International Journal of Agriculture Sciences
ISSN: 0975-3710 & E-ISSN: 0975-9107, Volume 13, Issue 10, 2021, pp.-10913-10916.
Available online at https://bioinfopublication.org/pages/jouarchive.php?id=BPJ0000217

Research Article

FORECASTING AREA, PRODUCTION AND PRODUCTIVITY OF CITRUS IN GUJARAT-AN APPLICATION OF ARTIFICIAL NEURAL NETWORK

PRITY KUMARI[1]* AND SATHISH KUMAR M.[2]
[1]Department of Basic Science, College of Horticulture, Anand Agricultural University, Anand, 388110, Gujarat, India
[2]International Agri-Business Management Institute, Anand Agricultural University, Anand, 388110, Gujarat, India
*Corresponding Author: Email - psingh2506@aau.in

Received: October 03, 2021; Revised: October 26, 2021; Accepted: October 27, 2021; Published: October 30, 2021

Abstract: Present study deals with artificial neural network model to forecast area, production and productivity of citrus in Gujarat state. Secondary data on area, production and productivity of citrus in Gujarat over the period 1991-92 to 2017-18 were collected form Directorate of Horticulture, Government of Gujarat. Time series secondary data on area, production and productivity of citrus were collected for the period 1958-59 to 2017-18 from National Horticultural Board. Different artificial neural network models were used to analyze the data in RStudio (version 3.5.2) software. The study revealed that area, production and productivity of citrus was best explained by 4:1s:1l, 2:2s:1l & 3:2s:1l ANN architectures, with forecasted value for 2018-19, 41.43 ('000' Ha.), 4143.00 ('000' MT) &10.20 (MT/Ha.) respectively, where area, production & productivity are likely to go down for the next year.

Keywords: *Forecasting, Area, Production, Productivity, Citrus and Artificial neural network model*

Citation: Prity Kumari and Sathish Kumar M. (2021) Forecasting Area, Production and Productivity of Citrus in Gujarat-An application of Artificial Neural Network. International Journal of Agriculture Sciences, ISSN: 0975-3710 & E-ISSN: 0975-9107, Volume 13, Issue 10, pp.- 10913-10916.

Introduction

India is the second largest producer of fruits and vegetables in the world after China. Horticultural crops constitute a significant portion of the total agricultural produce in India. It covers a wide cultivation area and contribute about 28 per cent of the Gross Domestic Product (GDP). It accounts 37 per cent of the total exports of agricultural commodities from India. India recorded highest ever horticulture production of 320.77 million tonnes from area of 25.66 million hectares. India is one of the largest producers of citrus in the world and Gujrat is the leading producer followed by Maharashtra, Madhya Pradesh, Tamil Nadu, Assam, Orissa and West Bengal. Citrus cultivated 81.0 ('000 Hectare) and achieved production was 704 ('000 MT) with productivity 8.7 (MT/ Hectare) during the period 2019-20 [1]. Gujarat n India and produced 6,00,000 tonnes (National Horticulture Board, 2017-2018). Artificial Neural Network model has many features which attract the researchers and it is contrast to many tradition techniques. It provides competitive results to various time series models such as ARIMA model.

Review of literature

Kumari Prity, *et al*., (2016) [2] studied statistical models for forecasting pigeon pea yield in Varanasi region. forecasting the yield of pigeon pea in Varanasi region by using 27 years of data from 1985-86 to 2011-12. Different linear and non-linear models like multiple linear regression (MLR), autoregressive integrated moving average (ARIMA) and artificial neural network (ANN) models were used. The best suited model was identified based on root mean squared error (RMSE). The study found that ANN was the best model having lowest RMSE forecasted pigeon pea yield during the year 2012-13 for Varanasi region. Kumari Prity, *et al.,* (2017) [3] studied forecasting models for predicting pod damage of pigeon pea in Varanasi region. Autoregressive integrated moving average (ARIMA) and artificial neural network (ANN) with multiple linear regression models were used to predicting perc cent pod damage in pigeon pea by pod borer in Varanasi region, Uttar Pradesh by using 27 years of data (1985-86 to 2011-12). The best suited model was assessed by root mean squared error (RSME).

The study revealed that ANN was found best model with lowest RSME having forecasted per cent of pod damage in pigeon pea 2012-13.

Material and Methods

Source of data

Secondary data on area, production and productivity of citrus in Gujarat over the period 1991-92 to 2017-18 were collected form Directorate of Horticulture, Government of Gujarat. Time series secondary data on area, production and productivity of citrus were collected for the period 1958-59 to 2017-18.

Analytical framework

In the present study, different neural network architectures were used to compare their ability for predicting area, production and productivity of citrus in Gujarat. RStudio (version 3.5.2) software used to analyze the data.

Artificial neural network (ANN)

ANNs are nonlinear data-driven models capable to perform modeling without a prior knowledge about the relationships between input and output variables. Its generalizing ability, after learning the data presented to structure, can often correctly infer the unseen part of a population even if the sample data contain noisy information. Time series can be modelled with the structure of a neural network by the use of time delay, which can be implemented at the input layer of the neural network. Such an ANN is termed as Time Delay Neural Network.

The structure of the neural network consists of:
1. Input Layer,
2. Hidden Layer,
3. Output Layer

The general expression for the final output value y_{t+1} in a multilayer feed forward time delay neural network is given by equation:

$$y_{t+1} = g\left[\sum_{j=1}^{q} \alpha_j f\left(\sum_{i=0}^{p} \beta_{ij} y_{t-i}\right)\right]$$

Where,
f and g denote the activation function at the hidden and output layers, respectively.
p is the number of input nodes (tapped delay),
q is the number of hidden nodes,
β_{ij} is the weight attached to the connection between i^{th} input node to the j^{th} node of hidden layer,
α_j is the weight attached to the connection from the j^{th} hidden node to the output node,
y_{t-i} is the i^{th} input (lag) of the series.
The main task of activation function is to map the outlying values of the obtained neural input back to a bounded interval such as [0,1] or [-1,1].

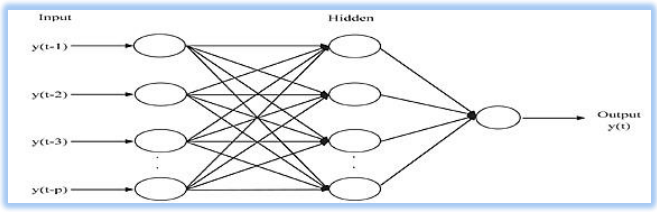

Fig-1 Time-Delay Neural Network (TDNN) with one hidden layer

Research Results

Area, production and productivity of citrus were analyzed through this study by using different neural network architecture. The empirical findings of citrus crop are as follow:

Forecasting of area for citrus

[Fig-2] shows chart series of area dataset for citrus from1991-92 to 2017-18. Also, the characteristics (basic statistics) of the data set used were presented in the [Table-1].

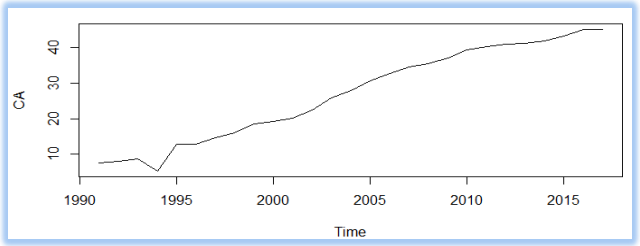

Fig-2 Area (In ' 000 Hectare) under citrus in Gujarat

Table-1 *Summary statistics of citrus area time series*

No. of observations	27
Minimum	5.4
Maximum	44.96
Mean	26.92
Median	27.93
Standard Deviation	13.18
Sem	2.54
Skewness	-0.14
Kurtosis	-1.53

Various architectures of neural network were tried considering the availability of data. Further, the model performance in training set and testing data set is given in [Table-2].

Table-2 Forecasting performance of ANN model for citrus area time series

Model	Parameters	RMSE	
		Training	Testing
2-1S-1L	5	34.703	1.608
3-1S-1L	6	34.700	1.606
4-1S-1L	7	32.648	0.682
2-2S-1L	9	34.759	1.070
3-2S-1L	11	35.112	0.871

Based on the lowest training RMSE, ANN model 4:1S:1I is selected. It is also assessed based on its hold out sampling (testing set) forecasting performance and is having lowest testing RMSE. Therefore, neural network architectures 4:1s:1I was used to forecast area of citrus in Gujarat.

[Table-3] reflects that the estimates of all weights associated with nodes of different layer. Input layer lag1, lag2, lag3 and lag4 are denoted by I1, I2, I3 & I4, Hidden layer node1 is denoted by H1 and output node is denoted by O, where biases of two nodes are given by the notation HB1 & OB. The forecasted value of citrus area in Gujarat for the year 2018-19 by 4:1s:1I neural network architecture was obtained as 41.43 ('000' Hectare.) with confidence interval 40.10 to 42.87.

Table-3 *ANN model parameter citrus area time series*

Weights between nodes		Biases	
I1:H1	0.303	Hidden node	
I2:H1	0.506	H_{B1}	-1.417
I3:H1	0.408	Output node	
I4:H1	0.192	O_B	3.196
H1:O	0.373		
Forecasting (2018-19)		C.I.	
41.43		40.10	42.87

Forecasting of production for Citrus

[Fig-4] shows chart series of production dataset for citrus from 1991-92 to 2017-18. Also, the characteristics (basic statistics) of the data set used were presented in the [Table-4].

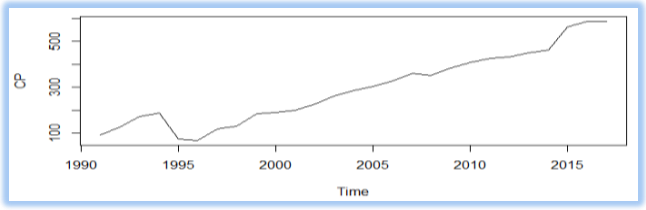

Fig-4 Production (In '000 MT) of citrus in Gujarat

Table-4 *Summary statistics of citrus production time series*

No. of observations	27
Minimum	68.7
Maximum	586.8
Mean	294.74
Median	285.26
Standard Deviation	158.42
Sem	30.49
Skewness	0.31
Kurtosis	-1.13

Various architectures of neural network were tried considering the availability of data. Further, the model performance in training set and testing data set is given in [Table-5].

Table-5 *Forecasting performance of ANN model for citrus production time series*

Model	Parameters	RMSE	
		Training	Testing
2-1S-1L	5	408.821	32.392
3-1S-1L	6	411.527	31.347
4-1S-1L	7	414.695	31.461
2-2S-1L	9	407.965	29.742
3-2S-1L	11	417.957	27.794

Based on the lowest training RMSE, ANN model 2:2S:1I is selected. It is also assessed based on its hold out sampling (testing set) forecasting performance, and the chosen model is having lowest testing RMSE too. Therefore, neural network architectures 2:2s:1I was used to forecast production of citrus in Gujarat.

[Table-6] reflects that the estimates of all weights associated with nodes of different layer. Input layer lag1 and lag2 are denoted by I1 & I2, Hidden layer node1 & node 2 are denoted by H1 & H2 and output node is denoted by O, where biases of three nodes are given by the notation HB1 HB2 & OB. The forecasted value of citrus production in Gujarat for the year 2018-19 by 2:2s:1I neural network architecture was obtained as 429.70 ('000' MT) with confidence interval 342.14 to 488.11.

Table-6 *ANN model parameter citrus production time series*

Weights between nodes		Biases	
I1:H1	1.598	Hidden node	
I2:H1	-3.268	H_{B1}	-1.148
I1:H2	5.713	H_{B2}	-1.637
I2:H2	0.224	Output node	
H1:O	0.319	O_B	4.576
H1:O	1.526		
Forecasting (2018-19)		C.I.	
429.70		342.14	488.11

Forecasting of productivity for citrus

[Fig-5] shows chart series of productivity dataset for citrus from 1991-92 to 2017-18. Also, the characteristics (basic statistics) of the data set used were presented in the [Table-7].

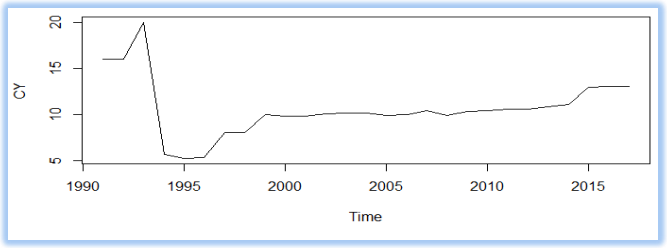

Fig-5 Productivity (In MT/Ha.) of citrus in Gujarat

Table-7 *Summary statistics of citrus productivity time series*

No. of observations	27
Minimum	5.3
Maximum	20
Mean	10.66
Median	10.21
Standard Deviation	3.17
Sem	0.61
Skewness	0.8
Kurtosis	1.28

Various architectures of neural network were tried considering the availability of data. Further, the model performance in training set and testing data set is given in [Table-8].

Table-8 *Forecasting performance of ANN model for citrus productivity time series*

Model	Parameters	RMSE	
		Training	Testing
2-1S-1L	5	8.112	2.370
3-1S-1L	6	7.551	0.681
4-1S-1L	7	7.710	0.333
2-2S-1L	9	7.672	0.998
3-2S-1L	11	7.550	0.207

Based on the lowest training RMSE, ANN model 3:2S:1I is selected. It is also assessed based on its hold out sampling (testing set) forecasting performance, and the chosen model is having lowest testing RMSE too. Therefore, neural network architectures 3:2s:1I was used to forecast productivity of citrus in Gujarat.

Table-9 *ANN model parameter citrus productivity time series*

Weights between nodes		Biases	
I1:H1	5.729	Hidden node	
I2:H1	0.086	H_{B1}	-1.485
I3:H1	-2.147	H_{B2}	1.511
I1:H2	-2.821	Output node	
I2:H2	-4.432	O_B	-3.752
I3:H2	0.002		
H1:O	-2.133		
H1:O	0.138		
Forecasting (2018-19)		C.I.	
10.20		9.80	10.64

[Table-9] reflects the estimates of all weights associated with nodes of different layer. Input layer lag1, lag2 and lag3 are denoted by I1, I2& I3, Hidden layer node1 & node 2 are denoted by H1 & H2 and output node is denoted by O, where biases of three nodes are given by the notation HB1 HB2 & OB.

The forecasted value of citrus productivity in Gujarat for the year 2018-19 by 3:2s:1I neural network architecture was obtained as 10.20 (MT/Ha.) with confidence interval 9.80 to 10.64.

Table-10 *Performance of different models for citrus*

Model for crops		Area (In '000' Ha.)	Production (In '000 MT)	Productivity (MT/Ha.)
Citrus	Model	4:1s:1I	2:2s:1I	3:2s:1I
	RMSE	32.64	407.96	7.55
	Forecast	41.43 (44.96)	429.70 (586.8)	10.20 (13.05)
	C.I.	40.10 to 42.87	342.14 to 488.11	9.80 to 10.64

[Table-10] shows area, production and productivity of citrus was best explained by 4:1s:1I, 2:2s:1I & 3:2s:1I ANN architectures, with forecasted value for 2018-19, 41.43 ('000' Ha.), 4143.00 ('000' MT) &10.20 (MT/Ha.) respectively, where area, production & productivity are likely to go down for the next year.

Conclusion

The study concluded that artificial performance of neural network models was better than classical time series model. To forecast the area, production and productivity of citrus in Gujarat was done better with help of hybrid time series model rather than single model. ANN model was finest model among all other hybrid model. Therefore, ANN model recommended to forecast all other agricultural and horticultural crops and it will be helpful to farmers and policy makers to make effective decision in advance.

Application of research: Forecasting area, production and productivity of citrus in Gujarat by using artificial neural network model.

Research Category: Agricultural Statistic

Acknowledgement / Funding: Authors are thankful to International Agri-Business Management Institute, Anand Agricultural University, Anand, 388110, Gujarat, India. Authors are also thankful to Department of Basic Science, College of Horticulture, Anand Agricultural University, Anand, 388110, Gujarat, India

****Principal Investigator or Chairperson of research: Dr Prity Kumari**
University: Anand Agricultural University, Anand, 388110, Gujarat, India
Research project name or number: Research station study

Author Contributions: All authors equally contributed

Author statement: All authors read, reviewed, agreed and approved the final manuscript. Note-All authors agreed that- Written informed consent was obtained from all participants prior to publish / enrolment

Study area / Sample Collection: National Horticultural Board

Cultivar / Variety / Breed name: Citrus

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.
Ethical Committee Approval Number: Nil

References

[1] National Horticultural Board (NHB) Data base (2017-2018) *Current Scenario of Horticulture in India.*
[2] Kumari Prity, Mishra G.C. and Srivastava C.P. (2016) *Journal of Agrometeorology*, 18(2), 306-310.
[3] Kumari Prity, Mishra G.C. and Srivastava C.P. (2017) *Journal of Agrometeorology*, 19(3), 265-269.
[4] Aguilar K.L., Mendoza A.B., Morales S.G. and Maldonado A.J. (2020) *Agriculture*, 10(2), 2-14.

[5] Dhaikar S.S. and Rode S.V. (2014) *International Journal of Innovative Research in Electrical, Electronics, Instrumentation and Control Engineering*, 2(1), 683-686.
[6] Diebold F.X. and Lopez J.A. (1996) *Handbook of statistics 14. Elsevier Science, Amsterdam.*
[7] Guo W.W. and Xue H. (2014) *Mathematical problems in Engineering*, 8(3), 4-10.
[8] Hamjah M.A. (2014) *Journal of Economics and Sustainable Development*, 5(7), 96-107.
[9] Hossain M.M., Abdulla F. and Majumder A.K. (2016) *American Journal of Agricultural and Biological Sciences*, 11(2), 93-99.
[10] Mayer D.G. and Stephenson R.A. (2016) *Acta Horticulture*, 1109, 265-270.
[11] Omar M.L., Dewan M.F. and Hoq M.S. (2014) *European Journal of Business Management*, 6(7), 244-255.
[12] Pardhi R., Singh R., Rathod S. and Singh P.K. (2016) *Econ. Affairs*, 61(4), 1-5.
[13] Peiris T.S.G., Hansen J.W., and Zubair L. (2008) *International Journal of Climatology*, 28, 103-110.
[14] Rathod S. (2018) *Journal of Agricultural Sciences*, 88(1), 22-27.
[15] Rathod S. and Mishra C.G. (2018) *Journal of Agricultural Science and Technology*, 20(3), 803-816.