Rice Yield Prediction for Cauvery Delta Zone of Tamil Nadu using Weather Based Statistical Model

G. Senthil Kumar[1*] and K. Subrahmaniyan[2]

[1]*Department of Rice, Tamil Nadu Agricultural University, Coimbatore – 641 003, India*
[2]*Tamil Nadu Rice Research Institute, Aduthurai, Thanjavur district, Tamil Nadu, India*

*Corresponding author

A B S T R A C T

Yield forecasting regression models utilise data on yield and weather variables for past several years pertaining to locations under consideration. By studying the relationship of yield with different weather elements, predictors are identified. Generally, rainfall, temperature, humidity, rainy days, dry days and cloud amount etc., during critical phases of crop growth fulfill the criteria to be predictors. The weather variability both within and between seasons is unmanageable source of variability in yield. The weather variables affect the crop differently during various stages of development. Thus, extent of weather influence on crop yield depends not only on the magnitude but also on the distribution pattern of weather variables over the crop season. Statistical method has been performed for forecasting crop yield for Rice crop at Cauvery delta zone of Tamil Nadu. The forecast has been developed by using crop yield data considering four weather variables (Maximum and Minimum temperature, Rainfall, Morning and Evening Relative Humidity) simultaneously. Long term weather (1995-2016) and historical crop yield (1999-2016) data were utilized in the model. District level rice yield forecast for delta districts *viz.*, Thanjavur, Thiruvarur, Nagapattinam, Trichy, Perambalur, Ariyalur and Cuddalore was issued by using the statistical model at mid-season (F2) and pre-harvest stage (F3) during *Kharif*, 2017 and *Rabi*, 2017-18.

Introduction

Variation in crop yield over years has two components. One is more or less systematic rise in yield derived from improved cultivars, better crop management and the interaction between cultivars and management (Boltan, 1981). Weather plays an important role in crop growth as well as crop development. Therefore, models based on weather parameters can provide reliable forecast of crop yield in advance of harvest. A number of yield forecasting models have been developed for various crops.

Yield forecasting regression models utilise data on yield and weather variables for past several years pertaining to locations under consideration (Surrender Paul *et al.,* 2012). By studying the relationship of yield with different weather elements, predictors are identified.

Generally, rainfall, temperature, humidity, rainy days, dry days and cloud amount etc., during critical phases of crop growth fulfill the criteria to be predictors (Jayantha Sarkar, 2003). Crop yield in different years is affected by technological factors will increase the yield smoothly through time and therefore, year-number can be used to study the overall effect of technology on yield. The weather variability both within and between seasons is unmanageable source of variability in yield. The weather variables affect the crop differently during various stages of development (Tripathi *et al.,* 2012). Thus, extent of weather influence on crop yield depends not only on the magnitude but also on the distribution pattern of weather variables over the crop season.

Materials and Methods

In Tamil Nadu, district level rice yield Forecast for Cauvery delta zone is more important because this zone is rice bowl of Tamil Nadu. The most commonly adopted cropping sequence in delta region is *Kuruvai* rice (*Kharif*) - thaladi rice (*Rabi*) – rice fallow black gram/gingelly/cotton   In the rice based cropping system, it is either single (Samba: 2.99 lakh ha) or double cropped (Kuruvai: 1.68 lakh ha and Thaladi: 1.44 lakh .ha). Pulses like Black gram (1.43 lakh ha) and green gram (0.46 lakh. ha) are next important crops grown in the rice fallows throughout the delta region from January onwards under no tillage condition. District level rice yield Forecast for delta districts *viz.*, Thanjavur, Thiruvarur, Perambalur, Nagapattinam,Cuddalore, Ariyalur and Trichy was issued by using Statistical Model at mid-season (F2) and pre-harvest stage (F3) during *Kharif*, 2017 and *Rabi* 2017-18. There is a need of dividing the crop season into different intervals. Thus, a technique based on relatively smaller number of manageable variables and at the same time taking care of

entire weather distribution may solve the problem. The regression model which was used for yield forecasting is weather indices based model which is modified Hendricks and Scholl method at IASRI (Agrawal and Mehta, 2007). Statistical method has been performed for forecasting crop yield for rice crop at selected districts. The forecast has been developed by using crop yield data considering the four weather variables (Maximum and Minimum temperature, Rainfall, Morning and Evening Relative Humidity) simultaneously. Long term weather (1995-2015) and historical crop yield (1999-2015) data were utilized in the model.

Final yield forecast will be given by using statistical regression model using this formula.

$$Y = A_0 + \sum_{i=1}^{p} \sum_{j=0}^{1} a_{ij} Z_{ij} + \sum_{i \neq i'=1}^{p} \sum_{j=0}^{1} a_{ii'j} Z_{ii'j} + cT + e$$

Where,

$$Z_{ij} = \sum_{w=1}^{m} r_{iw}^{j} X_{iw}$$

$$Z_{ii'j} = \sum_{w=1}^{m} r_{ii'w}^{j} X_{iw} X_{i'w}$$

Results and Discussion

Rice yield prediction during *Kharif*, 2017

District level rice yield forecasting models of rice are presented for 5 districts *viz.,* Thanjavur, Thiruvarur, Trichy, Nagapattinam and Cuddalore districts in Table 1. The weather data for maximum temperature (T max), minimum temperature (T min), relative humidity (RH I & RH II) and daily rainfall values were collected for the period of 1995 – 2016.

***Kharif* season – mid season forecast (F2)**

District level rice yield forecast was prepared and the forecasted yields are given during mid season of *Kharif,* 2017. Crop yield forecast for rice was given for five selected districts (Thanjavur, Thiruvarur, Trichy, Nagapattinam and Cuddalore) during *Kharif* season 2016. The highest paddy yield of 4972 kg/ha has been predicted for Thiruvarur district while the lowest yield has been predicted for Thanjavur district (3891 kg/ha). The major rice varieties grown in Cauvery delta zone

during *Kharif* season is ADT 43, ADT 45 and ADT 36.

***Kharif* season – pre- harvest forecast (F3)**

District level rice yield forecast was prepared and forecasted yields are given in Table 2. In F3 forecast, higher paddy yield of 4987 kg/ha was predicted in Trichy district followed by Thiruvarur district (4825 kg/ha). Lower yield of 3556 kg/ha was predicted in Thanjavur district.

Table.1 Crop yield forecast of *Kharif* Rice (F2: Flowering Stage) during 15th September, 2017

Districts	Equation	Forecast Yield 2017 (kg/ha)
Thanjavur	$Y=-1906.65+2.52(Z241)$	3891
Thiruvarur	$Y=2743.51+0.386(Z131)$	4972
Nagapattinam	$Y=11002.33+289.54(Z11)+0.15(Z240)$	3079
Trichy	$Y=2781.830791+3.29(Z121)$	4969
Cuddalore	$Y=283.72+1.047(Z21)$	4951

Table.2 Crop yield forecast of *Kharif* Rice (F3: Pre-Harvesting Stage) during 15th October, 2017 for Cauvery Delta Zone of Tamil Nadu

District	Equation	Forecast yield 2017 (kg/ha)
Thanjavur	$Y=3422.209+0.14(Z131)$	3556
Thiruvarur	$Y=4119.01+1.96(Z141)$	4825
Nagapattinam	$Y=11002.33+289.54(Z11)+0.15(Z240)$	4379
Trichy	$Y=-1449.89+210.76(Z21)$	4987
Cuddalore	$Y=8558.76+23.84(Z20)$	4435

Table.3 Verification of *Kharif*, 2017 yield forecast

Districts	Area (ha)	Predicted yield F3 (kg/ha)	Actual yield (kg/ha)	Yield difference (kg/ha)	Error (%)
Thanjavur	28298	3556	3712	-156	**-4.20**
Thiruvarur	18,394	4825	4489	336	**7.48**
Nagapattinam	22,683	4379	4012	367	**9.14**
Trichy	3430	4987	4880	107	**2.19**
Cuddalore	**8310**	**4435**	**4906**	**-471**	**-9.60**

Table.4 Yield Forecasting for *Kharif* rice during F2 (15th, September) & F3 (15th, October) 2017 at Cauvery Delta Zone in Tamil Nadu

Sl. No	Districts	Average yield (kg/ha)	Weather elements	Equation	Weather element	Equation
			F2 Forecasting date 15th, October 2017		**F3 Forecasting date 15th, October 2017**	
1	Thanjavur	3349	RH II	$Y=-1906.65+2.52(Z241)$	RH II	$Y=3422.209+0.14(Z131)$
2	Thiruvarur	2914	Tx Tx*RF	$Y=2743.51+0.386(Z131)$	Tx*RF	$Y=4119.01+1.96(Z141)$
3	Nagapattinam	2844	Tx*Tn	$Y=11002.33+289.54(Z11)+0.15(Z240)$	Tx*Tn	$Y=11002.33+289.54(Z11)+0.15(Z240)$
4	Trichy	3850	Tn	$Y=2781.830791+3.29(Z121)$	TnTn*RF	$Y=-1449.89+210.76(Z21)$
5	Cuddalore	3425	Tn	$Y=283.72+1.047(Z21)$	Tn*RHI	$Y=8558.76+23.84(Z20)$

Table.5 Crop Yield Forecast of Rabi Rice (F2: Flowering Stage) during 30th December, 2017 for Cauvery Delta Zone of Tamil Nadu

| District	Equation	Forecast yield, 2017 (kg/ha)
Thanjavur	$Y= -309.3 + 0.8(Z151)+2.1(Z241)$	2553
Thiruvarur	$Y= -1770 + 2.695(Z241)$	2503
Nagapattinam	$Y= 671.68 + 7.7 (Z241)$	2027
Trichy	$Y= -2312 + 0.2 (Z251)$	4556
Karur	$Y= 3212 + 0.3 (Z250)$	2474
Perambalur	$Y=26.6 + 2.6 (Z121)$	4516
Ariyalur	$Y= -2213 + 0.2 (Z250)$	3660
Cuddalore	$Y= -333.9 + 2.12 (Z141) +0.3 (Z250)$	3105

Table.6 Crop Yield Forecast of *Rabi* Rice Crop (F3: Pre-Harvesting Stage) during 30th January 2018 for Cauvery delta zone of Tamil Nadu

| District	Equation	Forecast yield, 2018 (kg/ha)
Thanjavur	$Y=6284.1 +150.4(Z11)$	4239
Thiruvarur	$Y=5722.4 +5.7(Z121) +26.4(Z51)$	4939
Nagapattinam	$Y= 2761.9 + 5.67(Z240) +1.0494 (Z230)$	4832
Trichy	$Y=4512.4 +1.7(Z120) + 0.4(Z51)$	4521
Karur	$Y=6882.4 +2.7(Z130) + 17.4(Z51)$	3886
Perambalur	$Y=4522.4 +15.7(Z241)$	3396
Ariyalur	$Y=3422.4 +2.7(Z51) + 4.6(Z350)$	4437
Cuddalore	$Y=5121.4 +2.9(Z241) + 14.4(Z51)$	4505

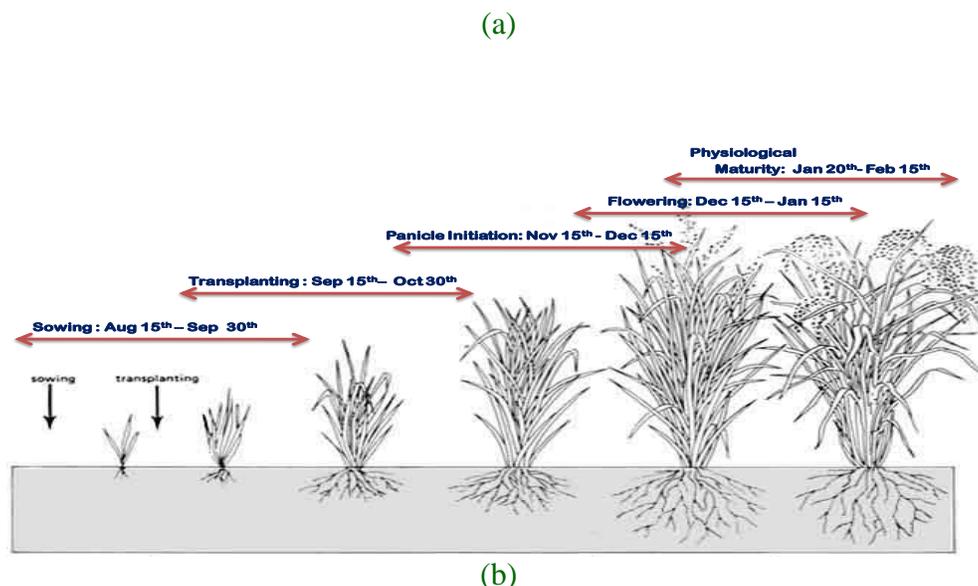**Table.7** Verification of *Rabi*, 2017-18 yield forecast

Districts	Area (ha)	Predicted yield (F3) (kg/ha)	Actual yield (kg/ha)	Yield difference (kg/ha)	Error (%)
Thanjavur	106077	4239	4010	229	5.71
Thiruvarur	128412	4939	4468	471	10.54
Nagapattinam	113537	4832	4047	785	19.40
Trichy	45780	4521	4659	-138	-2.96
Karur	12313	3886	4538	-652	-14.37
Perambalur	22997	3396	3887	-491	-12.63
Ariyalur	7167	4437	3958	479	12.10
Cuddalore	59434	4505	3935	570	14.49
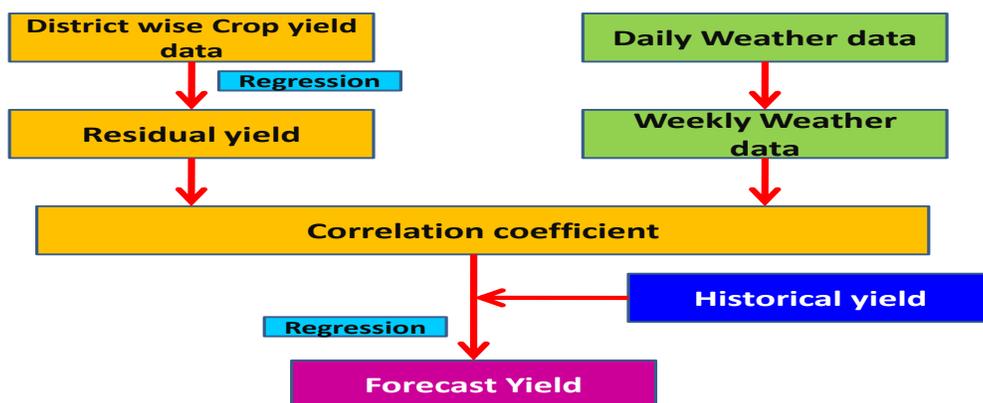
Fig.1 Growth stages of *Kharif* Rice

(a)

(b)
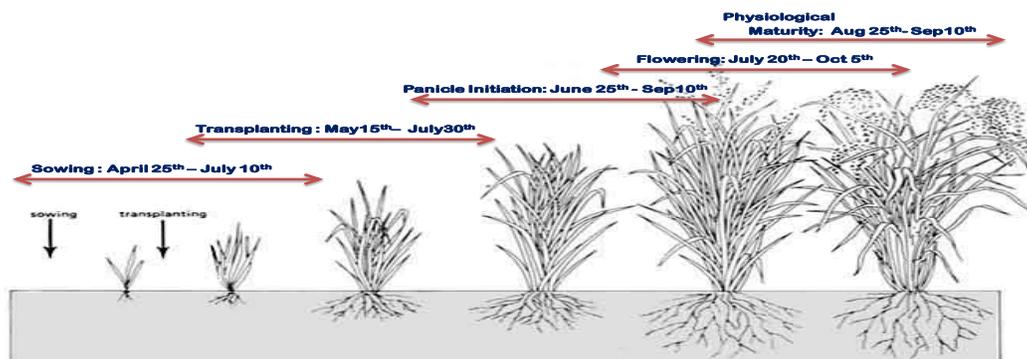
Fig.2 Growth stages of *Rabi* Rice

Verification of yield forecast *Kharif*, 2017

Verification of yield forecast by using actual yield indicated that actual yield was less than that of predicted yield in all districts. The error percentage varied from -9.60 to 9.14. The lacunae in the statistical model is that it is taking into consideration of weather parameters prevailed during the season only and not the management practices adopted by the farmers.

Rice yield prediction during *Rabi*, 2017-18

Mid-season forecast (F2)

District wise yield forecast for rice was given for 8 districts (Thanjavur, Thiruvarur, Trichy, Nagapattinam, Cuddalore, Karur, Perambalur and Ariyalur districts) during *Rabi*, 2016-17 for rice crop. The highest paddy yield of 4556 kg/ha was predicted for Trichy district. The major rice varieties during the *Rabi* season were CR1009, ADT 46, and BPT 5204.

Verification

Verification of yield forecast by using actual yield indicated that actual yield was less than predicted yield in Thanjavur, Thiruvarur, Nagapattinam, Ariyalur and Cuddaloredistricts. Actual yield was more than predicted yield in Trichy, Karur and Perambalur districts. The error percentage was very less in Trichy (-2.96). Nagapattinam and Cuddalore districts recorded the highest error percentage of 19.40, 14.49, respectively.

References

Agrawal, Ranjana and Mehta, S.C. (2007). Weather based forecasting of crop yields, pests and diseases – IASRI models. *Ind. J. Agri. Sci.,* 71(7): 487-490.

Boltan, F.E. (1981).Optimizing the use of water and nitrogen through soil and crop management. *Plant Soil.,* 58: 231-247.

Jayantha Sarkar, (2003). Forecasting rice and wheat yield over different meterological sub-divisions of India using statistical models. *J. Ind.Soc.Ag.Stat*. 56(1): 88-89.

Surrender paul, Chander shekar and S.C. Bhan. (2012). Cotton yield prediction

for Punjab using weather based statsistical models. *Journal of Agrometeorology.* 14(2): 184-186.

Tripathi, M.K., B. Mehra, N. Chattopadhyay and K.K. Singh. (2012). Yield prediction of sugarcane and paddy for districts of Uttar Pradesh. *Journal of Agrometeorology.* 14(2): 173-175.

How to cite this article:

Senthil Kumar. G. and Subrahmaniyan. K. 2020. Rice Yield Prediction for Cauvery Delta Zone of Tamil Nadu using Weather Based Statistical Model. *Int.J.Curr.Microbiol.App.Sci.* 9(06): 400-406. doi: https://doi.org/10.20546/ijcmas.2020.906.052