World Applied Sciences Journal 30 (3): 341-344, 2014
ISSN 1818-4952

DOI: 10.5829/idosi.wasj.2014.30.03.8

Horoscope Algorithm to Predict Potential Yield of Cassava

V.S. Santhosh Mithra, C.S. Abhinand and J.Sreekumar

Central Tuber Crops Research Institute, Thiruvananthapuram, India

Abstract: Potential yield of cassava vary greatly from one place to another. This variability is mainly due to the variation in weather parameters like maximum temperature, minimum temperature, sunshine hours and precipitation. Computation of potential yield of cassava of a place using the cassava simulation model SIMCAS requires weather and plant parameter data as input. When this is repeated for another location, the entire process should be repeated and it becomes cumbersome. Hence a simple algorithm based on fuzzy logic concepts is proposed here. All the spatial parameters and potential yield of cassava are divided into fuzzy sets and fuzzy inference rules (FIR) are formed on these sets. These fuzzy sets are arranged in the form of cells of Indian horoscope and potential yield is predicted based on FIR and these fuzzy sets. The algorithm was validated with values of simulated potential yield and this algorithm is found to about 90% accurate.

Key words: Cassava · Horoscope · Potential yield · Algorithm

INTRODUCTION

Cassava is the world's fourth most important source of energy and it is produced and consumed in tropics [1]. It is an important food crop in many poor countries. By achieving higher productivity in this crop in a shorter time, poverty alleviation efforts can be hastened. To achieve this target, growth simulation models are used in countries like Thailand to provide agro advisory systems to cassava farmers[2]. The models can be run using the known weather data and different dates of planting to find out potential yield and once it is found out, proper management practices which should be followed to maximize the yield can be found out. Computation of potential yield is done through crop simulation models. It is a cumbersome process and a lot of data is required to get accurate results. Hence a simple algorithm to predict the potential yield of cassava in any place based on the spatial information alone is an advantage. Potential yield of cassava is depended heavily on weather and soil factors which vary a great extent spatially as well as on the genetic makeup of the varieties.

This paper describes a novel method developed for predicting any spatially varying information. This algorithm can be used for predicting potential yield of cassava which varies greatly with the latitude, longitude and altitude of a place. The algorithm can be described as:

STEP1: Divide the latitude, longitude and altitude of the place logically into three fuzzy sets each. Let the latitudes are divided into $SET1_{lat}$, $SET2_{lat}$ and $SET3_{lat}$. Let the longitudes are divided into $SET1_{long}$, $SET2_{long}$ and $SET3_{long}$. Let the altitudes are divided into $SET1_{alt}$, $SET2_{alt}$ and $SET3_{alt}$.

STEP2: Arrange these sets in the form of a horoscope (Fig. 1) as:

Divide the spatially varying variable which is to be predicted, into three fuzzy sets and arrange them into the last three cells. Number the cells sequentially from $SET1_{lat}$ onwards.

STEP3: Establish fuzzy inference rules (FIR) to make predictions based on the fuzzy sets of the spatial parameters latitude, longitude and altitude.

STEP4: Find out the fuzzy set where the output falls based on the FIR on latitude, longitude and altitude information.

STEP5: Defuzzify the output to get crisp values.

Corresponding Author: V.S. Santhosh Mithra, Central Tuber Crops Research Institute, Thiruvananthapuram, India.

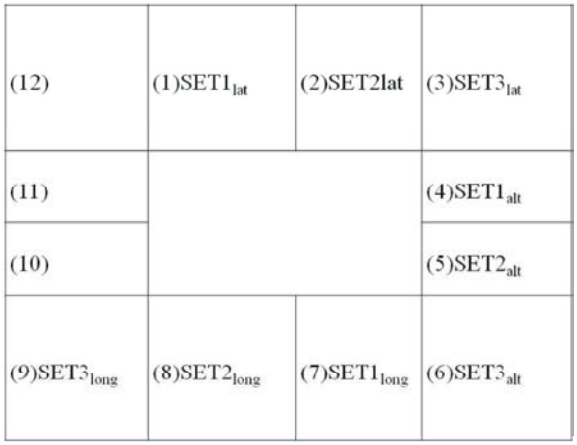

Fig. 1: Arrangements of sets in the horoscope

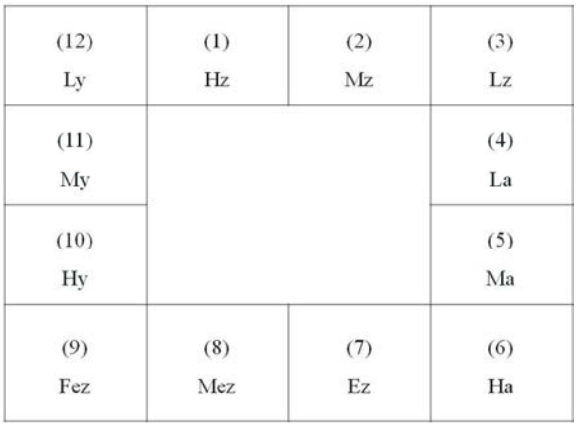

Fig. 2: Horoscope of cassava

This algorithm is demonstrated for calculating the potential yield of cassava in India based on the spatial details of the locality alone i.e. latitude, longitude and altitude. The method is similar to Indian system of horoscope which is used to predict the future of human beings based on the factor time. Hence the algorithm is named as "Horoscope algorithm".

India lies between latitude $8^0$4'28" N and $37^0$17'53" N and the longitudinal extent of the country is between $68^0$7'53" E and $97^0$24'47" E. Altitude of the country lies between 2.2m below MSL to 8586 m above MSL. Potential yield of cassava as per the simulation by the SIMCAS model for different agro climatic regions of India ranges between zero and 126.1 $MgHa^{-1}$. This algorithm to find out the potential yield of cassava in a locality is based on fuzzy logic concepts. Latitudes, longitudes, altitudes and potential yields were divided into three fuzzy sets each.

India is divided into fifteen agro climatic regions[3]. About five 5-10 representative locations were selected from each region and weather of these palaces were simulated using the software NewLocClim. Weather parameters simulated were the daily values of maximum temperature, minimum temperature, sunshine hours and precipitation. Potential yield of cassava in these locations were found out with the help of the cassava growth simulation model SIMCAS[4].

In the locations south of latitude 30^0N, cassava has a potential yield >40 Mg Ha^{-1} if planted anytime during the year. If the longitude of the place is towards the west of 90^0E, then also the potential yield of cassava is >40 Mg Ha^{-1}. If the altitude of the place is lower than 300m from MSL, similar potential yield trend is observed.

Indian system of horoscope was adopted for developing this algorithm. As per the Indian system of horoscope, position of the planets at the time of birth and position of the planets at the time of reference are important. In fact the time is divided in terms of the rotation speed of different planets. Similarly potential yield of cassava varies with the location as well as the time of planting. Hence in this algorithm space is divided in terms of latitude, longitude and altitude and time in terms of month.

The horoscope of cassava is shown in Fig. 2. There are 12 houses in the horoscope which are numbered sequentially. The houses 1-3 represent latitudinal houses. Houses 4-6, 7-9 and 10-12 represent altitudinal, longitudinal and potential yield houses respectively.

Description of the Horoscope

Basic Structure: Fig.2. shows the horoscope of cassava. There are twelve houses/blocks in it. First three houses represent fuzzy latitude classes Hz, Mz and Lz respectively. Houses 4,5 and 6 represent fuzzy altitude classes La, Ma and Ha respectively. Seventh, 8^{th} and 9^{th} houses represent the fuzzy longitude classes Ez, Mez and Fez respectively. Fuzzy potential yield classes Hy, My and Ly are represented by 10^{th}, 11^{th} and 12^{th} houses respectively.

Fuzzy Rules: Fuzzy rules were framed based on these fuzzy sets and their position in the horoscope. Assumptions based on the position of the fuzzy classes are:

- Influence of latitudinal classes on potential yield is reflected on its 8^{th} to 12^{th} houses
- Influence of altitudinal classes on potential yield is reflected on its 5^{th} to 9^{th} houses
- Influence of longitudinal classes on potential yield is reflected on its 2^{nd} to 6^{th} houses

Table 1: Distance of the corresponding potential yield fuzzy set from different latitude, altitude and longitude fuzzy sets at different months of planting

Conditions	J	F	M	A	M	J	J	A	S	O	N	D
If lat ∈ Hz	10^{th}				11^{th}				10^{th}			
If lat ∈ Mz	10^{th}	9^{th}			11^{th}				10^{th}			
If lat ∈ Lz	8^{th}			10^{th}			9^{th}			8^{th}		8^{th}
If alt ∈ La	7^{th}						8^{th}			7^{th}		8^{th}
If alt ∈ Ma		6^{th}					7^{th}			5^{th}		7^{th}
If alt ∈ Ha					7^{th}							
If long ∈ Ez	4^{th}				5^{th}					4^{th}		5^{th}
If long ∈ Mez					5^{th}							
If long ∈ Fez	3^{rd}		2^{nd}		4^{th}				3^{rd}			

Table 2: Details of the places where the horoscope algorithm was used for finding out the potential yield of cassava

Latitude (^{0} N)	Longitude (^{0} E)	Altitude (M above MSL)	Month of planting	Potential yield simulated (Mg Ha^{-1})
8.83	76.6	0	Jan	125.93
13.13	78.13	820	Feb	78.91
25.45	81.85	60	Mar	80.85
25.85	85.78	40	Apr	92.46
21.92	77.9	640	May	49.42
13.92	75.57	600	June	76.7
17.68	75.92	460	July	85.86
10.78	76.65	80	Aug	109.21
22.6	80.38	440	Sep	59.98
13.14	78.13	820	Oct	39.02
16.83	75.7	600	Nov	62.25
25.45	81.85	60	Dec	55.2

These rules vary with the month of planting also. Each crop is assumed to mature in 10 months. The details of the rules are given in Table 2.

Steps to Find out the Potential Yield

- Find out to which fuzzy sets your location belongs with respect to latitude, longitude and altitude.
- Based on the fuzzy rules given in Table 2, identify the potential yield house associated with each of these sets.
- Do defuzzification and find out the exact potential yield value of cassava in Mg Ha^{-1}.

Defuzzification: Defuzzification in this case is done in a non conventional way. Let the fuzzy sets SET_{lat}, SET_{alt} and SET_{long} represent the latitude, altitude and longitude fuzzy sets respectively of the location with membership function values mF_{lat}, mF_{alt} and mF_{long} respectively.

Steps of Defuzzification:

Step1: Select the potential yield class PY_{lat} associated with the fuzzy latitude set SET_{lat}, based on the fuzzy rules given in Table 2. Multiply the mean value of the PY_{lat} class ($PY_{lat}\hat{}$) with mF_{lat} to get P_{lat}.

$$P_{lat} = PY_{lat}\hat{} \times mF_{lat} \quad (1)$$

Step2: Select the potential yield class PY_{alt} associated with the fuzzy latitude set SET_{alt}, based on the fuzzy rules given in Table 2. Multiply the mean value of the PY_{alt} class ($PY_{alt}\hat{}$) with mF_{alt} to get P_{alt}.

$$P_{alt} = PY_{alt}\hat{} \times mF_{alt} \quad (2)$$

Step3: Select the potential yield class PY_{long} associated with the fuzzy latitude set SET_{long}, based on the fuzzy rules given in Table 2. Multiply the mean value of the Py_{long} class ($Py_{long}\hat{}$) with mF_{long} to get P_{long}.

$$P_{long} = PY_{long}\hat{} \times mF_{long} \quad (3)$$

Step4: Potential yield (PY) of the location is calculated as:

$$PY = \frac{P_{lat} + P_{alt} + P_{long}}{mF_{lat} + mF_{alt} + mF_{long}} \quad (4)$$

This method was used for calculating the potential yield of cassava at different locations in India on different months of planting (Table 2).

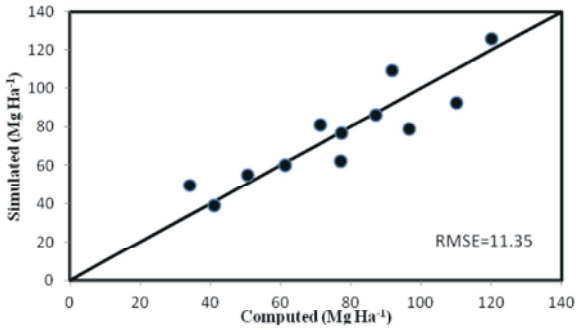

Fig. 3: Comparison of potential yield of cassava computed by horoscope algorithm and those simulated by SIMCAS model at various locations in India.

The horoscope algorithm was applied to find out the potential yield of cassava in these locations. The results showed good agreement (Fig. 3) between the simulated and the computed values (RMSE of 11.35).

In this paper the algorithm was used to find out the potential yield of cassava in a location where its spatial information like latitude, longitude and altitude are known. But this algorithm can be applied to find out any information which is spatially influenced. The spatial influence is mainly due to the spatial variation in weather, soil types etc. The algorithm can be applied to any system, not only for crops.

This method is having wide application in weather prediction, crop yield forecasting, early warning on pest and diseases etc which vary greatly from one place to another. The method can be modified and used for non spatial applications also.

REFERENCES

1. Cock, J.H., 1984. The physiology of tropical field crops.
2. Sarawat, V., Ratanasriwong, S. Puangprakon, K. Sringam and P. Jintrawet, 2004. 2nd World Congress on Computers in Agriculture and Natural Resources; August 9-12. Bangkok, Thailand, pp: 136.
3. Gajbhiye, K.S. and C. Mandal, 2000. Status of Farm Mechanization in India.
4. Santhosh Mithra, V.S., J. Sreekumar and C.S. Ravindran, 2013. Computer Simulation of cassava growth: A tool for realizing potential yield, Archives of Agronomy and Soil Science, 59(4): 603-623.