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FORECASTING YIELDS OF PEARL MILLET AND SORGHUM IN ARID REGIONS

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ABSTRACT

Yield forecast models for pearl millet and sorghum, the two major cereal crops of arid regions, have been developed. Yield of the pearl millet can be predicted at about 10 weeks after sowing, using the weighted rainfall, minimum temperature and eye estimates while that of the sorghum at about 11 weeks after sowing using the rainfall, maximum and minimum temperatures, average sunshine hours and eye estimates.

INTRODUCTION

Preharvest forecasting of crop yield is of vital importance to the policy makers and planners. The present system of forecasting crop production mostly based on visual observations by revenue officials or by subjective crop cutting surveys, often results in considerable delay. Bali (1970) and Khatri *et al.* (1983) have utilized eye estimates in developing the forecast models for different crops. An attempt was made to develop an early forecast model to predict *baira* (pearl millet) and *jowar* (sorghum) yields in Jodhpur, an arid district, with the help of meteorological parameters.

MATERIAL AND METHODS

Eight meteorological parameters viz. weighted rainfall (X_1), total crop season rainfall (X_2), maximum relative humidity (X_3), minimum relative humidity (X_4), maximum temperature (X_5), minimum temperature (X_6), potential evapo-transpriation (X_7), sunshine hours (X_8) during the crop period and the eye estimates of yields (X_9) for a period of 20 years (1961 to 1980) were taken for the study. The yield data for this period were obtained from the *Agricultural Situation in India* (Directorate of Economics and Statistics, Ministry of Food and Agriculture, Govt. of India), eye estimates of crop yields from the *Statistical Abstracts* (Government of Rajasthan) and weather data (X_2 to X_8) were obtained from the Climatology Section, CAZRI, Jodhpur. Weighted rainfall (X_1) derived from the weekly rainfall data was given by :

$$X_1 = \Sigma_i \, r_i \, X_{1i}$$

where r_i is the correlation of the amount of rainfall (X_{1i}) in the ith week with the final crop yield (Y) and the summation is over 12 weeks for *bajra* and 14 weeks for *jowar*. The standard week in which the rainfall was 20 cm or more was considered as sowing week for both the crops and meteorological variables were measured upto the maturity of the crop.

Step down regression procedure (Zar, 1974) was followed to fit multiple regression equation. To overcome multicollinearity, the independent variables from the equation having high correlation (± 0.8) was omitted. The absence of auto-correlation was ascertained by Durbin-Watson d statistics. (Chatterjee and Price, 1977).

The standard errors of regression estimates in each of the fitted regression equations are given in parentheses and their significance indicated by * for 5% and by ** for 1% level of significance.

RESULTS AND DISCUSSION

Bajra

The correlations among the nine independent variables and crop yield (the dependent variable) are set out in the upper diagonal of Table 1. The eve estimate exhibited highest correlation with yield (0.8403, positive and highly significant), followed by weighted rainfall (0.7313). Among the variables under consideration, the eye estimate, weighted rainfall, total rainfall and maximum temperature showed highly significant correlation at 1% level while maximum and minimum relative humidity and sunshine hours showed significant correlation at 5% level with yield. Potential evapotranspiration is the only variable which did not show any significant correlation with yield. The minimum temperature had significant correlation only with maximum temperature and potential evapotranspiration. The inter-correlation being more than $\pm$ 0.8, multicollinearity was expected among minimum relative humidity, maximum relative humidity and maximum temperature. The Durbin-Watson d statistics worked out to 2.24, indicating the absence of auto-correlation.

The regression equation fitted with all the variables is as follows :

(1) $Y_b = 1357.3849$
$+1.3350\ X_1 \quad +0.3191\ X_2$
(0.6425) (0.1885)
$-6.5308\ X_3 \quad +0.6425\ X_4$
(7.0925) (5.2862)
$-51.5524\ X_5 \quad +27.3487\ X_6$
(29.5658) (28.2909)
$-10.1702\ X_7 \quad +37.7290\ X_8$
(13.9360) (22.0181)
$+0.3840\ X_9$*
(0.1517)
$R^2 = 80\%$

A perusal of the equation (1) reveals that weighted rainfall (X_1), total rainfall (X_2), sunshine hours (X_8) and eye estimate (X_9) exhibited positively significant effects while the maximum temperature (X_5) exerted a significant negative effect on the yield of *bajra*.

By omitting the minimum and maximum relative humidity which exhibited multicollinearity and then following the step down procedure, the final equation emerged in the following form.

(2) $Y_b = 624.6344 + 1.2713\ X^*_1$
(0.5382)
$-17.1637\ X_5 + 0.4874\ X_9$**
(9.9661) (0.1295)

$R^2 = 78\%$ (highly significant).

This model, which includes three variables *i.e.* weighted rainfall, maximum temperature and eye estimate together accounting for 78% variations in the final

Table 1. Correlation Matrix of Bajra (Upper diagonal) and Jowar (Lower diagonal)

	Weighted rainfall	Total crop season rainfall	Maximum R. H.	Minimum R. H.	Maximum Temp.	Minimum Temp.	Potential evapo-transpiration	Sun-shine	Eye estimate	Crop yield
	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	Y
X_1		0.5186*	0.3801	0.4660*	−0.3470	−0.0172	−0.3414	−0.5330*	0.6147**	0.7313**
X_2	0.1191		0.2312	0.3472	−0.2882	0.0842	−0.0091	−0.5201*	0.4667*	0.6113**
X_3	0.5897**	0.2169		0.9288**	−0.8737**	−0.2909	−0.7036**	−0.6767**	0.4391	0.4703*
X_4	0.4348	0.3461	0.9288**		−0.8129**	−0.1760	−0.6302**	−0.7345**	0.5160*	0.5462*
X_5	−0.4669*	−0.2661	−0.8737**	−0.8129**		0.5123*	0.7761**	0.6518**	−0.4609*	−0.5731**
X_6	0.0392	0.1333	−0.2908	−0.1760	0.5123*		0.4470*	0.0267	0.1628	−0.0038
X_7	−0.2904	0 0115	−0.7036**	−0.6392**	0.7761**	0.4470*		0.5847*	−0.2714	−0.4115
X_8	−0.3259	−0.5285*	−0.6767**	−0.7345**	0.6518**	0.0267	0.5047*		−0.5084*	−0.5103*
X_9	0.3048	0.2902	0.3700	0.3790	−0.4126	0.2313	−0.3117	−0.5216*		0.8403**
Y	0.4145	0 3696	0.3991	0.4268	−0.4902*	0.2444	−0.3515	−0.4309	0.8224**	

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

crop yield, can be used as a forecast model for *bajra* yield two weeks before harvest in Jodhpur district.

Jowar

Correlations among the variables for *jowar* crop are presented in the lower diagonal of Table 1. Eye estimate showed highest positive and significant correlation with yield. The only other variable which showed significant but negative correlation was the maximum temperature. As in the case of *bajra* multicollinearity was suspected among the maximum temperature, minimum and maximum relative humidity. The absence of auto-correlation was indicated by the Durbin-Watson statistics which worked out to 2.4. The regression equation with all the nine variables along with its R^2 is given below :

(3) $Y_d = 1195.3195$
$+0.7112\ X_1$ $+0.1452\ X_2$
(0.9237) (0.1658)
$-10.0867\ X_3$ $+2.9620\ X_4$
(0.0592) (6.3918)
$-59.5508\ X_5$ $+51.6474\ X_6$
(29.3952) (27.0242)
$-8.3502\ X_7$ $+37.2436\ X_8$
(13.6320) (23.5192)
$+0.5560\ X_9$**
(0.1716)
$R^2 = 71\%$

The variables exerted positive as well as negative impacts on the productivity of *jowar*. However, only the effect of eye estimate was highly significant. Probably due to multicollinearity, some of the variables could not show significant effect. Omission of maximum and minimum relative humidity to avoid multicollnearity and step down regression method gave final prediction equation as follows·

(4) $Y_j = 107.6229$
$+0.1691\ X_2$ $-47.0890\ X_5$**
(0.1326) (15.5811)
$+48.5028\ X_6$* $+42.7944\ X_8$*
(20.5556) (19.9764)
$+0.6017\ X_9$**
(0.1491)
$R^2 = 76\%$ (highly significant).

The five variables viz., rainfall, maximum and minimum temperature, sunshine hours and eye estimate together accounted for 76% variations in the *jowar* yields.

The equations 2 and 4 can be used as the prediction equations for *bajra* and *jowar* yields, respectively in the Jodhpur district.

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