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Empirical model for turmeric (*Curcuma domestica* Val.) yield prediction

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Abstract

The mean weather variables namely maximum (TMAX) and minimum (TMIN) temperature, maximum (RHMAX) and minimum (RHMIN) relative humidity, rainfall (RAINF), rainy days (RAIND), evaporation (EVPN), wind speed at 8 feet height (WINDS), sunshine hours per day (SUNSH) and total solar radiation (RADN) of different months of turmeric crop season for twenty years (1979-80 to 1998-99) were correlated with yield (dry) in Coimbatore District, Tamil Nadu. Out of the ten variables studied, three variables (TMAX, RHMAX and RADN) did not show significant relationship with yield while the remaining seven variables had significant correlation with yield. These significant variables were further subjected to stepwise regression analysis and those variables, which could be related to yield variability reasonably (EVPN, RHMIN, RAINF, TMIN) were used in the final regression model. This model was used to estimate turmeric yield in Coimbatore District and it was found that the estimated and observed yields did not differ. This model ($Y= -11675.5119 - 591.0617\ EVPN_3 + 810.3569\ TMIN_5 + 12.1481\ RAINF_2 + 91.7499\ RHMIN_9$) can be used to predict the yield of turmeric and total production in Coimbatore District, Tamil Nadu, India.

Key words: *Curcuma domestica*, empirical model, turmeric, weather relationship, yield prediction.

Crop-weather models developed by using mathematical or statistical techniques express the complex relationships between the weather or climate and crop performance in a simple way (Baier 1979). Least-square regression is the backbone of quantitative research of crop-weather relationships. The general approach is to regress a time series of the dependent variable (yield) against independent variables of selected meteorological parameters (Jones 1982). The information gathered on how and at what stage of crop growth the climatic factors influence the yield, helps to derive complex variates that give appropriate weight to different factors for correlation with yield and varying climatic factors which can be used to predict yield, based on meteorological records (Watson 1963). Cultivation of spice crops including turmeric is governed by the prevalence of requisite climatic conditions occurring within a region and information on crop-weather relationships is meager (Venkatraman & Krishnan 1992).

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Turmeric (*Curcuma domestica* Val.) is an export-oriented spice. Prediction of turmeric yield in relation to weather parameters would help the policy makers and agencies involved in turmeric trade and export to speculate the trade based on the projected production. Hence, an attempt was made to develop an empirical model to predict turmeric yield based on weather variables. Data on area and production of turmeric in Coimbatore District, Tamil Nadu during 20 years (1979-80 to 1998-99) were collected from Seasons and Crop Report, Government of Tamil Nadu, Chennai, Agricultural and Fertilizer Statistics and the Fertilizer Association of India, Southern Region, Chennai and yield for hectare was calculated. Weather data were collected from Department of Agricultural Meteorology, Tamil Nadu Agricultural University, Coimbatore. Weather data for 20 years (1979-80 to 1998-99) were used in the study, except for solar radiation (1981-82 to 1998-99) and sunshine hours (1979-80 to 1996-97) for which data for 18 years was only available.

Kandiannan *et al.* (2000) delineated Coimbatore District as one of the efficient turmeric producing zone in Tamil Nadu. It was assumed that turmeric in this zone is planted in June and harvested at the end of February in the subsequent year. The weather variables in all the months from the time of planting to harvest were correlated with turmeric yield (dry). The variables having significant correlation with yield were selected and stepwise regression was fitted. Microsoft Excel computer package was used for the estimation of correlation coefficient and Microstat of Ecosoft Inc. computer package was used for stepwise regression model estimation. This multiple regression model was used for the estimation of yield and compared with observed yield.

Out of the ten weather variables tested, three variables namely TMAX, RHMAX and RADN were not having any significant relationship with yield while the other seven variables (TMIN, RHMIN, RAINF, RAIND, EVPN, WINDS and SUNSH) showed significant relationship with yield. The mean of the significant variables for $TMIN_5$, $TMIN_8$, $TMIN_9$, $RHMIN_9$, $RAINF_2$, $RAIND_6$, $EVPN_3$, $WIND_4$ and $SUNSH_8$ (numbers in the subscript are number of months after planting) were 21.4 ± 0.68°C, 18.0 ± 1.11°C, 18.8 ± 1.29°C, 33.3 ± 6.44 %, 43.8 ± 29.12mm, 6.7 ± 3.09 day, 6.5 ± 0.87 mm, 8.4 ± 2.04 km h^{-1} and 7.9 ± 1.06 hours, respectively. The magnitude of correlation was in the following order.

$RHMIN_9 > TMIN_9 > WIND_4 > RAINF_2 > SUNSH_8 > TMIN_8 > EVPN_3 > TMIN_5 > RAIND_6$

Among the significant weather variables identified, $EVPN_3$ and $SUNSH_8$ were having negative association and others were having positive relation with yield. The significant variables identified were further subjected to stepwise regression analysis. The stepwise regression variables that obtained is given below.

$$Y = -11675.5119 - 591.0617\ EVPN_3 + 810.3569\ TMIN_5 + 12.1481\ RAINF_2 + 91.7499\ RHMIN_9 \quad (R^2 = 0.8181)$$

Where,

Y - Predicted yield (kg ha^{-1})

Among the variables tested, second month (July) rainfall, third month (August) evaporation, fifth month (October) TMIN and ninth month (February) RHMIN account for maximum yield variability. Turmeric takes one month to germinate after planting and the crop is in the establishment stage during second month. RAINF during this time had a significant correlation (r=0.6024) with yield. Probably, the rainfall during this period helps in better establishment. In the third month, low rainfall coupled with high wind speed enhance the evaporation rate and induce water stress resulting in a negative relation (r=-0.4889) of EVPN with yield. Low temperature might favour the rhizome formation as indicated from the study that TMIN of fifth month had significant association (r=0.4538) with yield. Similarly, RHMIN of ninth month contributes towards yield (r=0.6575). Went (1957) opined that the beneficial effects ascribed to high relative humidity may be due to the equable

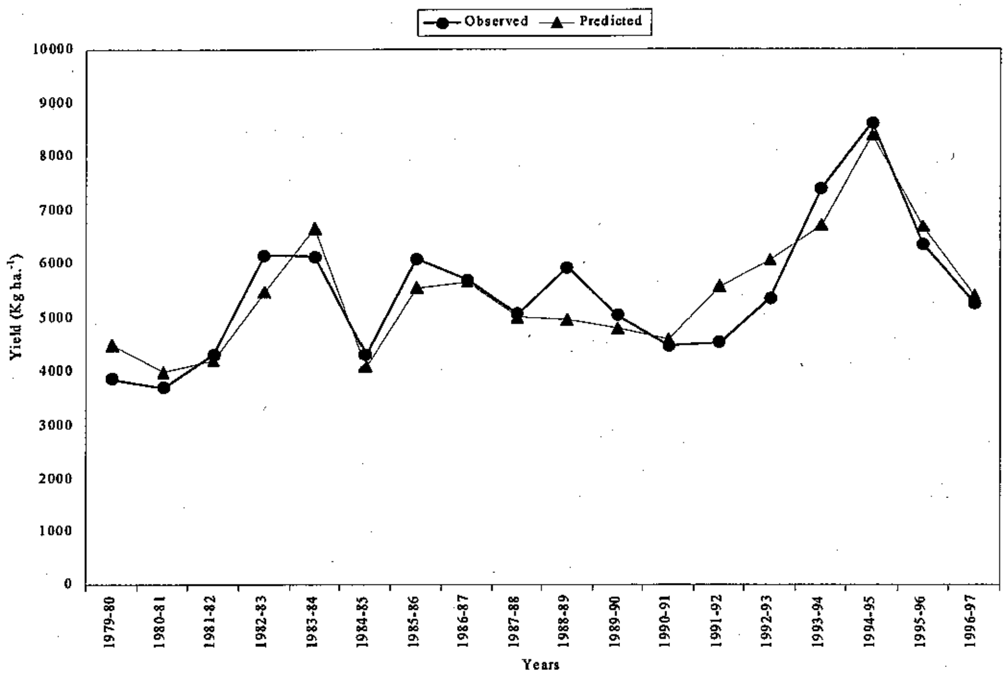

Fig. 1. Observed and predicted yield of turmeric

temperature regime and the consequent reduced heat load associated with them.

The calculated absolute values of yield did not differ much from the actual yield. The year-to-year fluctuations are also in the same direction and are comparable (Fig. 1). This model can be used for prediction of turmeric yield in Coimbatore District. Earlier such models for many crops were developed and used in India (NCMRWF 1990, Venkatraman & Krishnan 1992) and in other countries (Baier 1977; Frere & Popov 1979; WMO 1982). It is evident from this study that yield of turmeric can be predicted based on weather variables. Similar models can be developed for other agro-climatic regions/zones for prediction of turmeric production.

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