Annals of Arid Zone 31(1) 45-48 1992

Pearlmillet Yield Prediction Models For Kutch Region of India, Using Climatic Water Balance Parameters

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Abstract Three parameters viz; actual evapotranspiration (AE) during the total crop growing period, during the reproductive phase alone and also the Index of Moisture Adequacy (AE/PE) during reproductive phase have been worked out in respect of pearlmillet crop grown in Kutch region, for the period 1970 to 1988. Using the data for period 1970-84, various regression models were developed to predict and estimate the production of pearlmillet in the arid Kutch district of India. Among all the models, the reciprocal hyperbola curves gave the best fit and explained a maximum of 80% variation in pearlmillet yield. Performance of the models is also tested with data of later years, 1985-88. The suitability of these models for pearlmillet yield prediction has been discussed.

Key words Yield prediction model, Climatic parameter, Pearlmillet

Pearlmillet is grown extensively under rainfed condition in the Kutch region of India. The nature of rainfall and high atmospheric demand of water are the major climatic constraints that limit stable and successful crop production from this region (Singh et al. 1990). The yield variability of pearlmillet in this region (Singh et al. 1991) is also high (CV = 34.6%). In this context the prediction of pearlmillet yield using climatic data will have a great relevance for economic planning and for gearing up relief measures in the area in time. However, there are no such studies, carried out or reported for the estimation of pearlmillet yield from arid Kutch region. Therefore, in the present study an attempt has been made to develop regression models for predicting pearlmillet yield using climatic water balance parameters.

Materials and Methods

Daily rainfall data of Kutch district (12 raingauge stations) for the period of 1970-1988 were used in this study. Water budgeting based on the method of Thornthwaite and Mather (1955) was carried out using normal potential evapotranspiration (PE) values computed by Rao et al. (1971) through Penman's formula. The weekly actual evapotranspiration (AE) for each of the station for each of the year were calculated and mean weekly actual evapotranspiration (AE) values for the region were estimated. The climatic normals of different locations situated in Kutch region is presented in Table 1. The mean values of AE at various places during the cropping period is also calculated and mentioned in Table 1. These AE values are computed through weekly climatic water balance method. The weekly mean AE/PE values were also calculated for the different weeks of the growing season for the years 1970 to 1988. The water holding capacity of the soil profile (one metre depth) was assumed to be 150 mm. The commencement of crop growing season under rainfed farming was assumed as the first week of the cropping season when AE exceeded half the value of PE. The water used (AE) by pearlmillet during its 13 weeks of total life cycle as well as during its reproductive phase (7th–11th week after

Table 1 *Climatic normals of Kutch district.*

Station	Annual Rainfall (mm)	Rainy Days	Annual PE (mm)	Mean AE during cropping period (mm)
Bhuj	342.4	15.2	1897.0	232.0
Anjar	343.5	16.5	1825.0	268.0
Rahapur	365.4	16.2	1850.0	268.0
Bachau	383.0	15.1	1850.0	242.0
Mundra	439.7	18.1	1750.0	291.0
Khandla	433.2	20.4	1775.0	271.0
Nalia	451.9	13.7	1750.0	220.0
Mandvi	401.8	16.8	1760.0	278.0
Lakhapat	338.4	12.0	1800.0	254.0
Nakhatarana	381.6	14.2	1850.0	232.0

sowing) were computed. Similarly the mean AE/PE values during reproductive phase (7th-11th week) of pearlmillet crop have also been estimated for each individual year under study and these three parameters were used to correlate with pearlmillet yield data and also to develope the regression models for predicting the crop yield.

Results and Discussion

Development of prediction equations : Twenty five equations namely straight line, line through origin, reciprocal straight line, linear and reciprocal, hyperbola, reciprocal hyperbola, second order hyperbola, parabola, parabola at origin, power, modified power, root, super geometric, modified geometric, exponential, modified exponential, logarithmic, reciprocal logarithmic, hoerl function, modified hoerl, normal, log normal, beta, gamma and cauchy functions are fitted to the data using a computer software "Curvefit" prepared by Thomas (1986) based on the method developed by William (1985). The pearlmillet yield data of Kutch district during the period of (1970-1984) is correlated separately with total AE, AE during reproductive phase and AE/PE values during reproductive phase of pearlmillet crop of the region using all above equations. Among these reciprocal hyperbola of the form of $Y = X/(A \times X+B)$ gave the best fit explaining higher percentage of variation in yield in all three cases.

Prediction model using crop season AE values: The relationship between pearlmillet yield and its total water use (AE) during cropping period is worked out using the data for the period of 1970 to 1984. The closest association between these two parameters was found by fitting reciprocal hyperbola of the following type.

$$Y = X / (0.05559X + 25.47) \quad ...(1)$$

with $r = 0.7616$, Significant at 0.1% level and $df = 13$

where $Y =$ Yield of pearlmillet (q/ha^{-1}) and

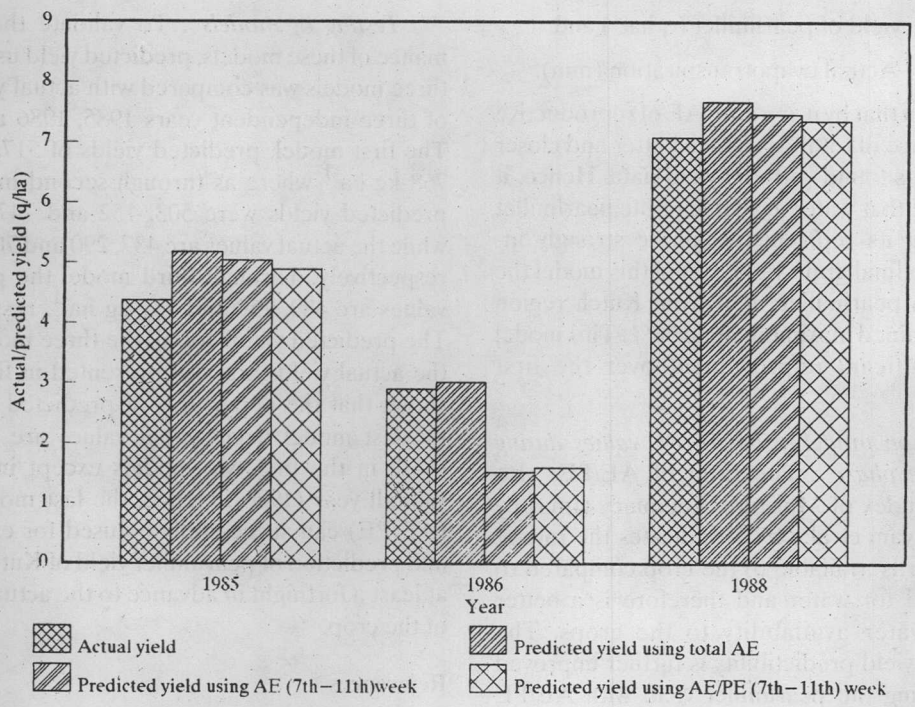
$X =$ Actual evapotranspiration (mm).

This model explained for about 58% variations in pearlmillet yield using crop AE during sowing to maturity (till harvest) period.

Prediction model using crop AE during reproductive phase : The correlation between pearlmillet yield and its water use (AE) during reproductive phase (7th-11th week) was worked out. The predictive equation of reciprocal hyperbola type which has given the best fit was obtained as

$$Y = X / (0.09708X + 4.483) \quad ....(2)$$

With $r = 0.8815$, Significant at 0.1% level and $df = 13$



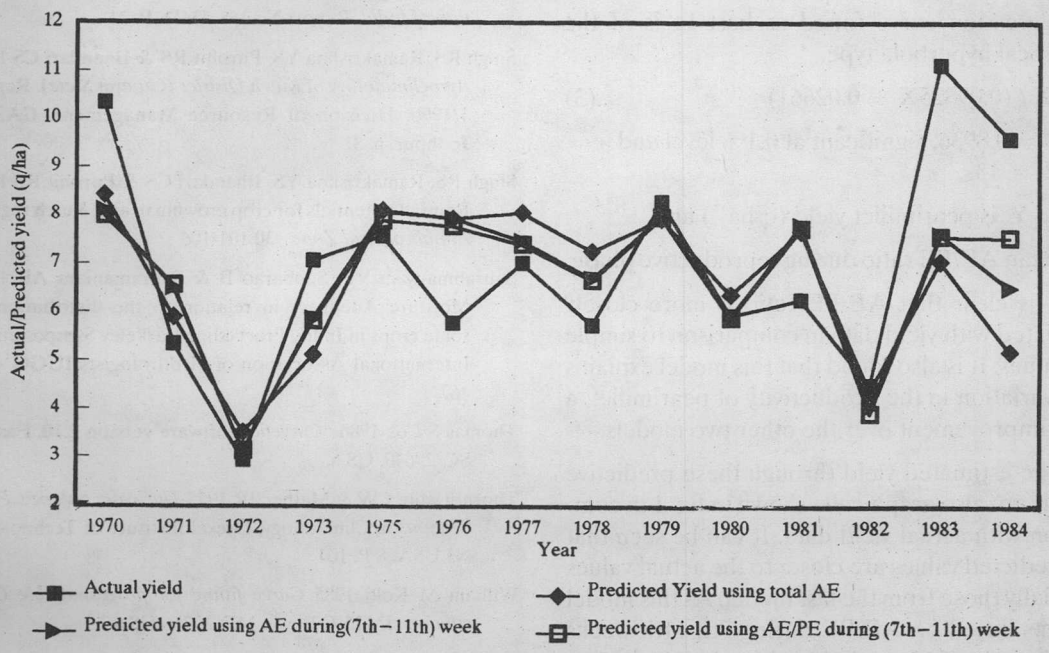


Fig 1. Actual vs estimated pearlmillet yield of kutch region

Fig 2. Performance of yield prediction models of pearlimillet Kutch region.

Where Y = yield of pearlmillet (q/ha^{-1}) and

X = Actual evapotranspiration (mm).

It is seen that by using crop AE of reproductive phase in place of total AE, much better and closer association is found with the yield data. Hence, it is indicative that water available to the pearlmillet crop during its reproductive phase strongly influences the final grain yield. Using this model the variation in pearlmillet yield from Kutch region can be explained maximum up to 78%. This model shows significant improvement over the first model.

Prediction model using AE/PE values during reproductive phase : The ratio of AE/PE, also named as Index of Moisture Adequacy (Ima) by Subrahmanyam et al. (1963) indicates the rate at which water is available to the crop compared to the demand for water and therefore is a better index of water availability to the crops. The pearlmillet yield predictibility is further improved by correlating the pearlmillet yield with AE/PE ratio during reproductive phase of crop. In this way the regression curve found as best fit is of the reciprocal hyperbola type.

$$Y = X / (0.09825X + 0.02661) \quad ....(3)$$

with r = 0.8936, significant at 0.1% level and
df = 13

Where Y is pearlmillet yield (q/ha^{-1}) and

X is mean AE/PE ratio during reproductive phase.

It is clear that AE/PE ratio is more closely associated with yield data in comparison to simple AE values. It is also found that this model explains 80% variation in the productivity of pearlmillet, a slight improvement over the other two models.

The estimated yield through these predictive models are also graphically shown in fig. 1 in comparison with actual yield data. It can be seen that the predicted values are closer to the actual values especially those from the last model. As this model predicts based on AE/PE during 7th-11th weeks for this crop of 13 week duration, this model can thus be successfully used for predicting pearlmillet yield before 15 days of crop harvest.

Testing of models : To validate the performance of these models, predicted yield using these three models was compared with actual yield data of three independent years 1985, 1986 and 1988. The first model, predicted yields of 517, 301 and 768 kg ha^{-1} where as through second model, the predicted yields were 503, 152 and 747 kg ha^{-1}, while the actual values are 437, 290 and 709 kg ha^{-1} respectively. Through third model the predicted values are 489, 159 and 737 kg ha^{-1}, respectively. The predicted yields for all the three models with the actual yields are also presented in fig2 which shows that the departures of predicted values in the last model from actual values are less than those in the first two models except in the low rainfall year (1986). Hence, the last model using (AE/PE) can successfully be used for estimation and prediction of pearlmillet yield of Kutch region at least a fortnight in advance to the actual harvest of the crop.

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(Received September 1991 Accepted, December 1991)