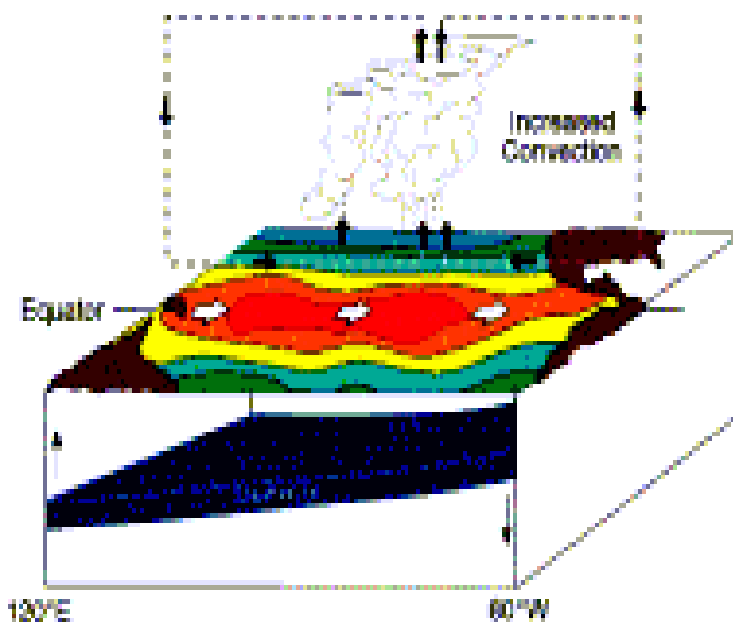
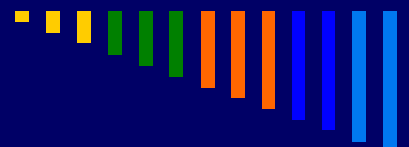


# *“The Impact of El Niño Southern Oscillation Events on Rainfall and Sugarcane Production In Guyana”*

El Niño Conditions



NOAA/PMEL/DAO





# *INTRODUCTION-*

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## *General*

- ★ **“World Agriculture, whether in developed or developing countries, remain very dependent on climate resources” (Bach,1993)**
  - ★ **Sugarcane is grown throughout the year in Guyana, hence directly affected by climate in terms of crop growth and yield**
  - ★ **“The productivity of this crop depends on a complex combination of climate, biophysical factors and management over time” (Pulwarty, 2001).**
-



# *INTRODUCTION-*

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## *Rationale*

- ★ Enhance understanding of forces that determine regional climate, which are not constrained within our shores but are of global origins.
  - ★ Part of a larger Caribbean initiative to establish a network of professionals to deal with climate variability and change
  - ★ The Guyana Sugar Industry is of significant socio-economic benefit to Guyana and the Caribbean
-



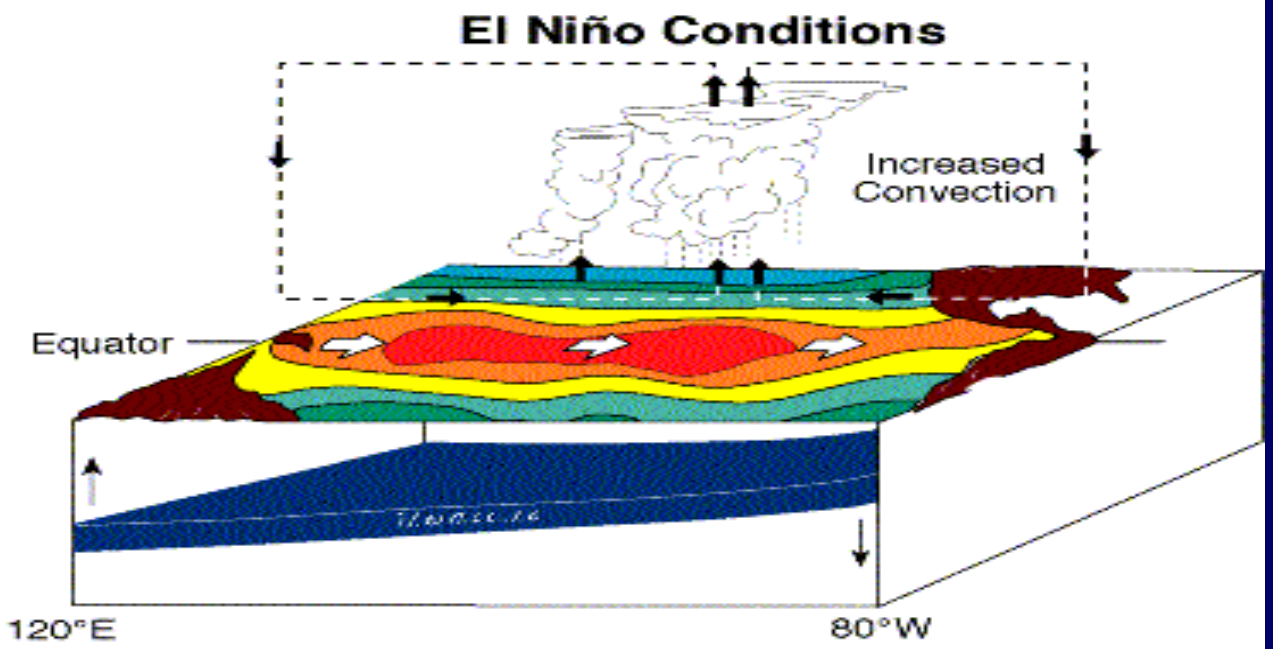
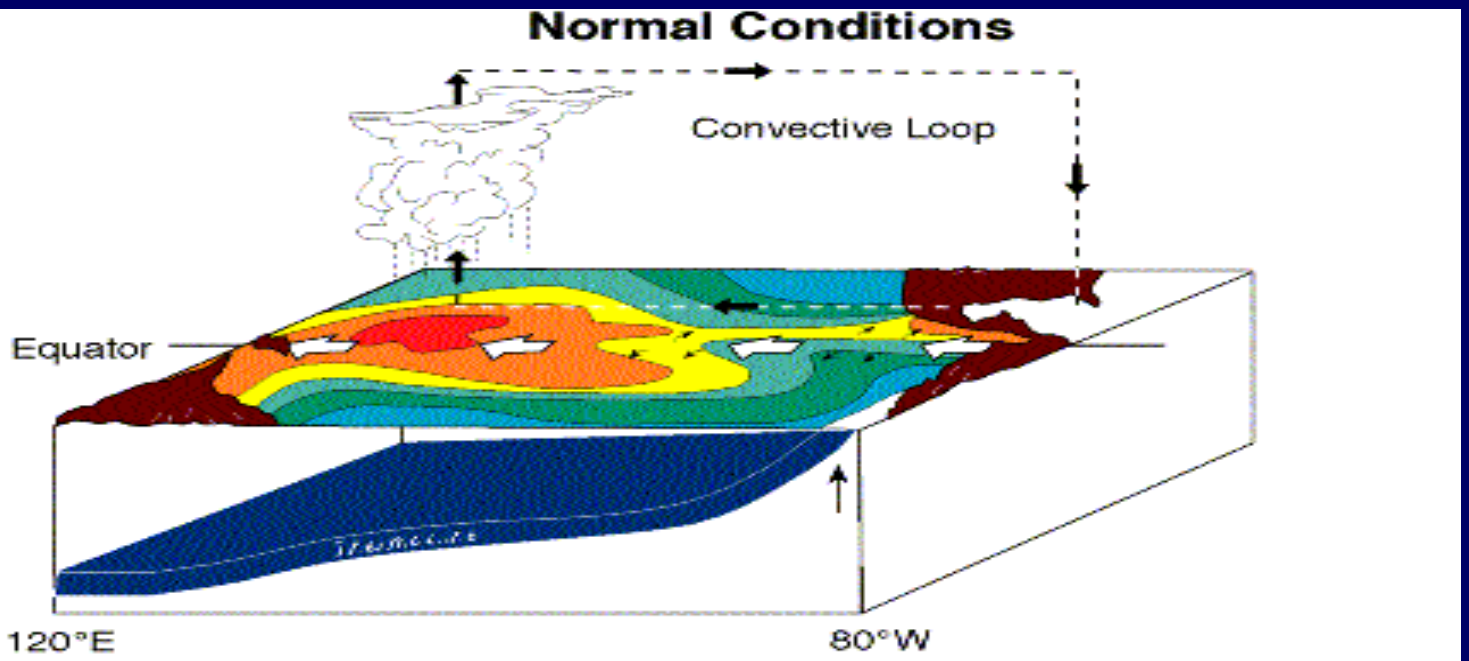
# *INTRODUCTION-*

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## *El Nino: Origin and Occurrence*

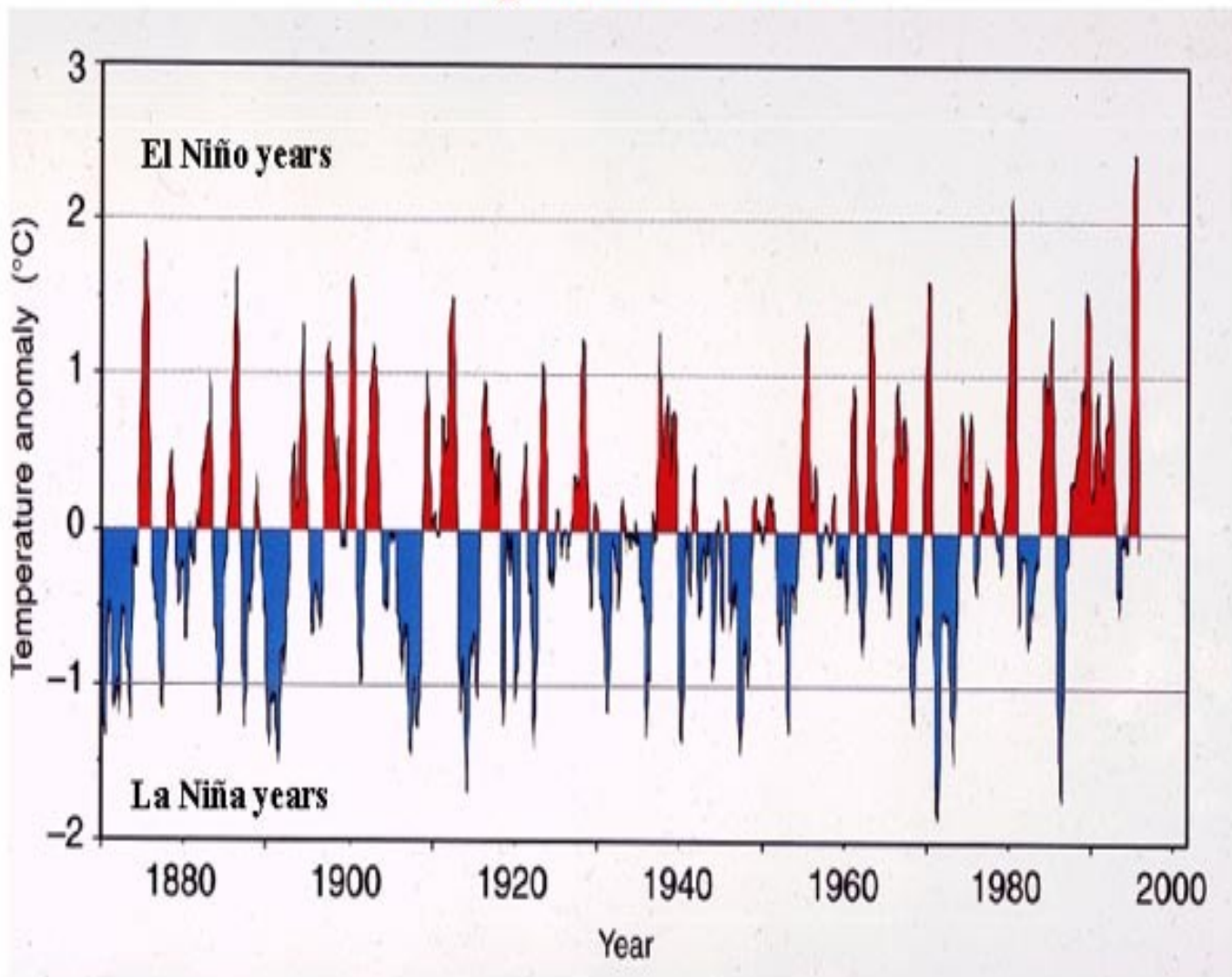
- ★ Little Boy or Christ child in Spanish
  - ★ The full coupling or exchange of energy between the atmospheric and oceanic systems in the tropical pacific
  - ★ When the eastern pacific sea surface temperature (SST) is higher than normal and the Southern Oscillation index is negative
  - ★ ENSO events occurs every 3 – 5 years
-

# Origin



# Occurrence

**Figure 14: The 1997/98 El Niño  
Strongest on Record\***



\*As shown by changes in sea-surface temperature (relative to the 1961-1990 average) for the eastern tropical Pacific off Peru



# *Specific* **OBJECTIVES**

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- ★ **To use local rainfall, sea surface temperatures and southern oscillation index data to investigate links with ENSO and rainfall**
- ★ **To use local rainfall, SST, SOI and past yield statistic data to analyze the impact of El Nino on sugarcane yields**
- ★ **Identify entry points for including climate information into the agricultural decision calendar for sugarcane production**





# *Methodology- DATA*

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## **From National Oceanic Atmospheric Authority (NOAA):**

- ★ **Atlantic sea surface temperatures (SST) (1950-2006)**
  - ★ **Southern Oscillation Index (SOI) NINO34 (1876-2006)**
-

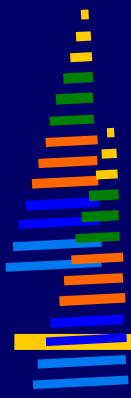


# *DATA -*

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## **From GUYSUCO:**

- ★ **Rainfall records from six estate locations from 1956-2006**
  - ★ **Yield data (TCH) by crop from 1956-2006**
  - ★ **Annual reports to document the influence of past management practices, pest out-breaks etc**
  - ★ **Direct discussions with local researchers and Agriculture staff**
-



# *DATA and METHOD*

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## **Methods - Six Estates Studied**

- ★ **Skeldon -SWR**
- ★ **Albion-AN**
- ★ **Blairmont-BCF**
- ★ **Enmore-EHP**
- ★ **La Bonne Intention-LBI**
- ★ **Wales-GV**





# *METHOD*

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## **Parameters Tested**

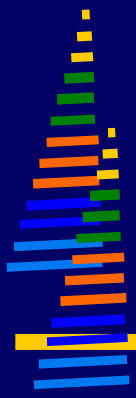
- ★ **ENSO indices vs. Rainfall (Total /average)**
  - ★ **ENSO indices vs. Yield**
  - ★ **Rainfall vs. Yield**
  - ★ **Critical Rainfall vs. Yield (Same / following year)**
  - ★ **Possible entry points in Agricultural calendar**
-



# *METHOD*

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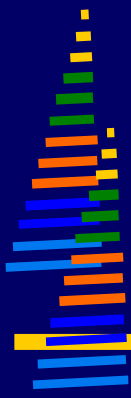
- ★ **Rainfall testing was done for Industry, Individual and Combinations (SK, SK/AL,BL,EDE/BL,EDE,WALES)**
  - ★ **Yield testing was done for Individual and Combinations**
  - ★ **Critical rainfall testing for Blairmont**
-



# *Statistical Analysis*

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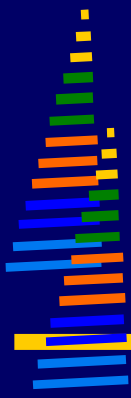
- ★ **Simple cross-correlation and multiple regression analysis**
  - ★ **Multiple regression analysis done using PROC REG procedure in SAS**
  - ★ **The probability level of testing significance determined by  $R^2$  and cv values**
-



## *Results/Discussion*

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- ★ **Multiple regression analyses conducted for rainfall vs indices revealed weak relationship (Table 1)**
  - ★ **Individual estates analyzed with same year's indices reflected relatively weak relationships, with tendency to fluctuate between locations (table2)**
  - ★ **Findings suggest that ENSO's influence on Guyana's rainfall may be affected by temporal and spatial variations**
-



# Results/Discussion

**Table 1: RAINFALL VERSUS ENSO INDICES (INDUSTRY)**

Rainfall Parameter	Variable Identifier	Coefficient of Determination	Coefficient of Variation
FCRFT	FCSST* FCSOI*	0.134	30
SCRFT	SCSST* SCSOI	0.126	28
FCRFA	FCSST* FCSOI*	0.178	26
SCRFA	SCSST* SCSOI*	0.161	26

**FCRFT- First Crop Rainfall Total**

**FCSST- First Crop Sea Surface Temperature**

**FCSOI - First Crop southern oscillation Indices**

**SCRFT- Second Crop Rainfall Total**

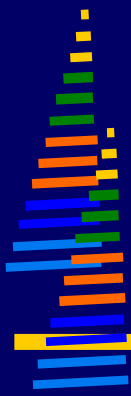
**SCSST- Second Crop Sea Surface Temperature**

**SCSOI- Second Crop Southern Oscillation Indices**

**FCRFA- First Crop Rainfall Average**

**SCRFA- Second Crop Rainfall Average**

(\*, \*\* significant at 5% and 1% level, respectively)

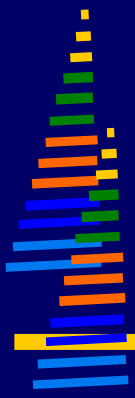


# Results/Discussion

**Table 2:** Rainfall versus ENSO indices (Skeldon, Albion and Enmore)

Estate Location	Rainfall Parameter	Variable Identifier	Coefficient of Determination	Coefficient of Variation
Skeldon	FCRFT	FCSST* FCSOI	0.102	27
	SCRFT	SCSST SCSOI	0.063	25
	FCRFA	FCSST* FCSOI*	0.12	22
	SCRFA	SCSST SCSOI*	0.13	22
Albion	FCRFT	FCSST* FCSOI*	0.169	25
	SCRFT	SCSST* SCSOI*	0.22	24
	FCRFA	FCSST* FCSOI*	0.193	23
	SCRFA	SCSST* SCSOI*	0.312	20
Enmore	FCRFT	FCSST* FCSOI*	0.184	33
	SCRFT	SCSST* SCSOI*	0.145	32
	FCRFA	FCSST* FCSOI*	0.2	31
	SCRFA	SCSST* SCSOI*	0.18	30

**Individual  
Estates**



# Results/Discussion

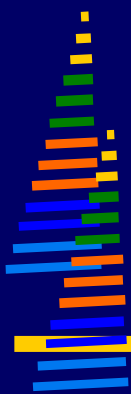
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**Table 3:** Rainfall versus ENSO indices (EHP-LBI-BCF)

Rainfall Parameter	Variable Identifier	Coefficient of Determination	Coefficient of Variation
FCRFT	FCSST FCSOI SCSST SCSOI*	0.28	27
SCRFT	FCSST FCSOI SCSST SCSOI*	0.21	27
FCRFA	FCSST FCSOI SCSST SCSOI*	0.30	25
SCRFA	FCSST FCSOI SCSST SCSOI*	0.24	25

**Combined locations reflected stronger relationships but reduction of significant cases**

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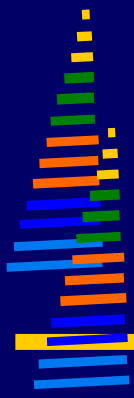


# Results/Discussion

**Table 4 : Yield versus same year ENSO indices and rainfall (Berbice and Demerara)**

Estate Location	Rainfall Parameter	Variable Identifier	Coefficient of Determination	Coefficient of Variation %
Berbice	FCYLD	FCRFT* FCRFA* FCSST FCSOI	0.14	15.4
	SCYLD	SCRFT SCRFA SCSST SCSOI	0.03	16.2
Demerara	FCYLD	FCRFT FCRFA FCSST FCSOI	0.009	19
	SCYLD	SCRFT SCRFA SCSST* SCSOI	0.048	20

**Analysis of rainfall vs yields for the provinces of Demerara and Berbice reflected few statistically weak relationships with only first crop rainfall for Berbice and SCSST for Demerara significant**

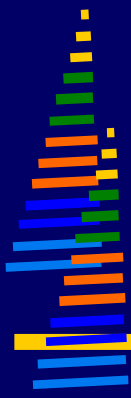


# Results/Discussion

**Table 5:** Yield versus previous year ENSO and rainfall indices (Skeldon and Wales)

Estate Location	Yield Parameter	Variable Identifier	Coefficient of Determination	Coefficient of Variation %
Skeldon	FCYLD	FCRFT FCRFA FCSST* FCSOI*	0.06	16
	SCYLD	SCRFT SCRFA SCSST SCSOI	0.001	18
Wales	FCYLD	FCRFT FCRFA FCSST FCSOI	0.11	18
	SCYLD	SCRFT SCRFA SCSST SCSOI	0.09	19

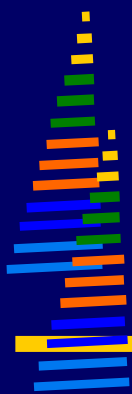
**Evaluation of yields vs rainfall and indices simultaneously, revealed relationships for indices only in the first crop for skeldon, however no relationship was realised at wales, located in another province another indication of spatial influence on ENSO.**



## *Results/Discussion*

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- ✧ **When analysis was done to determine the predictability of climate response on yields the following was observed;**
  - ✧ **Generally relationships were still weak, however in cases maintained significance (table 6)**
  - ✧ **These results were very similar to those observed in the Trinidad study.**
  - ✧ **It was concluded that ENSO is not the only mediating factor to sugarcane production but also climate variability at the particular location (Pulwarty 2001)**
-

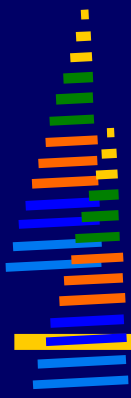


# Results/Discussion

**Table 6** Yield vs. ENSO indices and RF parameters for individual and combined sites

LOCATION	CROP YIELD	RAINFALL / ENSO INDICIES	COEFFICIENT OF DETERMINATION	EQUATION
BERBICE	FCYLD	FCRFT* FCRFA	$R^2 = 0.0218$ $R^2 = 0.006$	$y = 0.005x + 64.731$ $y = 0.0022x + 72.285$
SKELDON	FCYLD	FCSST FCSOI	$R^2 = 0.002$ $R^2 = 0.0004$	$y = -1.1083x + 74.878$ $y = 0.4728x + 74.883$
BLAIRMONT	FCYLD	FCRFT* FCRFA*	$R^2 = 0.0925$ $R^2 = 0.0645$	$y = 0.0069x + 67.261$ $y = 0.0703x + 68.831$
SKELDON/ ALBION	FCYLD	FCRFT*	$R^2 = 0.011$	$y = 0.0041x + 63.204$
SKELDON/ ALBION	FCYLD	FCSST* FCSOI*	$R^2 = 0.011$ $R^2 = 0.004$	$y = 3.2837x + 68.922$ $y = 3.7209x + 68.891$
EAST DEMERARA/ BLAIRMONT	FCYLD	FCRFT* FCRFA*	$R^2 = 0.048$ $R^2 = 0.0311$	$y = 0.0071x + 52.542$ $y = 0.0707x + 54.519$
EAST- DEMERARA	FCYLD	FCSOI	$R^2 = 0.0004$	$y = -0.6525x + 58.086$

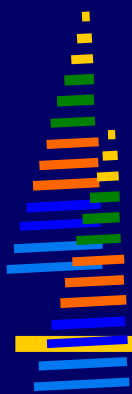
**Contributing factors other than climate include adoption of high yielding varieties, soil properties, pest and disease out breaks, timeliness of operations**



## *Results/Discussion*

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- ★ **This paper attempts to provide preliminary work with aim of realizing a predictive agro climatic model for sugarcane**
  - ★ **Analysis of the effect of ENSO on critical growing period at Blairmont**
  - ★ **There was a general improvement in the strength of the relationships when compared to results from other locations/combinations(table 7)**
-

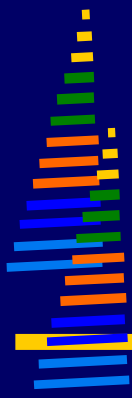


# Results/Discussion

**Table: 7** Yield versus ENSO influenced rainfall for critical growing periods at Blairmont

LOCATION	CROP YIELD	RAINFALL/ ENSO INDICES	DETERMINATION COEFFICIENT	EQUATION
BLAIR MONT	FCYLD	FCRFT* FCRFT*	$R^2 = 0.043$ $R^2 = 0.096$	$y = 0.0044x + 71.379$ $y = 0.0086x + 63.183$
BLAIR MONT	FCYLD	SCRFT* SCRFT*	$R^2 = 0.0334$ $R^2 = 0.0155$	$y = 0.0043x + 71.536$ $y = 0.0038x + 71.051$
BLAIR MONT	SCYLD	FCRFT* FCRFT *	$R^2 = 0.1693$ $R^2 = 0.087$	$y = 0.0105x + 64.843$ $y = 0.0076x + 69.713$
BLAIR MONT	SCYLD	SCRFT* SCRFT	$R^2 = 0.1$ $R^2 = 0.0075$	$y = 0.0126x + 61.311$ $y = 0.0025x + 78.203$

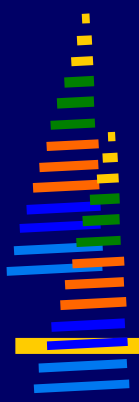
**Results considered significant since Blairmont considered most responsive to agronomic management and yields less influenced by factors other than climate**



## *Results/Discussion*

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- ★ **Statistically, ENSO related atlantic fluctuations lag behind pacific component by 4 to 5 months**
  - ★ **With weakest relationships in october, november, december,& most intense in april-july following year(Pulwarty 2001)**
  - ★ **Thus the planting,germination and elongation stages provides the first entry point for climate information in the calendar(Fig1)**
-



# Results/Discussion

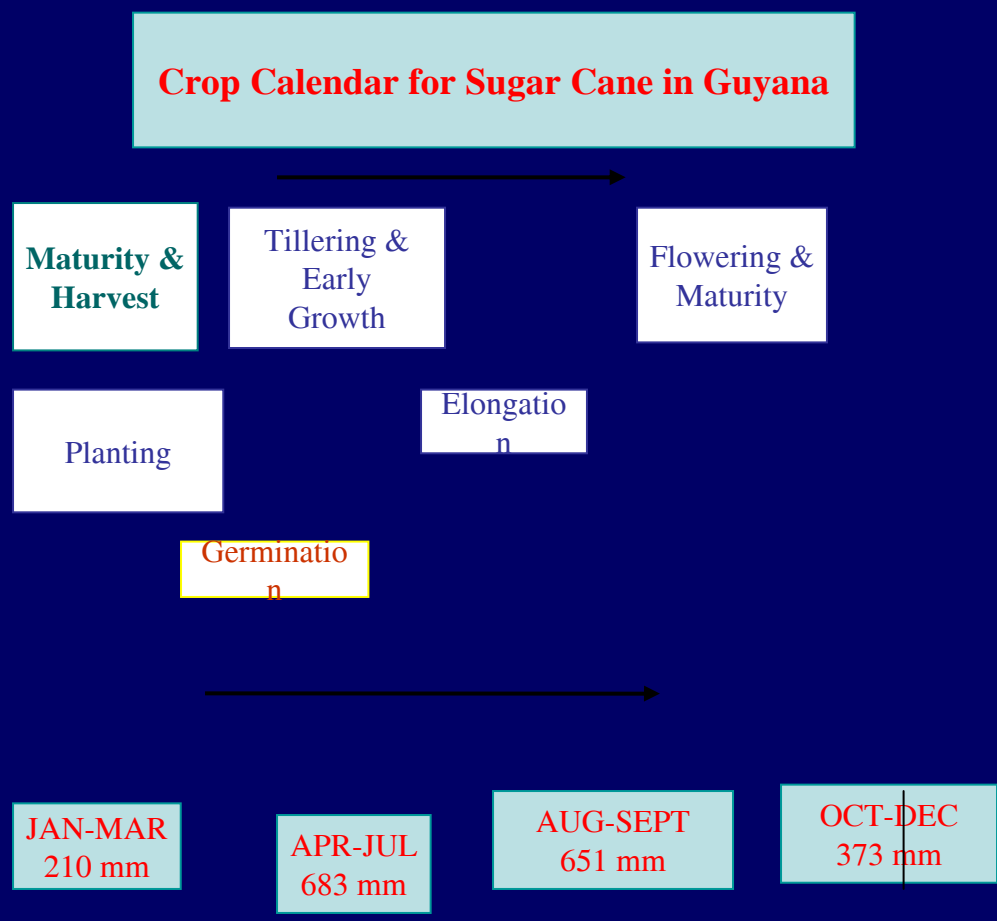
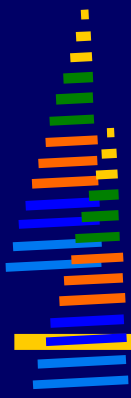


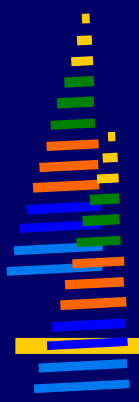
Figure 1.0: Agricultural calendar for the first crop (GuySuCo)



## *Results/Discussion*

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- ★ **For second crop maturity and harvesting stages presents the first entry point for predictive climate intervention**
  - ★ **The planting period in the second provides a opportunity for inclusion of climate information into Agri-calendar(Fig 2)**
-



# Results/Discussion

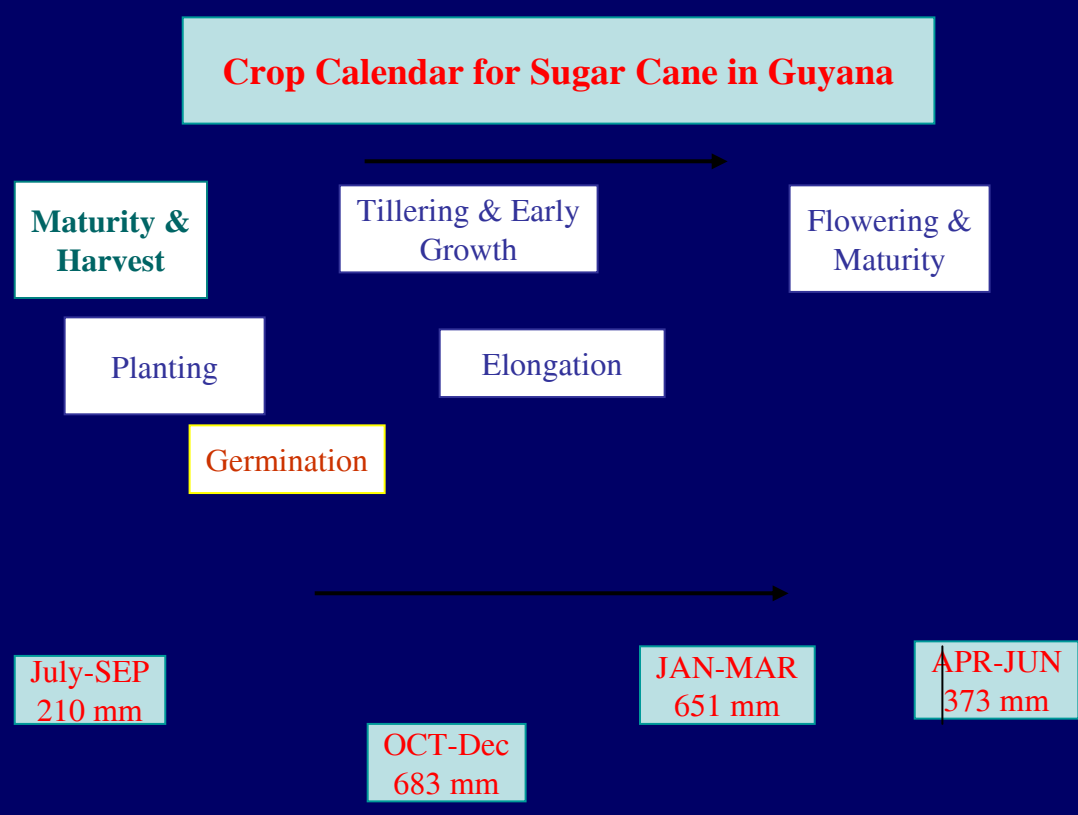


Figure 2.0: Agricultural calendar for the second crop (GuySuCo)



# CONCLUSION

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- ★ **There is a weak, significant linear relationship between ENSO events and Guyana's rainfall.**
  - ★ **ENSO influenced climate does impact on our sugarcane yield**
  - ★ **The possibility does exist to include climate information into the decision making calendar**
-



# *RECOMMENDATIONS*

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- ★ **Evaluation of historically strong El Nino and La Nina Events and their effect on yield(1989/90 and 97/99)**
  - ★ **Evaluation to determine which estate location does ENSO events have the greatest influence**
  - ★ **The formulation of an appropriate Agro-Climatic model for the industry**
-