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THE INFLUENCE OF WEATHER VARIABILITY ON YIELD AND PRODUCTION OF WHEAT (*TRITICUM* SPP.) CROP IN JUNAGADH DISTRICT OF GUJARAT STATE UNDER CLIMATE CHANGE

D.R. Vaghasiya*, M.C. Chopada, B.S. Gohil and H.N. Der
Department of Agronomy, Agrometeorological Cell,
Junagadh Agricultural University, Junagadh 362001 (Gujarat), India
E-mail: dhimantagmet@gmail.com

Abstract: An attempt has been made to quantify the effect of climate change on Wheat production and relationship between weather parameters and district level yield of wheat crop in Jamnagar district of Gujarat state. In this investigation, using original weather variables, week wise approach was used. The yield of the district was included as dependent variable and weather variables *viz*. minimum temperature (X_1), maximum temperature (X_2), morning relative humidity (X_3), afternoon relative humidity (X_4), sunshine hours (X_5) and total annual rainfall of past year (X_6) were analyzed for the crop weather relationship to develop regression model. The time trend (T) was also included as explanatory variable. The data pertaining for the period of 35 years weather and crop yield records of Junagadh district were collected. Result revealed that the model of 15 weeks crop period could be suggested as a pre-harvest forecast model. The variation explained by this model was 91.72% and simulated forecast error was less than 3%. This model could be utilized for pre-harvest forecast four weeks before expected harvesting period of Wheat crop.
Keywords: Weather variables, Wheat, Regression, Statistical model, Forecasting.

INTRODUCTION

For monsoon dependent country, timely and reliable forecast of crop yield is of great importance. Pre-harvest forecast of wheat yield is useful for advance planning, formulation and implementation of policies relating to import-export and exercising several other administrative measures. Forecast of agricultural production is useful to farmers, government and agribusiness industries. Timely forecast of crop productions is important for improving market efficiency. Processor in the marketing chain need forecast to aid in their purchasing and storing decisions. Even agricultural journalists require forecast and they provide indirect way for farmers and extension worker to receive outlook forecasts.

Wheat (*Triticum spp*.) is the most important grain crop both in regard to its antiquity and its use as a source of human food. Wheat serves as a staple food for about one billion people in as many as 43 countries of the world. Today, among the cereal crops grown in India, wheat

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comes next only to rice in terms of area and production. It is a member of *Poaceae* family and believed to be originated from the Middle-East region of Asia. India is the second largest producer of wheat in the world contributing about 80.80 million tones of grains with productivity of 2839 kg/ha from the area of 28.64 million hectares. In Gujarat, wheat occupies 8.53 lakh hectares with total production of 23.38 lakh tones and productivity of 2740 kg/ha (Anonymous, 2010). Wheat is grown in India under sub-tropical environment during *rabi* season. Well-drained loams and clayey loams are considered to be ideal for wheat. Continuous warm conditions prevailing in Central Zone restrict the yield in about 4.7 million hectares. In Gujarat (which is a part of Central Zone), wheat is generally grown under timely sown irrigated conditions.

The weather variables like rainfall, maximum and minimum temperature, relative humidity and sunshine hours affect growth and development in different ways and at different times during the growth cycle of the crop. The relationship between crop yields and weather parameters can be identified with the help of multiple regression models (Agrawal *et. al*, 2001).

MATERIALS AND METHODS

With a view to investigate the feasibility of estimating the yield of wheat crop based on weather variables using past weather records for Junagadh district. Considering the specific objective of the study, wheat yield data of Junagadh district for the years 1976 to 2010 were obtained from the Department of Economics, JAU, Junagadh. The complete meteorological data of Junagadh (Lat: $21^{o}31`$ N, Long: $70^{o}36`$E) were collected from Department of Agronomy, Agro-meteorological Cell, JAU, Junagadh for the corresponding period.

Weekly averaged data of weather variables *viz.* (1). Minimum temperature (X_1), (2). Maximum temperature (X_2), (3). Morning relative humidity (X_3), (4). Afternoon relative humidity (X_4), (5). Sunshine hours (X_5) and (6). Total annual rainfall of past year (X_6) was collected for growing season of wheat in Junagadh distract for the years under consideration.

The sowing of Wheat mainly concentrated around third week of October in Gujarat. Hence the data pertaining to the weather parameters for the period 42^{nd} week to 7^{th} week of next year were included in the present study.

For selecting the best regression equation among the number of independent variables, the stepwise regression procedure was used (Draper and Smith, 1966). The best regression equation for predictive purpose, should be such as would include as many independent

variables as possible, but at the same time, reject all those variables which do not contribute significantly to the prediction model**.** There is no unique statistical procedure to compromise between these two extremes, but stepwise regression analysis procedure which is generally applied under such circumstances and considered as the best selection procedure.

Though, the number of observations are less than the number of variables, the technique was adopted by turn to all the independent variables, along with a sub set of 24 to 28 variables to 35 years data (with F= 3, 2 to enter and remove) Further, this procedure was repeated for those entered explanatory variables in such a way that maximum coefficient of determination could be achieved**.**

Finally, selected explanatory variables in each model were used for regression analysis**.** The least squares solution for the model provided a set of normal equations to be solved for the 'k' partial regression coefficient and tested for their significance by 't' test and the regression sum of squares by the 'F' test (Snedecor and Cochran, 1967). Four sets of the multiple linear regression equations were obtained separately for 31 to 34 years data for each approach and predicted the yield of wheat**.**

Statistical computer software Microstat was used for the analysis of the data with the probability level 0.05 and 0.1 to remove the variables. The Using original weather variables, week wise approach were used.

With a view to assess the accuracy and capability of earlier forecasts at an interval of weeks, four models were fitted, considering up to 13, 14, 15 and 16 weeks after sowing during the crop period. The details of variables included in model up to 18 weeks crop period are given in Table 1. The time trend variable was included in this analysis as an explanatory variable.

The mathematical expression of this approach,

$$Y = A_0 + \sum_{i=1}^{p} \sum_{j=1}^{w} a_{ij} X_{ij} + bR + cT$$

Where,

Y = Average Wheat yield of district in kg/ha

$\mathbf{A_0}$ = Constant

$\mathbf{X_{ij}}$= Observed value of i^{th} weather variable in j^{th} week i = 1,2,... p = 6 and j = 1,2,...w = 13, 14, 15, 16

R = Total rainfall of past season of the district in mm.

T = Year number included to correct for the long term upward or downward trend in yield (T = 1,2…t=30)

$\mathbf{a_{ij}}$, **b** and **c** are partial regression coefficients associated with each $\mathbf{X_{ij}}$, rainfall and time trend **(T)** respectively.

RESULTS AND DISCUSSION

To determine the effect of week wise weather variables on Wheat yield, the variables which appeared in the equation and had significant partial regression coefficient were considered to have influence on wheat production. The results presented in two parts for each crop period for the model. First part deals with fitted regression equations and second part deals with their corresponding simulated forecasts for subsequent years not including for obtaining the regressions.

The result related to the 13 week crop period, represented in the table-2 revealed that there is a positive and significant effect of time trend (T), minimum temperature of 2nd week (X_{102}), maximum temperature of 5th,7th & 12th week ($X_{205,}$ $X_{207,}$ X_{212}), morning relative humidity of 13th week (X_{313}), afternoon relative humidity of 5th & 8th week (X_{405}, X_{408}) and sunshine hours of 2nd week (X_{502}) observed in all the four models. The negative and significant effect on wheat crop yield (Y) is observed in case of minimum temperature of 13th week (X_{113}), maximum temperature of 3rd & 4th week ($X_{203,}$ X_{204}), morning relative humidity of 4th& 5th week ($X_{304,}$ X_{305}), afternoon relative humidity of 2nd week (X_{402}) and sunshine hours of 4th week (X_{504}) corresponding to the sowing, vegetative, flowering and maturity stages of the crop. The coefficient of determination (R^2) varied from 87.56 to 89.55 % and the predicted values (Table-3) showed 0.02 to 16.87 per cent deviations from recorded yield of Junagadh district.

In case of 14 week crop period, in the table-4, result revealed that there is a positive and significant effect of time trend (T), minimum temperature of 3rd week (X_{103}) and morning relative humidity of 4th week (X_{304}) in all four models. The negative and significant effect influence on wheat crop is observed in case of minimum temperature of 13th week (X_{113}), maximum temperature of 4th, 7th, 12th& 14th week ($X_{204,}$ $X_{207,}$ $X_{212,}$ X_{214}), morning relative humidity of 5th& 7th week ($X_{305,}$ X_{307}), afternoon relative humidity of 4th week (X_{405}) and sunshine hours of 2nd week (X_{502}) correspond to the sowing, vegetative, flowering and maturity stages of the crop. The coefficient of determination (R^2) varied from 81.44 to 82.24 % and the predicted values (Table-5) showed 2.21 to 11.31% deviation from recorded yield of Junagadh district.

In case of 15 week crop period, in the table-6, result revealed that there is a positive and significant effect of minimum temperature of 1st, 7th& 15th week ($X_{101,}$ $X_{107,}$ X_{115}), maximum temperature of 14th week (X_{214}), morning relative humidity of 4th week (X_{304}) and sunshine hours of 4th week (X_{504}) in all four models. The negative and significant effect influence on wheat crop is observed in case of time trend (T), minimum temperature of 3rdweek (X_{103}), maximum temperature of 4th, 7th, 11th& 15th week ($X_{204,}$ $X_{207,}$ $X_{211,}$ X_{215}), morning relative humidity of 5th& 7th week ($X_{305,}$ X_{307}), afternoon relative humidity of 4th week (X_{405}) and sunshine hours of 2nd week (X_{502}) correspond to the sowing, vegetative, flowering and maturity stages of the crop. The coefficient of determination (R^2) varied from 89.52 to 91.72 % and the predicted values (Table-7) showed 2.65 to 15.71% deviation from recorded yield of Junagadh district.

In case of 16 week crop period, in the table-8, result revealed that there is a positive and significant effect of minimum temperature of 1st, 7th& 15th week ($X_{101,}$ $X_{107,}$ X_{115}), maximum temperature of 14th week (X_{214}), morning relative humidity of 2nd, 4th& 7th week ($X_{302,}$ $X_{304,}$ X_{307}) and sunshine hours of 8th week (X_{508}) in all four models. The negative and significant effect influence on wheat crop is observed in case of time trend (T), minimum temperature of 3rd week (X_{103}), maximum temperature of 4th, 7th, 11th& 15th week ($X_{204,}$ $X_{207,}$ $X_{211,}$ X_{215}), morning relative humidity of 5th (X_{305}), seasonal rainfall of (X_6) correspond to the sowing, vegetative, flowering and maturity stages of the crop. The coefficient of determination (R^2) varied from 87.44 to 89.20 % and the predicted values (Tabl-9) showed 7.28 to 18.28% deviation from recorded yield of Junagadh district. The finding results are also collaborate with those of Bal et al. (2004), Varmora et al. (2004), Khistaria et al. (2004) and Sreenivas et al. (2005).

Wheat is a Rabi (winter) crop. The effect of rainfall (X_6) on Wheat yield for different weeks, with their corresponding meteorological week (MSW) revealed that there is no significant effect of rainfall on Wheat crop in Junagadh district.

The comparison of the models with respect to their predictability and deviation of simulated forecasts from the actual yield revealed that in all fitted models, R^2 was not considerable and simulated forecasts deviated much more from observed yields. Therefore none of the model could be considered for pre-harvest forecast.

It could be observed from the results of Junagadh district that in all the approaches and models fitted, positive and significant effects of time trend was seen on the yield of wheat. It could also be noticed that for different models under different approaches, using original

weather variables 15 week period model was the best fitted. In case of 15 week period model R^2 was more than 90% and the deviations of simulated forecasts from recorded yield were less than 3%. Therefore, the following forecast model of wheat yield for Junagadh district is recommended,

The recommended model for Junagadh district is, (15 - week crop period)

$$\mathbf{Y = 16244.09 - 11.96^{**} T + 7.89^{**} X_{101} - 39.52^{**} X_{103} + 81.35^{**} X_{107} + 89.57^{**} X_{115} - 177.51^{**} X_{204} - 97.60^{**} X_{207} - 69.75^{**} X_{211} + 3.76^{**} X_{214} - 98.17^{**} X_{215} + 28.71^{**} X_{304} - 31.06^{*} X_{305} - 7.17^{*} X_{307} - 7.44^{**} X_{405} - 56.18^{**} X_{502} + 82.34^{**} X_{504}}$$

$$\mathbf{(R^2 = 91.72\%)}$$

CONCLUSION

For Junagadh district, the 15 weeks period model could be preferred for forecasting yield before four weeks in advance of expected harvesting period of wheat crop. The fitted model indicated that there is a positive and significant effect of minimum temperature of 1st, 7th& 15th week ($X_{101,}$ $X_{107,}X_{115}$), maximum temperature of 14thweek (X_{214}), morning relative humidity of 4th week (X_{304}) and sunshine hours of 4th week (X_{504}) in all four models. The negative and significant effect influence on wheat crop is observed in case of time trend (T), minimum temperature of 3rd week (X_{103}), maximum temperature of 4th, 7th, 11th& 15th week ($X_{204,}$ $X_{207,}$ $X_{211,}$ X_{215}), morning relative humidity of 5th& 7th week ($X_{305,}$ X_{307}), afternoon relative humidity of 4th week (X_{405}) and sunshine hours of 2nd week (X_{502}) correspond to the sowing, vegetative, flowering and maturity stages of the crop.

REFERENCES

[1]. Agrawal, R., Jain, R.C. and Mehta, H.C. (2001). Yield forecast based on weather variables and agricultural input on agroclimatic zone basis. *Indian J. Agril. Sci.,* **71**(7): 487-90.

[2]. Anonymous (2010). Directorate of economics & statistics, department of agriculture & co-operation, Ministry of Agriculture, Government of India, New Delhi.

[3]. Bal, S.K., Mukherjee, J., Mallick, K. and Hundal, S.S. (2004). Wheat yield forecasting models for Ludhiana district of Punjab state. *J. Agro. met.,* **6** (Sp. Issue): 161-165.

[4]. Draper, N.R. and Smith, H**.** (1966). "Applied Regression Analysis", Johan Wiley and Sons, New York.

[5]. Khistaria, M.K., Varmora, S.L., Dixit, S.K., Kalola, A.D. and Rathod, D.N. (2004). Pre-harvest forecasting of wheat yield from weather variables in Rajkot district of Gujarat. *J. Agro. Met.,* **6** (special issue): 197-203.

[6]. Shreenivas, G.; Raji, Reddy, D. and Narasimha Rao S.B.S. (2005). Influence of weather parameters on yield of lowland rice. *J. Agro. met.,* **7**(1):69-75.

[7]. Snedecore, G.W. and Cochran, W.G. (1967). Statistical Methods (6th Edition): Oxford and IBH Publishing Co. New Delhi.

[8]. Varmora, S.L.; Dixit, S.K.; Patel, J.S. and Bhatt, H.M. (2004). Forecasting of wheat yield on the basis of weather variables. *J. Agro. Met*., **6** (2): 223-228.

Table 1: Variables included in the model week wise approach up to 18 weeks crop period for wheat

Meteo. Std. week No. (MSW)	**Crop week No.**	**Temperature**		**Relative humidity**		**Sunshine hours**	**Rainfall**
		Min.	**Max.**	**M**	**A**		
		X_{1j}	X_{2j}	X_{3j}	X_{4j}	X_{5j}	X_6
42	01	X_{101}	X_{201}	X_{301}	X_{401}	X_{501}	X_6
43	02	X_{102}	X_{202}	X_{302}	X_{402}	X_{502}	
44	03	X_{103}	X_{203}	X_{303}	X_{403}	X_{503}	
45	04	X_{104}	X_{204}	X_{304}	X_{404}	X_{504}	
46	05	X_{105}	X_{205}	X_{305}	X_{405}	X_{505}	
47	06	X_{106}	X_{206}	X_{306}	X_{406}	X_{506}	
48	07	X_{107}	X_{207}	X_{307}	X_{407}	X_{507}	
49	08	X_{108}	X_{208}	X_{308}	X_{408}	X_{508}	
50	09	X_{109}	X_{209}	X_{309}	X_{409}	X_{509}	
51	10	X_{110}	X_{210}	X_{310}	X_{410}	X_{510}	
52	11	X_{111}	X_{211}	X_{311}	X_{411}	X_{511}	
1	12	X_{112}	X_{212}	X_{312}	X_{412}	X_{512}	
2	13	X_{113}	X_{213}	X_{313}	X_{413}	X_{513}	
3	14	X_{114}	X_{214}	X_{314}	X_{414}	X_{514}	
4	15	X_{115}	X_{215}	X_{315}	X_{415}	X_{515}	
5	16	X_{116}	X_{216}	X_{316}	X_{416}	X_{516}	
6	17	X_{117}	X_{217}	X_{317}	X_{417}	X_{517}	
7	18	X_{118}	X_{218}	X_{318}	X_{418}	X_{518}	
T= Time trend				**Y= Yield**			

Table 2: Regression equations for 13 - week crop period of Junagadh district

Variables in model	Models for different years			
	Model-I (31 year)	**Model-II (32 year)**	**Model-III (33 year)**	**Model-IV (34 year)**
Constant	**7337.29**	**8972.22**	**9691.63**	**9652.14**
T	28.81**	28.78**	24.00**	24.64**
X_{102}	36.41**	31.05**	36.42**	37.91**
X_{113}	-49.62**	-61.89**	-78.19**	-78.72**
X_{203}	-181.02**	-153.85**	-112.87**	-112.95**
X_{204}	-108.74**	-124.12**	-159.31**	-161.57**
X_{205}	124.97**	96.93**	89.84**	92.42**
X_{207}	15.48**	2.79**	-11.91**	-11.23**
X_{212}	41.03**	2.18**	-6.61**	-6.30**
X_{304}	-46.38*	40.99*	37.46*	36.59*
X_{305}	-13.49*	-45.28*	-44.16*	-43.91*
X_{313}	13.81**	-10.74**	-8.37**	-8.40**
X_{402}	-11.76**	4.81**	0.15**	1.03**
X_{405}	11.82**	-4.94**	-4.73**	-5.09**
X_{408}	19.63**	5.84**	4.17**	4.72**
X_{502}	140.61**	9.45**	28.09**	29.55**
X_{504}	-27.52**	68.64**	97.46**	95.10**
S.E.	287.75	291.25	307.49	298.94
R^2 (%)	**89.55**	**89.47**	**87.58**	**87.56**

*Significant at 5% level. ** Significant at 1% level.

Table 3: Simulated forecast values for 13 - week crop period of Junagadh district (week wise approach)

Year	Observed yield (kg/ha)	Predicted values (kg/ha)			
		Model-I(31 year)	**Model-II(32 year)**	**Model-III(33 year)**	**Model-IV(34 year)**
2007-08	**4225**	3512 (16.87)	--	--	--
2008-09	**2933**	3103 (5.82)	3120 (6.39)	--	--
2009-10	**3424**	3425 (0.03)	3425 (0.03)	3335 (2.57)	--
2010-11	**4314**	4177 (3.17)	4021 (6.78)	3709 (14.02)	3735 (13.40)

Figures in ( ) are percent deviation from observed yield.

Table 4: Regression equations for 14 - week crop period of Junagadh district

Variables Inmodel	Models for different years			
	Model-I (31 year)	**Model-II (32 year)**	**Model-III (33 year)**	**Model-IV (34 year)**
Constant	**12299.13**	**11295.74**	**12066.86**	**12093.22**
T	11.36**	4.27**	3.87**	5.11**
X_{103}	8.11**	5.72**	0.73**	1.18**
X_{113}	-71.75**	-44.05**	-48.65**	-48.55**
X_{204}	-137.82**	-125.60**	-137.79**	-139.86**
X_{207}	-45.23**	-44.05**	-46.81**	-44.19**
X_{212}	-26.58**	-28.38**	-25.39**	-24.17**
X_{214}	-2.85**	12.44**	5.95**	3.73**
X_{304}	38.14*	39.67*	39.06*	38.25*
X_{305}	-41.99*	-41.65*	-39.81*	-39.58*
X_{307}	-12.90**	-13.93**	-15.45**	-15.11**
X_{405}	-9.73**	-10.71**	-10.75**	-10.60**
X_{502}	-29.22**	-41.05**	-44.03**	-45.87**
S.E.	338.20	336.02	331.99	325.90
R^2 (%)	**81.44**	**82.24**	**81.90**	**81.73**

*Significant at 5% level. ** Significant at 1% level.

Table 5: Simulated forecast values for 14 - week crop period of Junagadh district (week wise approach)

Year	Observed yield (kg/ha)	Predicted values (kg/ha)			
		Model-I (31 year)	**Model-II (32 year)**	**Model-III (33 year)**	**Model-IV (34 year)**
2007-08	**4225**	4688 (10.96)	--	--	--
2008-09	**2933**	3223 (9.90)	3264 (11.31)	--	--
2009-10	**3424**	3348 (2.21)	3286 (4.01)	3245 (5.21)	--
2010-11	**4314**	3932 (8.85)	3868 (10.32)	3834 (11.11)	3867 (10.34)

Figures in ( ) are percent deviation from observed yield.

Table 6: Regression equations for 15 - week crop period of Junagadh district

Variables Inmodel	Models for different years			
	Model-I (31 year)	Model-II (32 year)	Model-III (33 year)	Model-IV (34 year)
Constant	**15897.39**	**15702.09**	**16244.48**	**16369.55**
T	-12.06**	-12.23**	-11.86**	-7.17**
X_{101}	1.58**	1.73**	7.89**	21.21**
X_{103}	-31.70**	-31.69**	-39.52**	-45.68**
X_{107}	79.46**	77.87**	82.35**	77.43**
X_{115}	90.59**	90.39**	89.57**	84.81**
X_{204}	-169.18**	-167.57**	-177.51**	-189.90**
X_{207}	-95.55**	-94.91**	-97.60**	-91.77**
X_{211}	-69.04**	-69.07**	-69.75**	-91.77**
X_{214}	5.26**	5.82**	3.76**	-0.09**
X_{215}	-95.06**	-94.66**	-98.17**	-94.48**
X_{304}	29.84**	30.00**	28.71**	24.93**
X_{305}	-32.60*	-32.68*	-31.06*	-28.81*
X_{307}	-6.44*	-6.32*	-7.17*	-6.87*
X_{405}	-7.64**	-7.78**	-7.44**	-6.16**
X_{502}	-52.26**	-52.61**	-56.18**	-59.86**
X_{504}	63.30**	72.69**	82.34**	68.94**
S.E.	282.29	273.44	265.81	274.33
R^2 (%)	**89.94**	**90.72**	**91.72**	**89.52**

*Significant at 5% level. ** Significant at 1% level.

Table 7: Simulated forecast values for 15 - week crop period of Junagadh district (week wise approach)

Year	Observed yield (kg/ha)	Predicted values (kg/ha)			
		Model-I (31 year)	Model-II (32 year)	Model-III (33 year)	Model-IV (34 year)
2007-08	**4225**	4337 (2.65)	--	--	--
2008-09	**2933**	3088 (5.29)	3072 (4.77)	--	--
2009-10	**3424**	2978 (13.01)	2958 (13.60)	2954 (13.71)	--
2010-11	**4314**	3646 (15.46)	3636 (15.71)	3675 (14.79)	3844 (10.87)

Figures in ( ) are percent deviation from observed yield.

Table 8: Regression equations for 16 - week crop period of Junagadh district

Variables In model	Models for different years			
	Model-I(31 year)	Model-II(32 year)	Model-III(33 year)	Model-IV(34 year)
Constant	**17907.17**	**17703.45**	**18683.88**	**18389.61**
T	-4.20**	-9.80**	-10.65**	-7.52**
X_{101}	8.51**	13.41**	22.47**	37.34**
X_{103}	-31.40**	-28.65**	-38.52**	-42.79**
X_{107}	74.91**	60.34**	64.00**	59.98**
X_{115}	120.17**	124.58**	124.14**	118.48**
X_{204}	-208.28**	-208.88**	-225.47**	-233.51**
X_{207}	-122.54**	-123.83**	-129.72**	-120.16**
X_{211}	-91.41**	-83.09**	-86.18**	-73.92**
X_{214}	5.86**	13.51**	12.91**	7.69**
X_{215}	-125.18**	-122.08**	-126.73**	-118.00**
X_{302}	6.57**	2.68**	2.32**	0.82**
X_{304}	19.24*	19.79*	17.56*	15.42*
X_{305}	-31.75*	-27.97*	-24.90*	-23.13*
X_{307}	0.26**	1.09**	0.18**	0.09**
X_{508}	93.91**	51.72**	53.14**	25.88**
X_6	-0.15**	-0.15**	-0.17**	-0.12**
S.E.	292.55	297.70	290.87	300.38
R^2 (%)	**89.20**	**89.00**	**88.88**	**87.44**

*Significant at 5% level. ** Significant at 1% level.

Table 9: Simulated forecast values for 16 - week crop period of Junagadh district (week wise approach)

Year	Observed yield (kg/ha)	Predicted values (kg/ha)			
		Model-I (31 year)	Model-II (32 year)	Model-III (33 year)	Model-IV (34 year)
2007-08	**4225**	4745 (12.30)	--	--	--
2008-09	**2933**	3146 (7.28)	3164 (7.87)	--	--
2009-10	**3424**	2891 (15.54)	2895 (15.43)	2885 (15.73)	--
2010-11	**4314**	3599 (16.57)	3525 (18.28)	3544 (17.84)	3694 (14.35)

Figures in ( ) are percent deviation from observed yield.