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ORIGINAL ARTICLE

Yield Estimation of Rice (*Oryza sativa L.*) in Katihar District of Bihar

Chandan Kumar Deep , Mahesh Kumar* and Subhash Kumar
Department of Statistics, Mathematics and Computer Application
Dr. Rajendra Prasad Central Agricultural University, Pusa, Samastipur, Bihar -848125
Corresponding Author: Email: *mahesh_smca@yahoo.co.in

ABSTRACT

Present research done in the year 2012, with the yield forecast models of rice (Oryza sativa L) based on Biometrical characters with farmers feedback in Katihar district of Bihar. The observations on plant biometrical characters such as average plant population per m² (X_1), average plant height in cm (X_2), average number of tillers per m² (X_3), average length of Panicle in cm (X_4), application of nitrogen (N) in kg/ha (X_5), application of phosphorus (P_2O_5) in kg/ha (X_6), application of potassium (K_2O) in kg/ha (X_7), irrigation level in numbers (X_8), disease infestation in percentage (X_9) and average plant condition (X_{10}) according to eye estimates of farmers were recorded from 50 plots 2 plots each one of 25 farmers of Katihar district of Bihar. Multistage stratified random sampling was used for selecting samples.. The villages were first stage unit, farmer's field as second stage unit and plots were third stage unit of selection. All possible regression analyses were carried out to select the best combination of variables on the basis of some important statistics such as , RMSE , AIC, BIC, R^2.Since R^2 is not the only criteria to judge the suitability of a model and sometimes value of R^2 is misleading ,so we calculate adj- R^2.Graph of Fit diagnostics for yield, Superimposition of graph of model predicted value and its residual as well as its actual value , clearly indicate the suitability of model developed. Further assessment regarding validity of model has been done on comparing the actual yield from 10 % of the observations not included in the model development with their predicted value and results shows close resemblance with the margin of error ranging from (2.35 – 6.79) .Thus preharvest estimation of yield of rice has been worked out ***14.88*** *q/h in Katihar district of Bihar for 2012-13 with the help of proposed model.*

Model for Katihar district for 2012-13

$$\hat{Y} = 11.38853 + 0.31433X_1 - 0.01607X_2 + 0.03195X_6 + 0.04057X_7 - 0.32147X_9 + 0.71324X_{10}$$

CV= 9.98 % , R^2 = 0.71, RMSE = 1.43, AIC=172.58, BIC=183.04, Residual=0.0005, Standard Error Mean predicted =0.35.

KeyWord*: forecast of rice yield, Biometrical Characters of rice, Farmers appraisal, Yield estimation*

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INTRODUCTION

Rice (*Oryza sativa* L.) is the staple food crop of state of Bihar. In Bihar rice is cultivated over an area of about 3.33 million hectare (8.22%) with production of 6.75 million tones and productivity 2.02 tones /hectare which is much lower than most of the rice growing states of the country. About 6.61 per cent of the total rice production is contributed by Bihar states with respect to India [1-2].

India stands in area and production 45.20 million hectare and 102 million tones respectively and accounts for about 14.14 per cent of the total rice production of the world. However, the average rice yield is only 2.26 tones /hectare in India which is much lower than most of the rice growing countries of the world.. Rice production area in the world is 164.80 million hectare with annual production of 721 million tones having productivity of 4.4 tones / hectare [3-7].

MATERIAL AND METHODS

The present study is based on the following technical programme of the work in katihar district of Bihar in 2012.

i. Identification measurable and non-measurable characters

ii. Selection of villages and farmers field for data on rice.
iii. Selection of best combination of yield attributing characters by least square technique .
iv. Validity testing of forecast model.

Measurable and non-measurable characters

Health and yield of the rice crop are affected by incidence of pest and diseases. For healthy crop, Biometrical character, chemical fertilizer is required in the form of nitrogen, phosphorus, and potassium as well as irrigation at various stages of crop development. The basis of observations, the following characters have been chosen for the development of forecast model.

S. No.	Variables	Codes of variables	Unit of Measurement	Type of characters
1.	Yield	Y	q/ha	Measurable
2.	Average plant population	X_1	per m^2	Measurable
3.	Average plant height	X_2	cm	Measurable
4.	Average number of tillers	X_3	per m^2	Measurable
5.	Average length of panicle	X_4	cm	Measurable
6.	Nitrogen (N)	X_5	kg/ha	Measurable
7.	Phosphorus (P_2O_5)	X_6	kg/ha	Measurable
8.	Potassium (K_2O)	X_7	kg/ha	Measurable
9.	Irrigation level	X_8	Numbers	Measurable
10.	Disease infestation	X_9	Percentage	Measurable
11.	Average plant condition	X_{10}	Eye estimate	Non-measurable

The last character is non-measurable since, it is based on human appraisal.

Data Collection from farmers field

Data collected on Rice from Katihar district of Bihar in 2012, randomly by three stages random sampling. Three stage random sampling will be taken the sampling strata is blocks, first stage unit are village ,2^{nd} stage units are farmers field and 3^{rd} stage units are plots in Katihar district. 5 village selected randomly, each contained randomly selected 5 farmer and each farmers field selected 2 plots so there are total no of sample size is 50, in Katihar district. The size of each plot will be taken one square meter for this crop. 10 % observation will be kept for modal validation purpose where 90 % observation will be used for developed linear model.

Statistic used in regression analysis

By all possible regression equation, the best subset has to be chosen on the basis of following criteria.
i. R^2 criteria (ii.) adj R^2 criteria (iii)Root Mean square criteria iv.AIC (v) BIC (vi) Cooks' D
vii Variance inflating factor

Validity Testing of forecast model

For the validity of regression model, the fulfillment of the following assumptions are required
i. Relationship between Y and X's is linear.
ii. The error have zero mean and constant variance
iii. The error are uncorrelated
iv. The error are normally distributed

Residual analysis and examination of predicted value are the two important aspects for testing the adequacy and the validity of model.

RESULTS AND DISCUSSION

Data collection

Data were collected from 25 farmers were selected (each from two samples), by simple random sampling, with three stages sample survey methods in different villages of Barari Blocks of Katihar district in the year 2012

Questionnaire development for data record

A questionnaire was developed for recording the observations of below characters.

Sl. No.	Name of variable	Code	Unit
1.	Yield	Y	q/ha
2.	Average plant population	X_1	per m^2
3.	Average plant height	X_2	cm
4.	Average number of tillers	X_3	per m^2
5.	Average length of panicle	X_4	cm
6.	Nitrogen (N) urea	X_5	kg/ha
7.	Phosphorus (P_2O_5)	X_6	kg/ha
8.	Potassium (K_2O) MOP	X_7	kg/ha
9.	Irrigation level (No. of irrigation)	X_8	Number
10.	Disease infestation	X_9	Percentage
11.	Average plant condition	X_{10}	Eye estimate

Estimation through all possible regression model

The all possible regression analysis were computed for 45 observation through SAS 9.3.. Out of 50 observation, 5 observation were kept for model validation and 45 observation were put for developing forecast model. The best five model were selected on the basis of RMSE, AIC , BIC, C.V. and R^2 value . After statistical analysis through software SAS 9.3 the low value of RMSE (1.43) and coefficient of variation (9.98 %) , R^2 (70.94%) is almost equal in all selected model, AIC (172.58) and BIC (183.04) are lower than other selected among five model Table-1. Among five selected model best Ist model has been presented in table 2. Although R^2 value is less than other selected but almost equal to other among selected model. References says that the large value of R^2 value do not necessarily imply that model is good as addition of variable will always increases R^2 for this reason ,many times R^2 adjusted is used as statistic for this purpose. Necessarily is that graph should superimposed / overlap to actual yield and estimated yield. If graph are superimposed /coincides to each other, model can be says good fitted. Even in some cases R^2 is more than 90% but graph are not superimposed to actual yield and estimated yield ,model is not good fit. In this research graph is superimposed / coincide to actual yield and estimated yield, it indicate model is good fitted. The value of standard error mean predicted, standard error residual, student residual are almost very low (Table-3) in comparison to other selected model in Katihar district. The root mean square error is also very low in comparison to other selected five model. The actual yield and predicted value is also very close to each other in Table -3. This indicated that, the selected regression subset consisting of X_1, X_2, X_6, X_7, X_9 and X_{10} could be considered the best subset for prediction purpose. The analysis for the selected subset for forecasting rice yield in Katihar district has been presented in Table- 2 (Ist model).

On the basis of above fact Ist model is best model for forecasting rice yield in Katihar district and has been presented in Table-2. The analysis of variance also Satisfied that F-value indicate that it is significant at 1 % and 5% level. The value variance inflating factor is less than 10 .so that there are no sign of multicollinearity . The Table -2 consisting of regression subset X_1, X_2, X_6, X_7, X_9 and X_{10} i.e. average plant population , average plant height, phosphorus (P_2O_5)kg/ha, Potash((K_2O), Disease infestation (%) and average plant condition (Eye estimate), respectively.

From Table 2 the regression comes to be significant and the regression X_1, X_6, X_7 , X_9, where also observed as significant at 1% and also at 5%. This indicated that the characters such as average plant population, phosphorus (P_2O_5)kg/ha, potassium(K_2O) and disease infestation explained 70.94% of variation in rice yield of Katihar district of Bihar.

The residual analysis for the subset has been presented in Table 3 The table indicated low value of residual for most of observations in Table-3 (Model –I). Plot for actual v's predicted value , After study among all the figure it is found that fig.-1 has been good fit for the first model. Fig-2 and Fig-3 shows the Fit diagnostic for yield and residual by regressor for yield respectively. The fig do not indicate any model violation.

Test for Reliability for proposed model

Propose model for Katihar district model number 1st presented in Table 2

$$\hat{Y} = 11.38853 + 0.31433X_1 - 0.01607X_2 + 0.03195X_6 + 0.04057X_7 - 0.32147X_9 + 0.71324X_{10}$$

Where,

Y	=	yield (q/ha)
X_2	=	average plant height
X_6	=	phosphorus (P_2O_5)kg/ha,
X_7	=	Potassium (K_2O) kg/ha.
X_9	=	Disease infestation
X_{10}	=	Average plant condition (Eye estimation)

Observations correspond to the variables included in the model has been given in Table 1. For each observation set, the estimated deviation and per cent error of forecast has been presented in Table- 4. It was observed that per cent error of forecast is below 6.79 per cent. This indicated that the model could be used to forecast rice in Katihar district with good accuracy. Thus preharvest forecasted yield of rice has been worked out **14.88** q/h in Katihar district of Bihar for 2012-13 with the help of proposed model..

Table -1 Selection of best 5 model by all possible regression statistic

Sl. No.	Independent variable sub set Model	(%) R^2	RMSE	AIC	BIC
1.	X1,X2,X6,X7,X9,X10	70.94	1.43	172.58	183.04
2.	X1,X2,X5,X6,X7,X9,X10	71.55	1.44	174.78	185.89
3.	X1,X2,X4,X5,X6,X7,X9,X10	71.70	1.46	177.86	189.45
4.	X1,X2,X3,X4,X5,X6,X7,X9,X10	71.79	1.47	181.26	193.13
5.	X1,X2,X3,X4,X5,X6,X7,X8,X9,X10	71.84	1.49	184.93	196.86

Table -2 : Forecasting rice yield by Regression analysis for the 1st model in Katihar district

Regression equation

$\hat{Y}$ =11.38853+ 0.31433X_1 - 0.01607X_2 +0.03195X_6 + 0.04057X_7- 0.32147X_9 +0.71324X_{10}

Variable	Parameter Estimate	Standard Error	t-value	Pr >| t |	Variance Inflation
Constant	11.38	3.34	3.41**	0.00	0
X_1	0.31	0.10	2.88**	0.00	1.04
X_2	-0.02	0.01	-1.16	0.25	1.18
X_6	0.03	0.01	2.92**	0.00	1.32
X_7	0.04	0.01	3.24**	0.00	1.71
X_9	-0.32	0.06	-4.98**	<.00	1.43
X_{10}	0.71	0.37	1.90*	0.06	1.25

CV = 9.98 %, R^2 = 0.71, Adj R^2 = 0.66, RMSE = 1.43

ANOVA

Source	d.f.	S.S.	M.S.	F-value	Pr > F
Model	6	190.97	31.83	15.46**	<.00
Error	38	78.22	2.06		
Total	44	269.200			

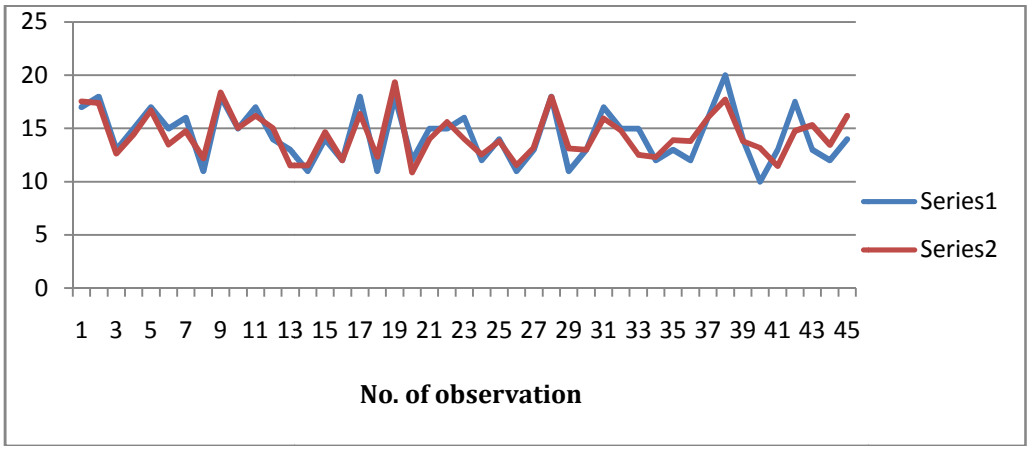
Table -3: Best subset for Estimation of Rice yield by Residual analysis in Katihar district for 1st model

Obs.	Dependent variable	Predicted value	Std. error mean predicted	Residual	Cook's D
1.	17.000	17.529	0.536	-0.529	0.004
2.	18.000	17.386	0.640	0.613	0.008
3.	13.000	12.641	0.725	0.358	0.004
4.	15.000	14.456	0.506	0.543	0.003
5.	17.000	16.698	0.482	0.301	0.001
6.	15.000	13.470	0.522	1.529	0.029
7.	16.000	14.746	0.540	1.253	0.021
8.	11.000	12.207	0.565	-1.207	0.022
9.	18.000	18.385	0.510	-0.385	0.002
10.	15.000	15.041	0.602	-0.041	0.000
11.	17.000	16.196	0.354	0.803	0.003
12.	14.000	15.049	0.664	-1.049	0.027
13.	13.000	11.548	0.548	1.452	0.029
14.	11.000	11.534	0.411	-0.534	0.002
15.	14.000	14.666	0.352	-0.666	0.002
16.	12.000	12.013	0.673	-0.013	0.000
17.	18.000	16.359	0.620	1.640	0.053
18.	11.000	12.339	0.600	-1.339	0.032
19.	18.000	19.333	0.844	-1.333	0.100
20.	12.000	10.875	0.479	1.125	0.012
21.	15.000	13.997	0.477	1.003	0.010
22.	15.000	15.602	0.425	-0.602	0.003
23.	16.000	14.004	0.582	1.995	0.065
24.	12.000	12.544	0.438	-0.544	0.002
25.	14.000	13.820	0.401	0.179	0.000
26.	11.000	11.555	0.627	-0.555	0.006
27.	13.000	13.200	0.533	-0.200	0.001
28.	18.000	17.962	0.660	0.037	0.000
29.	11.000	13.136	0.692	-2.136	0.125
30.	13.000	12.999	0.748	0.000	0.000
31.	17.000	15.934	0.455	1.065	0.010
32.	15.000	14.807	0.540	0.192	0.000
33.	15.000	12.528	0.685	2.471	0.162
34.	12.000	12.311	0.791	-0.311	0.004
35.	13.000	13.890	0.680	-0.890	0.021
36.	12.000	13.804	0.405	-1.804	0.021
37.	16.000	15.992	0.517	0.007	0.000
38.	20.000	17.715	0.443	2.284	0.042
39.	14.000	13.804	0.492	0.195	0.000
40.	10.000	13.195	0.517	-3.195	0.122
41.	13.000	11.477	0.573	1.522	0.036
42.	17.500	14.782	0.713	2.717	0.224
43.	13.000	15.305	0.414	-2.305	0.037
44.	12.000	13.457	0.408	-1.457	0.014
45.	14.000	16.188	0.506	-2.188	0.054

Table -4 :Forecasting error for observations not included in model building for Katihar district of Bihar (1st Model)

$\hat{Y}$ =11.38853+ 0.31433X_1 - 0.01607X_2 +0.03195X_6 + 0.04057X_7- 0.32147X_9 +0.71324X_{10}

Sl. No.	X_1	X_2	X_6	X_7	X_9	X_{10}	Y	$\hat{Y}$	$Y - \hat{Y} = \hat{e}_i$	$\frac{\hat{e}_i}{\hat{Y}} \times 100$
1	16.5	102.2	50	0	12	3	14	14.81	-0.81	5.40
2.	18	101.7	0	0	10	3	15	14.34	0.66	4.60
3.	16.5	100	40	60	5	4	21	19.93	1.07	5.39
4.	15.5	92.2	40	0	10	3	16	14.98	1.01	6.79
5.	14	105	40	0	20	2	10	10.37	-0.37	-3.63



Actual yield(series-1) and Predicted Yield(Series-2)

Figure- 1 and 1st Model

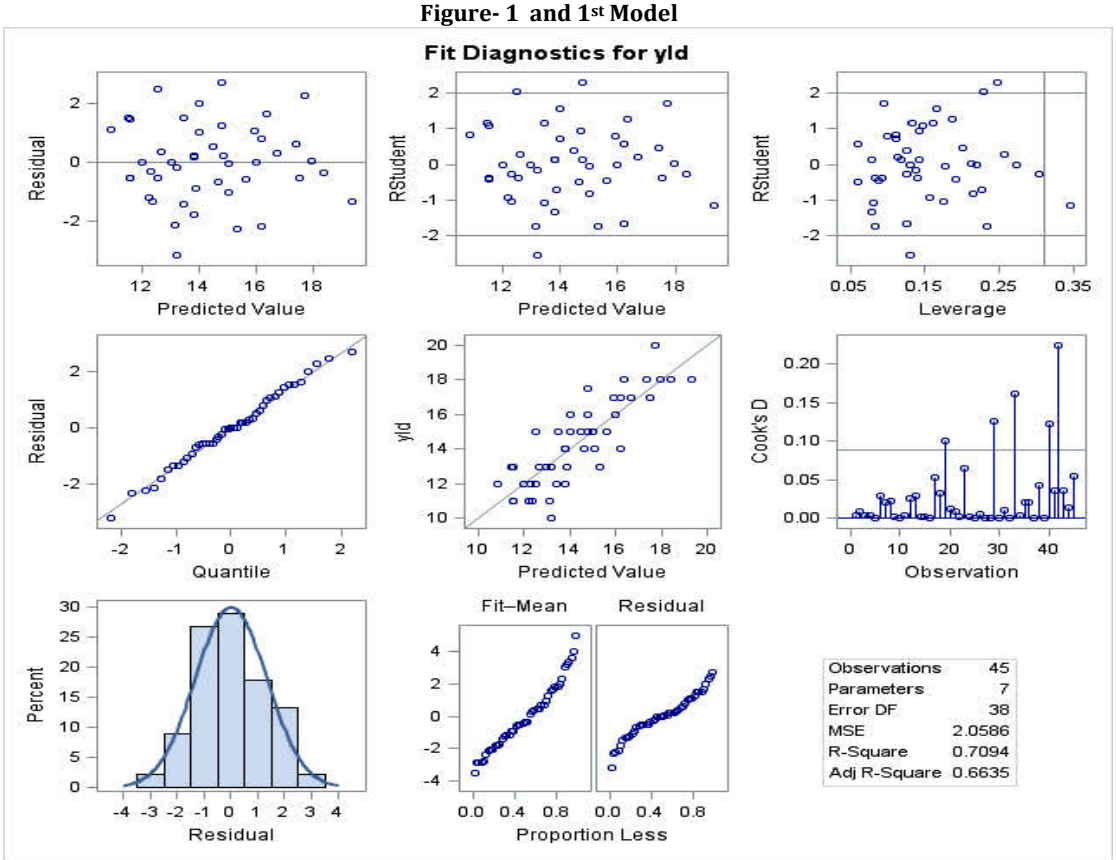


Fig-2 : Shows the Fit diagnostic for yield

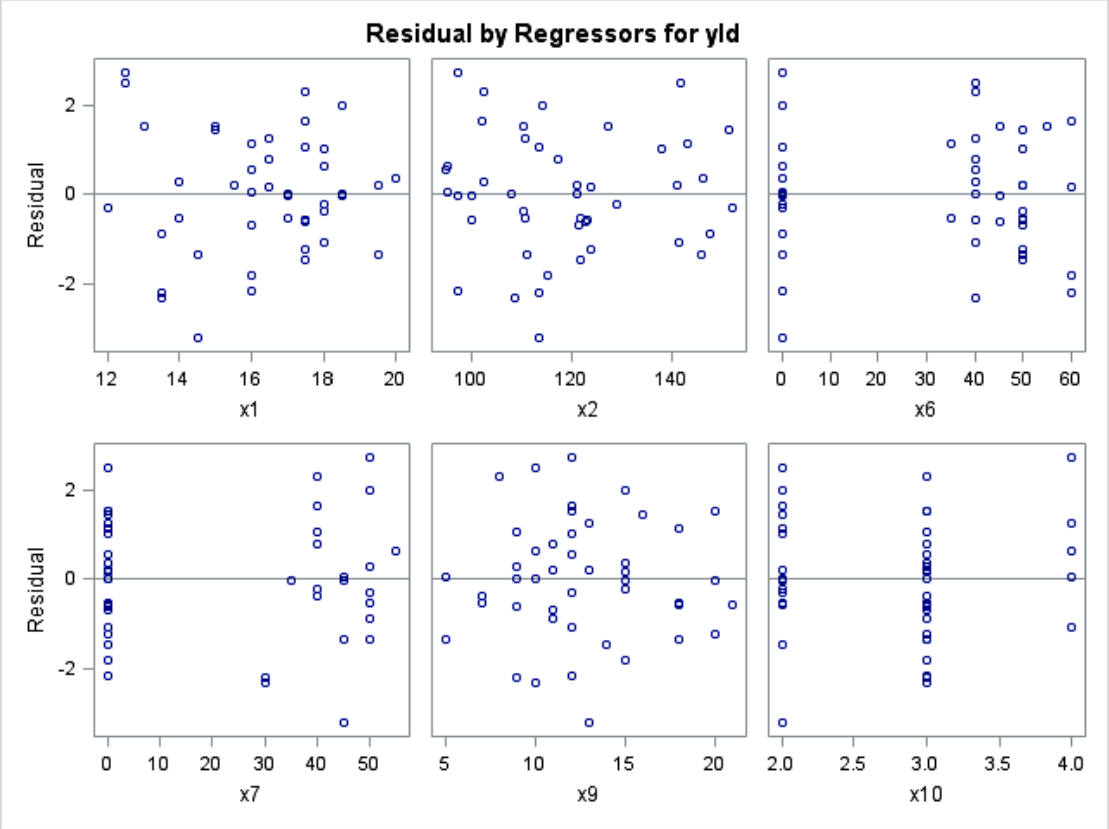


Figure-3: Residual by regressor for yield respectively

REFERENCES

1. Agarwal, R., Jain, R.C. and Jha, M.P. (1986). Models for studying rice crop-weather relationship, *Mausam*, **37** : 67-70.
2. Agarwal, R., Jain, R.C., Jha, M.P. and Singh, D. (1980). Forecasting of rice yield using climatic variables. *Indian J. of Agril. Sci.* **50** :(9) 680-684.
3. Agrawal, Ranajana and Jain, R.C. (1996). Forecast of sugarcane yield using eye estimate alongwith plant characters. *Biometrical Journal*, **38** (5) : 731-739.
4. Chadha, R.S. (1959). Crop forecasting in Japan. *Agriculture situation in India*. **13** (12) : 1037-45.
5. Chowdhury, A. and Sarwade, G. (1985). Evaluating the effect of Technology and weather fluctuation on rice yields in Punjab, Mausam **36** : 209-214.
6. Das, J.C., Mehra, A.K. and Madnani, M.L. (1971). Forecasting the yield of principal crops in India on the basis of weather paddy/rice *Indian J of Meteorology.* Hydrology and Geophysics. **22** : 47-52.
7. Ghadekar, S.R., Khatta, K.D., Chipde, D.L. and Das, S.N. (1992). Studies on the growth, development. Yield and photo-thermal requirements of wheat under different weather conditions in Nagpur region. *Ind. J. of Agri. Res.* **26** (4) : 195-204.