International Journal of Agriculture Sciences
ISSN: 0975-3710 & E-ISSN: 0975-9107, Volume 10, Issue 11, 2018, pp.-6198-6199.
Available online at https://www.bioinfopublication.org/jouarchive.php?opt=&jouid=BPJ0000217

Research Article

MATHEMATICAL MODELING ON RAINFALL AND GROUNDNUT PRODUCTIVITY IN BHAVNAGAR DISTRICT OF GUJARAT

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Received: May 28, 2018; Revised: June 05, 2018; Accepted: June 06, 2018; Published: June 15, 2018

Abstract: The district-wise average yield data of groundnut and daily rainfall data were used over a period of 47 years *i.e.*, from 1970-2017. Aggregate rainfall approach and different models *viz*., Linear, Quadratic, Cubic, Quartic, Exponential, Wilmink, Parabolic Exponential, Wood's Gamma, Inverse Quadratic, Mixed Log, Heat Capacity, Monomolecular were tried to fit the mathematical models on rainfall and groundnut productivity in Bhavnagar district of Gujarat. The appropriate mathematical model was selected on the basis of adjusted R^2, significant regression co-efficient, co-efficient of determination (R^2) and RMSE. Among the different linear and non-linear models fitted, the maximum adjusted R^2 of 40 percent was observed in case of Quadratic model with the comparatively lower values of root mean square (324.0) in comparison to that of other fitted models. In general, it could be observed that, none of the fitted models could be recommended as perharvest forecast models, because of low to moderate predictability. This suggests that inclusion of certain other weather parameters like temperature, relative humidity, daily sunshine and wind speed in the models, may improve the predictability of the groundnut productivity.

Keywords: Groundnut, Rainfall distribution

Citation: Chaudhari G.B., *et al*., (2018) Mathematical Modeling on Rainfall and Groundnut Productivity in Bhavnagar District of Gujarat. International Journal of Agriculture Sciences, ISSN: 0975-3710 & E-ISSN: 0975-9107, Volume 10, Issue 11, pp.- 6198-6199.

Introduction

India is one of the major oilseeds producing country in the world. Among the five major oil seed crops *viz*. groundnut, castor, mustard, linseed and sesame grown in the country, groundnut (*Arachis hypogaea* L.) occupies the first rank in terms of area and production. Groundnut is main crop of Saurashtra region of Gujarat is predominantly grown as rainfed as well as summer season. The region comprises of six districts *viz*. Junagadh, Amreli, Rajkot, Bhavnagar, Jamnagar and Surendranagar. The year to year fluctuation in the crop yields are mainly attributable due to the variation in rainfall and its distribution. Khatri and Patel, (1982) [1] studied the effect of rainfall distribution along with the estimates for five major groundnut growing districts of Saurashtra region using 21 years data (1957-77). The effects of rainfall pattern on the productivity of groundnut were studied by Suryanarayana, *et al*., (1982); Sahu, *et al*., (2004); Patel and Vaishnav, (1990) [2,3,4] studied the effect of rainfall on groundnut yield under dry framing situation of Gujarat. Khatri and Patel, (1990) [5] tried to locate critical phases in groundnut crop by selecting rainfall variables through stepwise regression analysis technique. The effects of rainfall distribution on the yield of groundnut during its growth period were studied by Singh and Singh, (1994) [6] in Rajkot district of Gujarat. Forecasting of groundnut yield using rainfall variables for Saurashtra region of Gujarat was studied by Parmar, *et al*., (2004) [7]. The present investigation has been taken up to fit mathematical models on rainfall and groundnut productivity in Bhavnagar district of Gujarat

Materials and Methods

Among six major groundnut-growing districts of Saurashtra region, Bhavnagar district was selected for the present study. The district-wise average yield data over a period of 47 years *i.e*., from 1970-2017 was collected from the Directorate of Agriculture, Gujarat state, Gandhinagar [8]. The daily rainfall during the crop season *i.e*., from 3rd June to 30th September (23rd to 39th MSW) recorded at the Bhavnagar weather station was used in the study. Aggregate rainfall approach and different models were applied to fit the mathematical models on rainfall and groundnut productivity in Bhavnagar district of Gujarat. For aggregate rainfall approach, total of 17 weeks rainfall (23rd to 39th MSW) was considered as predictor variable. Total growth period has been considered as 120 days. The following models are employed in the present investigation.

Linear Model: $Y=a+Bx$
Quadratic Model: $Y=a+bX+cX^2$
Cubic Model: $Y=a+bX+cX^2+dX^3$
Quartic Model: $Y=a+bX+cX^2+dX^3+eX^4$
Exponential Model: $Y=a * \exp(b*X)$
Wilmink Model: $Y=a+b \exp(- k*X)+ cX$
Parabolic Exponential Model: $Y=a \exp(bX - cX^2)$
Wood's Gamma Model: $Y=aXbe-cX$
Inverse Quadratic Model: $Y=a+bX-cX^2$
Mixed Log Model: $Y=a+bX^{1/2}+c \ln X$
Heat Capacity Model: $Y=a+bX+c/X^2$
Monomolecular Model: $Y = c –(c-a) \exp(-b*X)$

Where, Y = District average yield in kg/ha, X= Aggregate rainfall (*i.e*., 23rd to 39th meteorological standard weeks), a, b, c, d and e are parameters

Table-1 Characteristics of fitted mathematical models

Models	Regression Coefficients					Goodness of fit	
	a	b	c	d	e	R^2 [Adj.R^2]	RMSE
Linear	115.480	1.310**	-	-		0.36[0.34]	337.7
Quadratic	-554.575	4.334*	0.002*	-		0.44[0.40]	324.0
Cubic	-890.700	6.697	-0.008	-0.003		0.44[0.38]	328.9
Quartic	202.615	-4.624	0.032	-0.001	-0.002	0.44[0.36]	333.1
Exponential	369.301	0.001*	-	-	-	0.31[0.29]	351.1
Wilmink	179.524	-1152525	1.208**	-		0.38[0.34]	338.7
Parabolic Exponential	96.926	0.007*	0.005*	-		0.42[0.38]	329.1
Wood's Gamma	0.003	2.681*	0.004	-		0.43[0.39]	324.4
Inverse Quadratic	-554.575	4.335**	0.003	-	-	0.43[0.39]	324.0
Mixed Log	-7409.89	-104.091	1706.045	-	-	0.43[0.39]	324.8
Heat Capacity	557.458	0.7054	-0.002	-	-	0.41[0.37]	3.29.8
Monomolecular	-1232.38	0.004	1115.836*			0.43[0.39]	324.1

Results and Discussion

In order to justify the objectives of the present investigation, an attempt was made through mathematical models to study influence rainfall on groundnut productivity in Bhavnagar district of Gujarat. Among the fitted mathematical models, the model having highest adjusted R^2 with significant F value was selected, so that it satisfies test for goodness of fit. The characteristics of fitted mathematical models [Table-1] are presented. The data presented in [Table-1] revealed that among the different linear and non-linear models fitted, the maximum adjusted R^2 of 40 percent was observed in case of Quadratic model with the comparatively lower values of root mean square (324.0) in comparison to that of other fitted models. All the estimated values of the parameters in the model were found to be within the 95% confidence interval indicating that the parameters were significant at 5% level of significance. For this district, the value of adjusted R^2 varied from 0.29 to 0.40 in all the fitted models. Thus, it could be noticed that variation explained by various fitted models were moderate. In general, it could be observed that, none of the fitted models could be adopted/recommended as perharvest forecast models, because of low to moderate predictability. This suggests that inclusion of certain other weather parameters like temperature, relative humidity, daily sunshine and wind speed in the models, may improve the predictability of the groundnut productivity. Ramchandran and Rajegowda, (1987) [9] studied the water balance and groundnut yield in the tropical semi-arid climate of Bangalore. They revealed that yield of crop and water balance components ratios were found positively correlated. Khichar, *et al*., (1996) [10] studied crop yield variation in relation to moisture adequacy index at Haryana. They selected four crops *viz*., maize, groundnut, pearlmillet and greengram and found that the crop yield was directly associated with moisture adequacy index. The R^2 values varied from 0.71 to 0.83. Thus, it is clear from the discussion that amount of rainfall alone could not determine the groundnut yield. The related studies, suggested that water balance or soil moisture index, which integrates the effect of temperature, crop coefficient at different phenophases, soil physical parameters along with the rainfall distribution could determine the groundnut productivity to a large extend.

Application of research: Study the effect of rainfall and its distribution on groundnut productivity and extreme possibility of pre harvest forecast of groundnut production

Research Category: Agricultural Statistics

Abbreviation

MSW: Meteorological Standard Weeks

Acknowledgement / Funding: Authors are thankful to College of Agricultural Information Technology, Anand Agricultural University, Anand, 388 110, Gujarat, India.

***Research Guide or Chairperson of research: Dr R. S. Parmar**

University: Anand Agricultural University, Anand, 388 110, Gujarat

Research project name or number: PhD Thesis,

Author Contributions: All author equally contributed

Author statement: All authors read, reviewed, agree and approved the final manuscript

Conflict of Interest: None declared

Ethical approval: This article does not contain any studies with human participants or animals performed by any of the authors.

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