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Estimation of cotton yield based on weather parameters of Junagadh district in Gujarat state

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ABSTRACT

The study was carried out to find the quantitative relationship between weather parameters and district level yield of cotton. For this purpose 32 years weather and crop yield records of Junagadh district (India) were collected. A twenty six week crop period model was recommended for pre harvest forecast due to higher R^2 value and lower simulated forecast deviation. The time trend, maximum temperature, morning and evening relative humidity significantly affected crop yield.

Key words: Cotton, prediction equation, forecasting, weather variables.

Crop weather models have become key to predict crop yield in a vast country like India for planners and policy makers. Cotton is an important cash crop grown under rain fed as well as irrigated condition in India. Junagadh district belongs to South Saurstra Agroclimatic zone and has a productivity 638 kg ha^{-1}. with total area of about 30500 hactares under cultivation. The relationship between crop yield and weather parameters is generally carried out with the help of multiple regression models(Agrawal & Mehta, 2001). The present study was undertaken to investigate the feasibility of estimating the yield of cotton crop based on weather variables using past weather records for Junagadh district **(**Dubey *et al.*,1995 and Singh & Singh, 1988)

MATERIALS AND METHODS

To meet the objective, the yield data of cotton crop for the period of recent 32 years (1975-76 to 2006-07) of Junagadh district were collected from Season and Crop Report published by Directorate of Agriculture, Gujarat State (Anonymous, 2006-07). Corresponding data on weather parameters were collected from meteorological observatory situated in Junagadh and Anand Agricultural Universities. While data for the period from 22nd meteorological standard week (MSW) to 47th week of each year were collected. For selecting best regression equation with significant weather variables, the stepwise regression procedure was adopted for 28 years data i.e. 1075-76 to 2002-03. The simulated forecasts based on these selected variables for next four years i.e. 2003-04 to 2006-07 and deviation from the actual yields were worked out.

To achieve earliest forecasts four models were fitted by using original weather variables, week wise considering up to 17, 20, 23 and 26 weeks of crop period. The time trend variable was included in this analysis as an explanatory variable.

The variables used in this study were weekly average of,

(1) Rainfall (m.m.) (X_1)
(2) Maximum temperature (^{0}C) (X_2)
(3) Minimum temperature (^{0}C) (X_3)
(4) Morning relative humidity (%) (X_4)
(5) After noon relative humidity (%) (X_5)
(6) Sunshine hours (X_6)

The mathematical expression of this approach,

$$Y = A + \sum_{i=1}^{p} \sum_{j=1}^{w} a_{ij} X_{ij} + bT$$

Where,

Y = Average cotton yield of district kg ha^{-1}
A = 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= 17, 20, 23, 26
T = Year number included to correct for the long term upward or downward trend in yield (**T**= 1,2,**.... t**)
$\mathbf{a_{ij}}$, and **b** = are partial regression coefficients associated with each Xij, and time trend respectively**.**

RESULTS AND DISCUSSION

The results are presented in two parts for different models. First part deals with fitted regression equations.

Table 1: Variables included in the model week wise approach up to 26 weeks crop period.

Meteo. Std. week No. (MSW)	Crop week No.	Rain fall (mm)	Temperature (^{0}C)		Relative humidity (%)		Sunshine hours
			Max.	Min.	M	E	
		X_{1j}	X_{2j}	X_{3j}	X_{4j}	X_{5j}	X_{6j}
22	01	X_{101}	X_{201}	X_{301}	X_{401}	X_{501}	X_{601}
23	02	X_{102}	X_{202}	X_{302}	X_{402}	X_{502}	X_{602}
24	03	X_{103}	X_{203}	X_{303}	X_{403}	X_{503}	X_{603}
25	04	X_{104}	X_{204}	X_{304}	X_{404}	X_{504}	X_{604}
26	05	X_{105}	X_{205}	X_{305}	X_{405}	X_{505}	X_{605}
27	06	X_{106}	X_{206}	X_{306}	X_{406}	X_{506}	X_{606}
28	07	X_{107}	X_{207}	X_{307}	X_{407}	X_{507}	X_{607}
29	08	X_{108}	X_{208}	X_{308}	X_{408}	X_{508}	X_{608}
30	09	X_{109}	X_{209}	X_{309}	X_{409}	X_{509}	X_{609}
31	10	X_{110}	X_{210}	X_{310}	X_{410}	X_{510}	X_{610}
32	11	X_{111}	X_{211}	X_{311}	X_{411}	X_{511}	X_{611}
33	12	X_{112}	X_{212}	X_{312}	X_{412}	X_{512}	X_{612}
34	13	X_{113}	X_{213}	X_{313}	X_{413}	X_{513}	X_{613}
35	14	X_{114}	X_{214}	X_{314}	X_{414}	X_{514}	X_{614}
36	15	X_{115}	X_{215}	X_{315}	X_{415}	X_{515}	X_{615}
37	16	X_{116}	X_{216}	X_{316}	X_{416}	X_{516}	X_{616}
38	17	X_{117}	X_{217}	X_{317}	X_{417}	X_{517}	X_{617}
39	18	X_{118}	X_{218}	X_{318}	X_{418}	X_{518}	X_{618}
40	19	X_{119}	X_{219}	X_{319}	X_{419}	X_{519}	X_{619}
41	20	X_{120}	X_{220}	X_{320}	X_{420}	X_{520}	X_{620}
42	21	X_{121}	X_{221}	X_{321}	X_{421}	X_{521}	X_{621}
43	22	X_{122}	X_{222}	X_{322}	X_{422}	X_{522}	X_{622}
44	23	X_{123}	X_{223}	X_{323}	X_{423}	X_{523}	X_{623}
45	24	X_{124}	X_{224}	X_{324}	X_{424}	X_{524}	X_{624}
46	25	X_{125}	X_{225}	X_{325}	X_{425}	X_{525}	X_{625}
47	26	X_{126}	X_{226}	X_{326}	X_{426}	X_{526}	X_{626}

Table 2: Regression equations obtained by using original weather variables; week wise approach. (17 weeks)

Variables in the equation		Years		
		1975-76 to 2002-03	1975-76 to 2003-04	1975-76 to
Constant		- 894.52	- 1274.82	- 1539
T		9.12 **	11.62 **	12
X_{208}		32.81 **	41.78 **	47
X_{217}		- 16.60 **	- 18.08 **	- 18
X_{510}		8.64 **	10.19 **	10
S.E.		47.97	58.71	60
R^2 (%)		81.77	84.58	89

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

Second part deals with their corresponding simulated forecasts for subsequent years not included for obtaining the regression equations (Varmola *et al.*, 2004).

The results related to 17 weeks crop period, (Table 2) indicated that there is a positive and significant influence of time trend (T), maximum temperature of 8th week (X_{208}) and afternoon relative humidity of 10 th week (X_{510}). A negative

Table 3: Simulated forecasts based on the fitted equations

Year	Observed yield (kg ha^{-1})	Simulated forecast (kg ha^{-1})			
		1975-76 to 2002-03	1975-76 to 2003-04	1975-76 to 2004-05	1975-76 to 2005-06
2003-04	879	767			
		(-12.74)	-----	----	----
2004-05	957	826	937		
		(-13.69)	(-2.09)	-----	----
2005-06		949	1088	1164	----
	1171	(-18.96)	(-7.08)	(-0.60)	
2006-07	841	694	775	851	858
		(-17.48)	(-7.85)	(3.09)	(2.02)

Figures in parenthesis are per cent deviation from observed yield.

Table 4: Regression equations obtained by using original weather variables; week wise approach. (26 weeks), Dist: JUNAGADH

Variables in the equation	Years			
	1975-76 to 2002-03	1975-76 to 2003-04	1975-76 to 2004-05	1975-76 to 2005-06
Constant	234.56	226.49	204.99	205.93
T	8.19 **	8.34 **	8.63 **	8.93 **
X_{208}	20.85 **	21.42 **	22.72 **	24.90 **
X_{217}	-21.08 **	-21.17 **	-21.34 **	-22.94 **
X_{408}	-8.25 **	-8.46 **	-8.88 **	-9.19 **
X_{425}	6.96 **	7.04 **	7.18 **	7.36 **
X_{510}	4.57 **	4.63 **	4.78 **	4.73 **
S. E.	30.43	29.79	30.01	31.20
R^2 (%)	93.30	96.36	97.55	98.34

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

and significant influence on cotton crop is observed in case of maximum temperature of 17 th week (X_{117}). These variables explained 82 to 91 per cent variations in the yield of cotton crop. The simulated forecasts (Table 3) showed 1 to 19 per cent deviations from recorded yield of Junagadh district.

In case of 20 and 23 weeks duration models, the fitted equations followed the same trend as the one for 17 weeks crop period model.

The results, obtained in case of 26 weeks model (Table 4), revealed that in addition to 17 weeks model, morning relative humidity of 8th week (X_{408}) negatively influenced and morning relative humidity of 25 th week (X_{425}) , positively influenced the yield of cotton. Influence of other variables X_{208} , X_{217} and X_{510} remained same as per 17th weeks model. These variables explained 93 to 98 per cent variations in the yield of cotton crop. The simulated forecasts (Table 5) showed 1 to 9 percent deviations from recorded yield of cotton in Junagadh district.

Comparison of the models, with respect to their predictability and the deviations of simulated forecasts from the actual yields, revealed that for both the models fitted in this approach, R^2 was very high (> 98%) in case of 26 weeks crop model and deviations of simulated forecasts from observed yields were less than 10 percent. Therefore recommended forecast model of cotton yield for Junagadh district is,

$$Y = 205.93 + 8.93^{**} T + 24.90^{**} X_{208} - 22.94^{**} X_{217} - 9.19^{**} X_{408} + 7.36^{**} X_{425} + 4.73^{**} X_{510}.$$

(Unadjusted R^2 = 98.34%)

CONCLUSION

The bumper yield of cotton during the crop year of 2005-06 in the state as well as in the district (1171 Kg ha^{-1}) was observed due to introducing B.T. cotton and favorable weather for crop conditions. The data of crop season for the 2005-06 were not involved in constructing the models. Therefore relatively higher deviation during crop year 2005-06 was observed.

Table 5: Simulated Forecasts based on the fitted equations

Year	Observed yield (kg ha^{-1})	Simulated forecast (kg ha^{-1})			
		1975-76 to 2002-03	1975-76 to 2003-04	1975-76 to 2004-05	1975-76 to 2005-06
2003-04	879	861 (-2.05)	-----	-----	-----
2004-05	957	903 (-5.64)	912 (-4.70)	-----	-----
2005-06	1171	1063 (-9.22)	1075 (-8.20)	1101 (-5.98)	-----
2006-07	841	797 (-5.23)	804 (-4.40)	818 (-2.73)	830 (-1.31)

Figures in parenthesis are per cent deviation from observed yield.

The fitted model suggested that the yield of cotton in Junagadh district was observed to be increase nearly 9 kg / ha. per annum due to technological advancement during the study period. The morning relative humidity of 25th week (46th msw) and after noon relative humidity of 10th week (31st msw) were also beneficial to improve the productivity of cotton in Junagadh district. The maximum temperature of 17th week (38th msw) and minimum relative humidity of 8th week (29th msw) were found to adversely affect on average cotton yield in the district.

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