Int.J.Curr.Microbiol.App.Sci (2020) *9*(11): 1469-1477

International Journal of Current Microbiology and Applied Sciences
ISSN: 2319-7706 **Volume 9 Number 11 (2020)**
Journal homepage: http://www.ijcmas.com

Original Research Article https://doi.org/10.20546/ijcmas.2020.911.173

Fitting Crop Production in Northern Zone of Kerala during El Niño Conditions

R. K. Rajesh Krishnan* and P. K. Retheesh

Regional Agricultural Research Station, Kasargod, Kerala, India

**Corresponding author*

Keywords

El Niño conditions, Fitting crop production

Article Info

Accepted:
12 October 2020
Available Online:
10 November 2020

A B S T R A C T

Weather data collected from the agromet observatory located at Regional Agricultural research station, Kasargod was used for markov chain analysis to mark the weekly wet and dry spell distribution in the region during the climatic conditions El Nino and La Nina. Weather cock software and manual calculation was done to arrive at the results. Both initial and conditional probability was found out for annual, SW Monsoon and NE Monsoon weeks based on the methodology. The length of growing period was also calculated based on this for three climatic situations based on the method suggested by FAO, El nino conditions possess better LGP (31 weeks) as compared with Lanina and neutral years.

Introduction

Rainfall is a unique weather variable which shows higher degrees of variation in its spatial and temporal distribution over earth's surface, Since the land use pattern and vegetation over a region is largely influenced by rainfall, its spatial distribution over the growing period of crops play a vital role in the success and failure of crops. Water excess as well as less than the crop requirement has effect on the crop growth. Hence study on identifying the continuous wet spell and dry spell can aid in identifying the successful crop-growing period of a region within a year. Even though there are many methods which can predict the dry and wet spells Markov chain analysis is a better methodology to predict these in terms of probability.

The information on occurrence of dry and wet spell can apparently provide an idea about the crop growing period on weekly basis and planning agricultural operations like sowing, weeding, irrigation etc on rainfed farming areas. Hence markov chain analysis can be used as a best option with limited data available areas to calculate the wet and dry spell probability where precipitation and evaporation data is available. It can be used as a decision support tool in farm planning for crop production within the growing season. Indian agriculture is directly related with the monsoon and hence performance of monsoon

greatly impacts cropping pattern and food production of the nation. But most often, it is the quantity of the monsoon rainfall is used for estimating the impact of monsoon. In reality it is the distribution of rainfall within the year along with quantum decides the farming operations. Very few attempts have been made to analyse the rainfall effects on the basis of wet and dry spells to arrive at the crop growing decisions. In general, it is reviewed that there will be decrease in rainfall for SW monsoon and increase in rainfall during NE monsoon for peninsular region during El Niño years and vice versa for La Niña years. Markov chain tool is implicated here to find out the distribution of wet spells during El Niño and La Niña years compared with neutral years so as to find the maximum possible wet period which helps in identifying maximum cropping duration for respective periods.

Materials and Methods

Weather data collected from the agromet observatory located at Regional Agricultural research station, Pilicode was used for this markov analysis. The coordinates of the observatory are 11.2^{o}N, 77.5^{o}E, 13MSL. Weekly rainfall and evaporation data for 52 standard weeks were collected from 1961 to 2018 and the El Niño, La Niña and neutral years were found out based on information provided by NOAA and years were classified accordingly (Table 1).

Markov chain analysis was implicated as mentioned by Veeraputhiran *et al.,* to categorize wet and dry weeks. Weather cock software and manual calculation was done to arrive at the results. Based on the evaporation data in Kasaragod, wet spells are those weeks where annual weekly precipitation exceeds the weekly evaporation. Here it was 27 mm. Hence wet weeks were ones with precipitation more than 27 mm and dry weeks with precipitation less than 27 mm. Markov chain analysis was done for annual weekly (1 to 52 weeks), SW monsoon (22 to 39 weeks) and NW monsoon (40 to 52 weeks) as defined by IMD and it was separately done for all the climatic situations of El Niño, Lanina and neutral years. Both initial and conditional probability was found out for the above mentioned periods based on the following methodology.

a Initial Probability

P(W) = n(W)/n(W+D) *100
P(D) = n(D)/ n(D+W) *100
P(W): Probability of the week being wet
P(D): Probability of the week being dry
n(W): Frequency of wet weeks
n(D): Frequency of dry weeks
n(D + W): Total no. of weeks

b. Conditional Probability

P (W/D) = n(W/D)/ nD*100
P (D/D) = n(D/D)/ nD*100
P (W/W) = n(W/W)/ nW*100
P (D/W) = n(D2W1)/ nW*100

P (W/D): Probability of a week being wet after a week being dry

P (D/D): Probability of a week being dry after a week being dry

P (W/W): Probability of a week being wet after a week being wet

P (D2/W1): Probability of a week being dry after a week being wet

N (W/D): Frequency of wet week after dry week

n (D/D): Frequency of dry week after dry week

n (W/W): Frequency of wet week after wet week

n (D/W): Frequency of dry week after wet week

n D: Total frequency of dry weeks

n W: Total frequency of wet weeks

Results and Discussion

The results obtained from the analysis are presented in Table 2 and 3. Table 2 provides the initial probability of occurance of wet and dry spells for 52 standard weeks individually.

Initial probability

From the table 3 it can be inferred that during all the three climatic situations there is very little probability is there for wet spells during the first 14 weeks of respective years, expect for neutral years where minor probability is there at the start of summer season. But during the end weeks of summer season, Neutral years showing better probability of wet spell than other climatic situations.

The probability is higher when it approaches the monsoon season in all climatic situations. During the SW monsoon period, all of the situations do not exert much impact on the wet spell period and the probability remains around 0.9 except at the end of the season.

During NE monsoon period, even though neutral situation showing some better probability at the start of the season, El Niño conditions provide higher probability for rest of the season.

Table.1 Various El Niño, Lanina and neutral years

El nino	La Niña	Neutral
1969	**1964**	**1961**
1976	**1971**	**1962**
1977	**1974**	**1966**
1979	**1983**	**1967**
2004	**1984**	**1978**
2006	**2000**	**1980**
2014	**2005**	**1981**
1963	**2008**	**1985**
1968	**2016**	**1989**
1986	**2017**	**1990**
1994	**1970**	**1992**
2002	**1995**	**1993**
2009	**2011**	**1996**
1965	**1973**	**2001**
1972	**1975**	**2003**
1987	**1988**	**2012**
1991	**1998**	**2013**
1982	**1999**	
1997	**2007**	
2015	**2010**	
2018		

Table.2 Frequency analysis on wet spells and dry spells during Annual rainfall, SW monsoon and NE Monsoon

	Annual			SW Monsoon			NE Monsoon		
Probability	El Nino	La Niña	Neutral	El Nino	La Niña	Neutral	El Nino	La Niña	Neutral
P(W)	27	23	25	17	17	17	6	4	5
P(D)	25	29	27	0	0	0	7	9	8
P(W/W)	24	22	24	17	17	17	4	4	5
P(D/D)	22	28	26	0	0	0	4	8	7
P(W/D)	3	1	1	0	0	0	2	0	0
P(D/W)	3	1	1	0	0	0	3	1	1
LGP	El Nino 19(07th May)-49(09th Dec) 31 weeks			La Niña 21(21st May)-47(25th Nov) 27 weeks			Neutral 20(14th May)-49(09th Dec) 29 weeks		

Table.3 Conditional probability for 52 Meteorological Standard weeks

	P(W/W)			P(D/W)			P(D/D)			P(W/D)		
WEEK	**El Niño**	**La Niña**	**Neutral**	**El Niño**	**La Niña**	**Neutral**	**El Niño**	**La Niña**	**Neutral**	**El Niño**	**La Niña**	**Neutral**
1	0.00	0.00	0.00	0.00	0.00	1.00	1.00	1.00	0.93	0.00	0.00	0.07
2	0.00	0.00	0.00	0.00	0.00	1.00	1.00	0.95	1.00	0.00	0.05	0.00
3	0.00	0.00	0.00	0.00	1.00	0.00	1.00	1.00	1.00	0.00	0.00	0.00
4	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1.00	1.00	0.00	0.00	0.00
5	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1.00	1.00	0.00	0.00	0.00
6	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1.00	1.00	0.00	0.00	0.00
7	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1.00	1.00	0.00	0.00	0.00
8	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1.00	1.00	0.00	0.00	0.00
9	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.95	1.00	0.00	0.05	0.00
10	0.00	1.00	0.00	0.00	0.00	0.00	1.00	0.95	1.00	0.00	0.05	0.00
11	0.00	0.00	0.00	0.00	1.00	0.00	1.00	1.00	1.00	0.00	0.00	0.00
12	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.95	1.00	0.00	0.05	0.00
13	0.00	0.00	0.00	0.00	1.00	0.00	1.00	1.00	0.94	0.00	0.00	0.06
14	0.00	0.00	0.00	0.00	0.00	1.00	0.95	0.95	0.94	0.05	0.05	0.06
15	0.00	0.00	1.00	1.00	1.00	0.00	0.89	0.84	1.00	0.11	0.16	0.00
16	0.50	0.33	0.00	0.50	0.67	1.00	0.83	0.94	0.94	0.17	0.06	0.06
17	0.25	0.00	0.00	0.75	1.00	1.00	0.94	0.83	0.75	0.06	0.17	0.25
18	0.00	0.33	0.50	1.00	0.67	0.50	0.72	0.88	0.85	0.28	0.12	0.15
19	0.60	0.33	0.25	0.40	0.67	0.75	0.80	0.88	0.62	0.20	0.12	0.38
20	0.50	0.67	0.67	0.50	0.33	0.33	0.79	0.71	0.55	0.21	0.29	0.45
21	0.33	0.86	0.56	0.67	0.14	0.44	0.71	0.62	0.88	0.29	0.38	0.13
22	0.83	0.91	1.00	0.17	0.09	0.00	0.50	0.44	0.36	0.50	0.56	0.64
23	1.00	1.00	1.00	0.00	0.00	0.00	0.25	0.20	0.00	0.75	0.80	1.00
24	0.94	1.00	1.00	0.06	0.00	0.00	0.50	0.00	0.00	0.50	1.00	0.00
25	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00

26	1.00	1.00	0.94	0.00	0.00	0.06	0.00	0.00	0.00	0.00	0.00	0.00
27	0.95	1.00	0.94	0.05	0.00	0.06	0.00	0.00	0.00	0.00	0.00	1.00
28	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	1.00
29	1.00	0.95	1.00	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00
30	0.90	0.89	1.00	0.10	0.11	0.00	0.00	0.00	0.00	0.00	1.00	0.00
31	1.00	0.94	0.94	0.00	0.06	0.06	0.00	0.50	0.00	1.00	0.50	0.00
32	0.90	1.00	1.00	0.10	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1.00
33	0.89	0.95	0.94	0.11	0.05	0.06	0.00	0.00	0.00	1.00	0.00	0.00
34	0.78	0.79	0.88	0.22	0.21	0.13	0.00	0.00	1.00	1.00	1.00	0.00
35	0.75	0.94	0.71	0.25	0.06	0.29	0.75	0.50	0.33	0.25	0.50	0.67
36	0.69	0.71	0.67	0.31	0.29	0.33	0.43	0.33	0.60	0.57	0.67	0.40
37	0.69	0.79	0.70	0.31	0.21	0.30	0.57	0.50	0.57	0.43	0.50	0.43
38	0.33	0.86	0.60	0.67	0.14	0.40	0.13	0.83	0.71	0.88	0.17	0.29
39	0.45	0.46	0.88	0.55	0.54	0.13	0.56	0.57	0.44	0.44	0.43	0.56
40	0.56	0.67	0.75	0.44	0.33	0.25	0.73	0.64	0.40	0.27	0.36	0.60
41	0.25	0.70	0.83	0.75	0.30	0.17	0.50	0.70	0.60	0.50	0.30	0.40
42	0.75	0.70	0.67	0.25	0.30	0.33	0.42	0.60	0.80	0.58	0.40	0.20
43	0.38	0.64	0.67	0.62	0.36	0.33	0.71	0.78	0.50	0.29	0.22	0.50
44	0.29	0.56	0.40	0.71	0.44	0.60	0.54	0.82	0.71	0.46	0.18	0.29
45	0.38	0.43	0.33	0.63	0.57	0.67	0.75	0.69	0.91	0.25	0.31	0.09
46	0.67	0.14	0.00	0.33	0.86	1.00	1.00	0.92	0.64	0.00	0.08	0.36
47	0.25	0.00	0.20	0.75	1.00	0.80	0.69	0.94	1.00	0.31	0.06	0.00
48	0.00	1.00	0.00	1.00	0.00	1.00	1.00	0.89	0.94	0.00	0.11	0.06
49	0.00	0.00	1.00	0.00	1.00	0.00	0.90	1.00	0.94	0.10	0.00	0.06
50	0.00	0.00	0.00	1.00	0.00	1.00	0.83	0.95	0.93	0.17	0.05	0.07
51	0.00	0.00	0.00	1.00	1.00	1.00	1.00	0.95	1.00	0.00	0.05	0.00
52	0.00	0.00	0.00	0.00	1.00	0.00	1.00	1.00	0.94	0.00	0.00	0.06

Table.4 Initial probability for 52 Meteorological Standard weeks

	P(W)			**P(D)**		
WEEK	El Niño	La Niña	Neutral	El Niño	La Niña	Neutral
1	0.00	0.00	0.06	1.00	1.00	0.94
2	0.00	0.05	0.00	1.00	0.95	1.00
3	0.00	0.00	0.00	1.00	1.00	1.00
4	0.00	0.00	0.00	1.00	1.00	1.00
5	0.00	0.00	0.00	1.00	1.00	1.00
6	0.00	0.00	0.00	1.00	1.00	1.00
7	0.00	0.00	0.00	1.00	1.00	1.00
8	0.00	0.00	0.00	1.00	1.00	1.00
9	0.00	0.05	0.00	1.00	0.95	1.00
10	0.00	0.10	0.00	1.00	0.90	1.00
11	0.00	0.00	0.00	1.00	1.00	1.00

12	0.00	0.05	0.00	1.00	0.95	1.00
13	0.00	0.00	0.06	1.00	1.00	0.94
14	0.05	0.05	0.06	0.95	0.95	0.94
15	0.10	0.15	0.06	0.90	0.85	0.94
16	0.20	0.10	0.06	0.80	0.90	0.94
17	0.10	0.15	0.24	0.90	0.85	0.76
18	0.25	0.15	0.24	0.75	0.85	0.76
19	0.30	0.15	0.35	0.70	0.85	0.65
20	0.30	0.35	0.53	0.70	0.65	0.47
21	0.30	0.55	0.35	0.70	0.45	0.65
22	0.60	0.75	0.76	0.40	0.25	0.24
23	0.90	0.95	1.00	0.10	0.05	0.00
24	0.90	1.00	1.00	0.10	0.00	0.00
25	1.00	1.00	1.00	0.00	0.00	0.00
26	1.00	1.00	0.94	0.00	0.00	0.06
27	0.95	1.00	0.94	0.05	0.00	0.06
28	1.00	1.00	1.00	0.00	0.00	0.00
29	1.00	0.95	1.00	0.00	0.05	0.00
30	0.90	0.90	1.00	0.10	0.10	0.00
31	1.00	0.90	0.94	0.00	0.10	0.06
32	0.90	1.00	1.00	0.10	0.00	0.00
33	0.90	0.95	0.94	0.10	0.05	0.06
34	0.80	0.80	0.82	0.20	0.20	0.18
35	0.65	0.85	0.71	0.35	0.15	0.29
36	0.65	0.70	0.59	0.35	0.30	0.41
37	0.60	0.70	0.59	0.40	0.30	0.41
38	0.55	0.65	0.47	0.45	0.35	0.53
39	0.45	0.45	0.71	0.55	0.55	0.29
40	0.40	0.50	0.71	0.60	0.50	0.29
41	0.40	0.50	0.71	0.60	0.50	0.29
42	0.65	0.55	0.53	0.35	0.45	0.47
43	0.35	0.45	0.59	0.65	0.55	0.41
44	0.40	0.35	0.35	0.60	0.65	0.65
45	0.30	0.35	0.18	0.70	0.65	0.82
46	0.20	0.10	0.29	0.80	0.90	0.71
47	0.30	0.05	0.06	0.70	0.95	0.94
48	0.00	0.15	0.06	1.00	0.85	0.94
49	0.10	0.00	0.12	0.90	1.00	0.88
50	0.15	0.05	0.06	0.85	0.95	0.94
51	0.00	0.05	0.00	1.00	0.95	1.00
52	0.00	0.00	0.06	1.00	1.00	0.94

Table.5 Length of growing period for each climatic condition

	El Nino			La Niña			Neutral		
	PE = 27.0 mm, FC= 50 mm, **△St** = Change in soil storage								
Week	**P**	**P-PE**	**△St**	**P**	**P-PE**	**△St**	**P**	**P-PE**	**△St**
1	0.0	-27.0	0	0.0	-27.0	0.0	8.2	-18.8	0.0
2	0.0	-27.0	0	2.0	-25.0	0.0	0.0	-27.0	0.0
3	0.0	-27.0	0	0.0	-27.0	0.0	0.0	-27.0	0.0
4	0.0	-27.0	0	0.0	-27.0	0.0	1.0	-26.0	0.0
5	0.0	-27.0	0	0.5	-26.5	0.0	0.0	-27.0	0.0
6	0.7	-26.3	0	0.0	-27.0	0.0	0.3	-26.7	0.0
7	1.0	-26.0	0	0.0	-27.0	0.0	1.2	-25.8	0.0
8	0.1	-26.9	0	0.4	-26.7	0.0	0.2	-26.8	0.0
9	0.6	-26.4	0	1.8	-25.2	0.0	0.0	-27.0	0.0
10	0.2	-26.8	0	5.0	-22.0	0.0	0.0	-27.0	0.0
11	0.6	-26.4	0	0.5	-26.5	0.0	0.3	-26.7	0.0
12	1.1	-25.9	0	16.9	-10.1	0.0	0.0	-27.0	0.0
13	3.1	-23.9	0	0.0	-27.0	0.0	3.3	-23.7	0.0
14	4.4	-22.6	0	4.8	-22.2	0.0	4.9	-22.1	0.0
15	9.4	-17.6	0	11.0	-16.0	0.0	4.7	-22.3	0.0
16	15.4	-11.6	0	10.5	-16.5	0.0	6.3	-20.7	0.0
17	6.7	-20.3	0	12.8	-14.2	0.0	14.4	-12.6	0.0
18	20.7	-6.3	0	9.6	-17.4	0.0	10.9	-16.1	0.0
19	39.6	12.6	***12.6***	14.9	-12.1	0.0	24.6	-2.4	0.0
20	32.6	5.6	***18.2***	26.5	-0.5	0.0	64.0	37.0	***37.0***
21	46.3	19.3	***37.5***	48.2	21.2	***21.2***	91.2	64.2	***50.0***
22	96.6	69.6	***50***	138.4	111.4	***50.0***	118.3	91.3	***50.0***
23	186.8	159.8	***50***	184.0	157.0	***50.0***	237.2	210.2	***50.0***
24	225.1	198.1	***50***	240.2	213.2	***50.0***	287.6	260.6	***50.0***
25	239.9	212.9	***50***	252.1	225.1	***50.0***	252.7	225.7	***50.0***
26	263.4	236.4	***50***	206.3	179.3	***50.0***	221.6	194.6	***50.0***
27	246.5	219.5	***50***	212.3	185.3	***50.0***	228.1	201.1	***50.0***
28	283.9	256.9	***50***	227.8	200.8	***50.0***	270.5	243.5	***50.0***
29	242.0	215.0	***50***	223.9	196.9	***50.0***	254.9	227.9	***50.0***
30	209.7	182.7	***50***	212.8	185.8	***50.0***	222.2	195.2	***50.0***
31	209.0	182.0	***50***	197.0	170.0	***50.0***	196.5	169.5	***50.0***
32	157.6	130.6	***50***	187.8	160.8	***50.0***	200.5	173.5	***50.0***
33	128.4	101.4	***50***	150.8	123.8	***50.0***	163.2	136.2	***50.0***
34	89.9	62.9	***50***	117.5	90.5	***50.0***	119.8	92.8	***50.0***
35	83.2	56.2	***50***	104.2	77.2	***50.0***	89.5	62.5	***50.0***
36	67.5	40.5	***50***	89.7	62.7	***50.0***	67.7	40.7	***50.0***
37	60.5	33.5	***50***	98.9	71.9	***50.0***	49.4	22.4	***50.0***
38	44.9	17.9	***50***	92.3	65.3	***50.0***	55.0	28.0	***50.0***
39	39.0	12.0	***50***	67.6	40.6	***50.0***	82.6	55.6	***50.0***
40	44.4	17.4	***50***	49.9	22.9	***50.0***	72.9	45.9	***50.0***
41	55.9	28.9	***50***	45.0	18.0	***50.0***	66.2	39.2	***50.0***
42	36.5	9.5	***50***	50.6	23.6	***50.0***	35.8	8.8	***50.0***

43	22.6	-4.4	***45.6***	42.3	15.3	***50.0***	62.7	35.7	***50.0***
44	36.1	9.1	***50***	26.3	-0.7	***49.3***	38.1	11.1	***50.0***
45	38.7	11.7	***50***	22.0	-5.0	***44.3***	17.7	-9.3	***40.7***
46	21.7	-5.3	***44.7***	7.2	-19.8	***24.5***	19.5	-7.5	***33.2***
47	28.6	1.6	***46.3***	4.7	-22.3	***2.2***	24.8	-2.2	***31***
48	1.1	-25.9	***20.4***	13.2	-13.8	0.0	9.4	-17.6	***13.4***
49	5.1	-21.9	***0***	0.7	-26.3	0.0	10.9	-16.1	***0.0***
50	10.6	-16.4	0	4.9	-22.1	0.0	6.8	-20.2	0.0
51	0.1	-26.9	0	3.9	-23.1	0.0	0.6	-26.4	0.0
52	0.7	-26.3	0	2.2	-24.8	0.0	3.0	-24.0	0.0
LGP	El Nino 19(07th May)-49(09th Dec) 31 weeks			La Niña 21(21st May)-47(25th Nov) 27 weeks			Neutral 20(14th May)-49(09th Dec) 29 weeks		

Conditional probability

The probability for continuous wet period can be seen in all the three situations during SW monsoon period. But during summer and NE monsoon period, El Niño conditions are having less probabilities for continuous wet spell, means probabilities are there for breakage of wet spells which may arise as a threat for rainfed cultivation during those periods.

Frequency analysis

From table 4 it can be inferred that the rainfall distribution is not at all affected during SW monsoon period for any of the climatic phenomenon. It is impacted much on the NW monsoon and summer periods. From both seasonal and annual distribution, it is evident that El Niño conditions increases the rainfall distribution to surplus for around 2-4 weeks in a year.

Length of growing period

The length of growing period was calculated for three climatic situations based on the method suggested by FAO, where the mean weekly precipitation exceeds the mean weekly evapotranspiration may be the wet weeks and period of continuous wet weeks along with stored soil moisture to meet the evapotranspiration requirement being the length of growing period (Table 5). It is inferred that since there is increased impact on NE monsoon, El nino conditions have better LGP (31 weeks) as compared with Lanina and neutral years. Even though LGP starts around the start of SW monsoon period; it ends at different stages during a year.

In conclusion apart from normal Indian conditions, even though the rainfall quantum is higher during the Lanina period, the distribution of rainfall is more during El Niño years, which enlighten the future possibilities of crop production in the area on behalf of the changing global climate scenarios.

References

Jeevananda Reddy, S. (1983). "Agro climatic classification of the Semi-Arid Tropics. A method for the computation of classificatory variables". Agricultural Meteorol., 30, 185-200.

Kingra, P.K., Gill, K.K and Singh, S. (2013). "Wet and Dry Spell Analysis for Crop Planning in Sub-Mountainous Punjab using Markov Chain Approach", J. Agrl. Phy., 13(2), 193-202

Krishnamurthy, K.N., Gowda, M and Vasanthkumar, T. (2015). "Markov Chain Model for Probability of weekly rainfall in Mandya district, Karnataka",

Intl. J. Innov. Res. Sci., 4,7, 6644 -6650. Selvaraju, R., Balasubramanian, T.N and Geethalakshmi, V. (1998). "On the variation of North east monsoon rainfall over Coimbatore during warm and cold phases of the El- Nino/Southern Osciallation (ENSO)", Vayu mandal, 50-53.

Veeraputhiran, R., Karthikeyan, R., Geethalakshmi, V., Selvaraju, R., Sundarsingh, S.D and Balasubramaniyan, T. N. (2003). "Crop planning – Climate Atlas, Manual", A. E. publications, Coimbatore - 41.

How to cite this article:

Rajesh Krishnan, R. K. and Retheesh, P. K. 2020. Fitting Crop Production in Northern Zone of Kerala during El Niño Conditions. *Int.J.Curr.Microbiol.App.Sci.* 9(11): 1469-1477.
doi: https://doi.org/10.20546/ijcmas.2020.911.173