72	16.6	186.4
6	Ghazibad	3777	Y=5048.4+(53.4*Z11)	0.64	37.9	199.7
7	Meerut	3937	Y=3102.7+(29.8*time)+(.04*Z451)	0.79	56.9	145.1
8	Muzaffarnagar	3259	Y=5294.9+(58.7*Z11)	0.44	16.7	199.9
9	Rampur	3585	Y=3507.9+(.48*Z351)+(36.1*Z21)+(6.7*Z11)+(-.2*Z341)+(12.1*time)	0.92	41.6	115.3
10	Saranpur	3868	Y=2869.7+(.07*Z351)+13.9*Z51)	0.71	25.2	164.8
11	Shajanpuar	2925	Y=3071.3+(.5*Z351)+(12.2*Z41)+(39.8*time)+(-27.4*Z31)*(.07*Z451)+(25.2*Z21)	0.96	38.9	86.8

Table 3. Pre-harvest yield forecasting statistical model (f3 stage) of mustard crop for different districts of Western Uttar Pradesh

S. No.	District	yield 2017-18	Equation	R^2	F	Std. error
1	Aligarh	1737	Y=2156.0+(15.9*Z51)+(23.0*time)	0.73	20.6	159.3
2	Baghpat	1061	Y=981.3+(24.5*time)+(35.4*Z21)+(3.6*Z20)	0.78	27.1	83.4
3	Bareily	2777	Y=1198.9+(0.64*Z121)+(8.81*Z41)	0.69	14.4	170.2
4	Bijnor	1309	Y=981.3+(24.5*time)+(35.4*Z21)+(3.6*Z20)	0.87	31.3	89.7
5	Bulandshar	1066	Y=2876.9+(28.09*Z11)+(0.13*Z251)	0.81	32.6	79.8
6	Ghazibad	1215	y=905.0+(0.65*Z121)+(9.9*Z41)	0.77	25.8	85.1
7	Meerut	1246	Y=1197.3+(0.6*Z121)+(8.8*Z41)	0.78	27.2	83.3
8	Muzaffarnagar	1185	Y=213.2+(20.1*Z11)+(1.4*Z121)	0.57	10.3	114.3
9	Rampur	2850	Y=1984.5+(32.1*Z21)+(.2*Z131)	0.76	32.7	111.1
10	Saharanpur	2647	Y=2361.7+(27.6*Z21)+(48.1*Z451)+(0.38*time)	0.68	21.4	171.9
11	Shajanpuar	3892	Y=2782.9+(42.8*time)+(.16*Z351)+(75.6*Z21)	0.83	31.3	182.4

Table 4. Pre-harvest yield forecasting statistical model (f3 stage) of potato crop for different districts of Western Uttar Pradesh

S.No.	District	yield 2017-18	Equation	R^2	F	Std. error
1	Aligarh	26098	Y=52221.4+(12.6*Z121)+(293.3*Z11)	0.85	23.9	956.4
2	Baghpat	22098	y=42543.9+(288.7*Z11)+2.34*Z241)	0.91	40.9	843.1
3	Bareily	22693	Y=-4180.8+(357.9*Z41)+(68.1*Z51)	0.88	30.3	106.8
4	Bijnor	22097	Y=42539.7+(288.8*Z11)+(2.3*Z241)	0.91	33.3	843.3
5	Bulandshar	20805	y=19692.8+(55.0*Z51)	0.74	26.5	903.5
6	Ghazibad	25181	Y=-13503.2+(4.0*Z151)+57.0*Z41)+263.1*time)(1.4*Z120)	0.98	91.3	662.2
7	Meerut	21431	Y=1055.3+(7.5*Z141)+(5.1*Z251)	0.96	104.8	746.2
8	Muzaffarnagar	17438	Y=4999.6+(1073.9*Z11)	0.54	96.8	257.3
9	Rampur	25448	Y=14532.8+(1.9*Z451)	0.71	22.4	846.7
10	Saharanpur	17863	Y=38339.7(3.1*Z151)+(12.0*Z131)+(-3.0*Z351)+(-.15*Z350)	0.99	144.5	406.9
11	Shajanpuar	16351	Y=4139.1+(37.2*time)+(149.3*Z41)+(1.7*Z130)	0.81	102.6	241.3

Table 5. Validation of statistical model in 2015 and 2016 for wheat, mustard and potato different 11 districts of western Uttar Pradesh

	Error percent of forecasts from observed yield (2015)			Error percent of forecasts from observed yield (2016)		
District	**Wheat**	**Mustard**	**potato**	**Wheat**	**Mustard**	**potato**
Aligarh	7.7	2.6	2.3	5.2	7.6	5.7
Baghpat	-4.3	0.8	3.5	-7.1	-3.2	2.4
Bareily	4.1	4.0	-8.9	2.5	1.8	-8.2
Bijnor	0.3	5.8	3.5	0.1	6.0	0.9
Bulandshar	7.0	7.8	4.6	3.7	7.2	5.6
Ghazibad	1.4	-0.4	-6.1	-1.3	-4.1	-4.6
Meerut	6.8	6.2	-5.7	5.1	8	-4.6
Muzaffarnagar	6.8	0.8	-7.1	4.6	4.4	-5.6
Rampur	-1.2	3.1	-2.2	-3	1.0	-3.8
Saharanpur	7.3	4.1	-2	4.9	3.7	0.7
Shajanpuar	-4.5	2.7	2.9	-2.4	0.3	1.3

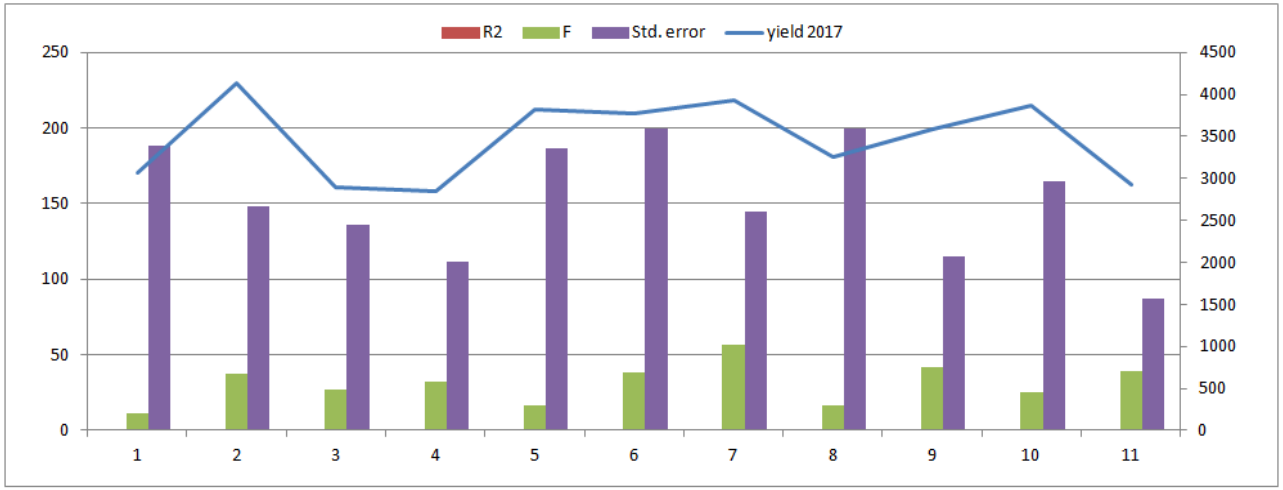

Fig. 1. Pre-harvest yield forecasting statistical model (f3 stage) of wheat crop for different districts of Western Uttar Pradesh

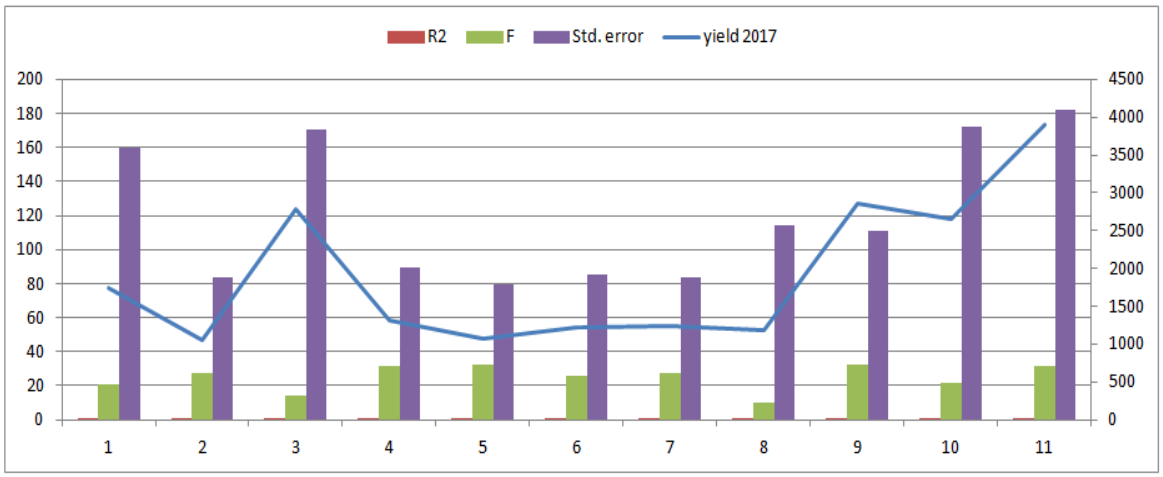

Fig. 2. Pre-harvest yield forecasting statistical model (f3 stage) of mustard crop for different districts of Western Uttar Pradesh

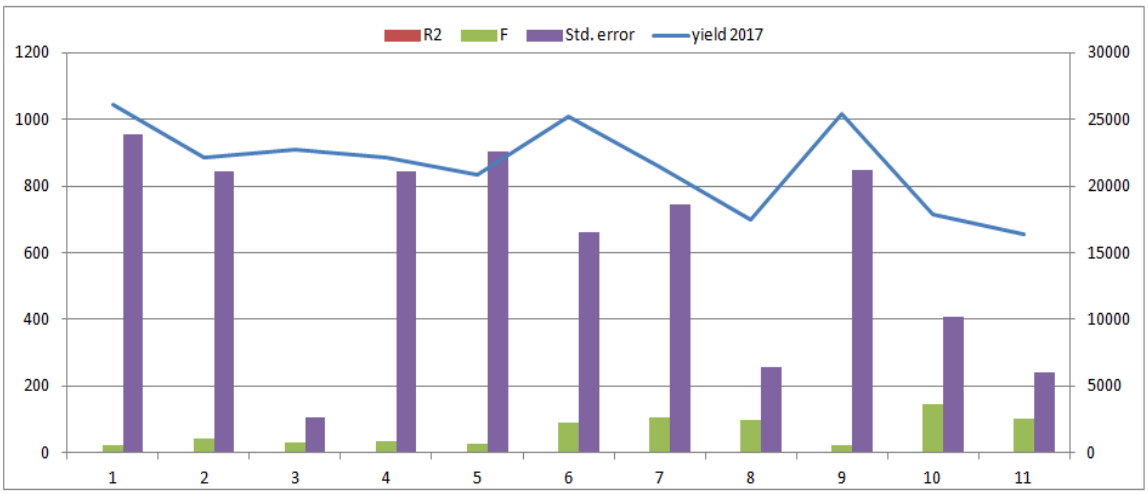

Fig. 3. Pre-harvest yield forecasting statistical model (f3 stage) of mustard crop for different districts of Western Uttar Pradesh

most important parameters. The coefficient of determination R^2 ranged between 0.54 to 0.99 and F ranged 23.9 to 144.5 and std. error 106.8 to 956.4 that these models (Table-4 &Fig 3) can be used for predicting the potato yield in the 11 districts of western Uttar Pradesh. The Maximum temperature is the most important parameters common in all the models for potato crop in most of the 11 districts under study of western Uttar Pradesh. Hence these models can be used to forecasting wheat, mustard and potato crop yield in the 11 districts under study.

Time series data on yield of potato and weekly data from 40th SMW of the previous year to 6th SMW of the following year on five weather variables viz., Minimum Temperature, Maximum Temperature, Relative humidity 08.30hrs, Relative humidity 17.30 hrs, and Wind-Velocity covering the period from 1992 to 2017 have been utilized for development of preharvest forecast model. Statistical methodologies using multiple regression, principal component analysis for developing pre-harvest forecast model have been described. In both models (one based on regression and one from principal component) have been developed.

3.4 Validation of Statistical Model

Between the actual and predicted value of wheat, mustard and potato crop yield for Aligarh,

Baghpat, Barielly, Bijnor, Bulandshahar, Gaziabad, Meerut, Muzaffarnagar, Rampur, Saharnpur and Sahjahnpur Western Uttar Pradesh in used developing the Statistical Model is present in the (Table-5). Results show that in the different 11 districts for the year 2015 and 2016 present of 2015-2016 the percentage error where also calculated that the actual yield and forecasted yield is acceptable ranged between the ±0.1 to 8.9 percent [14].

4. CONCLUSION

It is concluded that during both the years of validation the observed yields were in good agreement with forecasted yield for wheat, mustard as well as potato crop.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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