

Analysis of climatic factors affecting sugarcane germination in Numan, Adamawa State, Nigeria.

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ABSTRACT

This study investigates the relationship between climatic elements and the germination of sugarcane at Savannah Sugar Company, Numan. The empirical work adopted the phenological approach to crop-climate relationship. Correlation and regression techniques were used to determine the nature and extent of the relationship between climatic factors and germination/yield. The climatic variables used are total rainfall, relative humidity, mean maximum temperature, mean minimum temperature, evaporation, mean wind velocity and sunshine. The result shows that of the seven variables, total rainfall and mean minimum temperature were significant at 90% confidence level. Relative humidity and mean evaporation were significant at the 95 and 99% confidence level respectively. The four factors accounted for 86.4 % in the germination and yield variation of sugarcane in the study area. The implication of these findings were also discussed with regards to sugarcane cultivation in Numan, Adamawa state, Nigeria.

Keywords: Climate, germination, yield, sugarcane

INTRODUCTION

Nigeria imports 90% of her sugar needs, a policy which allows not only sugar but the cane as well to be imported at a marginal tariff rate of 10%. It is no wonder the industry minister was quoted as saying “Nigeria has spent the sum of N51.6 billion on the importation of sugar into the country in the past ten years” (A.I.T, 2000). Olaniran (1988) reported that the prospect of spatial expansion of potential cropland for sugarcane is limited to the flood plains of the rivers Niger and Benue where the consumptive water requirement of the crop during a minimum growing period of 270 days can be met by irrigation. Moreover, the National Sugar Development Council (NSDC) has identified more than 150,000 hectares of ‘Fadama’ land distributed nationwide and suitable for sugarcane cultivation, (Aliyu, 1998).

Clements (1995) stated that a good germination is a pre-requisite for good stalk growth and excellent sugar recovery. Generally in the field of ecology, two main theories directed towards explanation of the ultimate performance of particular plant species in particular places are the chemical theory and the physiographic theory. While the chemical theory postulates that the chemical composition of the substrate largely determines the species that will grow upon it, the physiographic theory is of the opinion that only factors of physiography such as exposure, moisture and others are the main

determiners of the performance of the species in an area. It is the latter opinion that informed the need for a critical analysis of the external climatic factors affecting sugarcane germination in Savannah Sugar Company, Numan, in Adamawa State, Nigeria.

Researches on the cane plant are many and varied covering the weather variables and cultural practices such as weeding, fertilizer and irrigation. Savannah Sugar Company Numan has benefited from these advances in technology and improvement in the method of sugarcane crop husbandry in the past twenty years. Notwithstanding these advances the yield of sugarcane in the area is still variable over the years (Table 1). Though the influence of climate is easily recognized in crop production, there is generally too little information on climatic factors influencing sugarcane germination in Nigeria despite the increasing attention being given to sugarcane production in recent times.

Several authors Das (1935), Varahula (1936) Clements (1940) and Clements *et al* (1952) are of the opinion that, when climatic conditions does not favour proper or normal germination, the cane plant undergoes internal reactions that tend towards preserving its life, but at the expense of a greatly reduced efficiency. It therefore becomes necessary to identify the climatic variables influencing the germination and consequent yield of sugarcane at the Savannah Sugar Company over a period of twenty years (1981 – 2000).

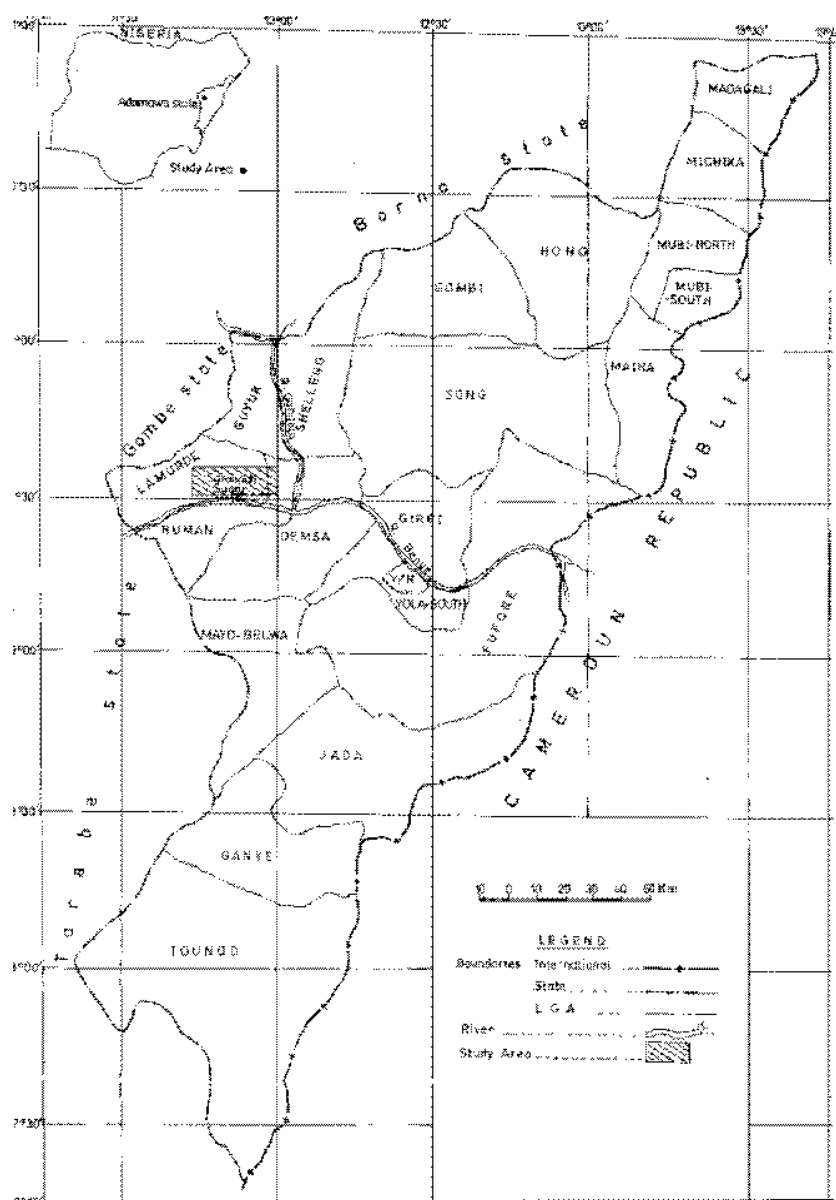


Fig. 1. Map of Adamawa State showing the location of Savannah Sugar Company.

MATERIALS AND METHOD

The study area

Savannah Sugar Company is located near Numan, Adamawa State on latitude $9^{\circ} 31'N$ and longitude $11^{\circ} 49'E$ (Fig.1). Relief in the area is generally low, ranging between 152m to 180m above sea level. The company cane farm covers some 29,000 hectares. The climate of the area is characterized by two distinct seasons (wet and dry). The wet season spans from April to October while the dry season extend from November to March. The mean annual rainfall is about 960.3mm, with a standard deviation of 458.5 and a coefficient of variation of 47.7. Average monthly temperature fluctuates between $18^{\circ}C$ during the coldest month (December/January) to $38^{\circ}C$ during the hottest (March/April). Relative humidity varies from 30% during the dry season to about 80% during the wet season. The juvenile soil of alluvium and hydromorphic origin with pH value of 5.0 – 6.5 covers

the study area. The area falls under the guinea savannah vegetation with tall grasses and scattered economic trees.

Data collection

Two sets of secondary data were collected for this study. Daily, monthly and annual data on rainfall, relative humidity, maximum and minimum temperatures, evaporation, wind velocity and sunshine hours for 20 years (1981 – 2000) were collected from the meteorological station of the Agronomy Division of Savannah Sugar Company Numan. Two years in the stated period, which were dedicated to factory renovation, was not included in the analysis.

Cane yield data for the period under study were also collected from the Agronomy Division of Savannah Sugar Company Numan.

Data analysis

The empirical method of determining climate - agriculture relationship was adopted in this study. This method involves studying

Table 1. Yield of Sugarcane at SSCL, Numan, Adamawa State.

Year	Yield (tones/ha)	Date of Planting
1980/81	88.64	30/3/1981
1981/82	77.45	27/3/1982
1980/83	56.13	14/4/1983
1983/84	XXX	XXX
1984/85	45.65	11/2/1985
1985/86	43.89	23/3/1986
1986/87	46.56	10/5/1987
1987/88	38.28	10/5/1988
1988/89	44.70	06/5/1989
1989/90	49.48	30/4/1990
1990/91	44.52	20/4/1991
1991/92	49.24	23/4/1992
1992/93	41.07	04/4/1993
1993/94	47.02	14/5/1994
1994/95	43.42	11/5/1995
1995/96	36.92	03/5/1996
1996/97	25.25	24/4/1997
1997/98	XXX	XXX
1998/99	46.91	17/4/1999
1999/00	59.23	08/6/2000

XXX Company under renovation, no production.

Source: 1999/2000 Crop Report (Savannah Sugar Company Limited)

agriculture and climatic data for as long a period as consistent records of both agriculture and climate allows and deducing agroclimatological relationship from the analysis of the data. Olaniran and Babatolu (1987) have suggested the use of phenological stages as time interval for processing data on climatic variables influencing agricultural production rather than using the whole year. This will help to detect the critical physiological stages for yield formation. On this basis, the data collected were processed using the growth cycle of Sugarcane as identified by the agronomy division of the sugar company.

Duration of the germination and other stages was established through personal communications with research fellows at Savannah Sugar Company Numan. The germination stage spans a period of 3 weeks or 21 days. The summary of the data from the germination stage is presented in Table 2.

External climatic variables covering the germination period (21 days) were correlated with cane yield in order to understand the nature and extend of the role played by each variable in the germination/yield process. Regression analysis was also used to determine the contribution of each climatic variable to the variation in the germination/yield of sugar cane in the study area. The Minitab

statistical package was used to analyzed the data and acceptance was at the 90,95% and 99% significance level because of data limitation.

RESULTS AND DISCUSSION

The results of the correlation and regression between climatic elements and the germination stage at Savannah Sugar Company Numan are presented in Table 3. The analysis covers the period between planting and germination, which is three weeks or 21 days. The result shows that of the seven meteorological variables, only four are significant namely total rainfall, mean relative humidity, mean minimum temperature and mean evaporation.

Total rainfall and minimum temperature are negatively correlated and significant at 90% confidence level. The result shows that too much rains at the time of planting is detrimental to the cane setts. This may explain why planting in Savannah Sugar Company between 1982 – 2000 were done between February to May when the rains are not fully established. Too much rain after sett laying may result in water logging which will lead to cane rot. This finding support the earlier works of Jika (1997) who stated that the best period for planting commercial cane for the Mills (SSCL) is between November – April. These are rainless months in the study area. Therefore, the negative effect of rainfall could be checked through controlled irrigation. The regression analysis of this period with total rainfall also yields an equation, $Y = 110 - 0.0682x_1$, with a coefficient of determination (R^2) of 21.0. These mean that total rainfall at germination account for 21% of yield variation of sugar cane in the study area. The negative relationship in the regression equation implies that a unit increase in total rainfall above normal at this stage will result in a decline in yield per hectare of 0.0682kg/ha.

The negative correlation of mean minimum temperature at germination means that very cold periods are not conducive to sugarcane germination. Humbert (1963) found out that temperature effects are particularly noticeable in germination studies. Optimum germination temperature lies between 90°F and 100°F (32–38°C). Whenever the temperature drops below 70°F (21°C) germination is either very slow or a failure. Earlier investigators learned that hot water treatment of seeds results in increase germination when seed is planted in cold soils (Humbert, Ibid).

Mean relative humidity also exhibits a strong negative correlation with germination at 5% confidence level. This is so because during the planting/germination period (Nov. – May) the rains have not commence in this part of the country, therefore, relative humidity is very low with the air being dry, cool and suitable for germination. The regression equation generated shows that a slight deviation from the mean will also result in yield decline by 0.223kg/ha. Whereas mean sunshine has a positive but insignificant relationship, mean evaporation at germination stage shows a strong positive correlation

Table 2. Summary of climatic variables at germination stage (3 weeks or 21 days).

Years	Total RF (mm)	Mean RH (%)	Mean Tmax (°C)	Mean Tmin (°C)	Mean Evap. (mm)	Mean wind Vel.(km)	Mean SS (hrs)	Annual yield (kg/ha)
1981	0.0	35.9	23.2	16.3	58.09	155.65	9.17	88.64
1982	0.1	36.95	42.2	27.28	60.38	202.79	8.29	77.45
1983	0.0	39.23	44.27	30.57	64.95	192.05	9.02	56.13.
1984	**	**	**	**	**	**	**	**
1985	0.0	14.66	37.90	22.57	12.76	103.32	5.92	45.65
1986	6.5	51.0	42.90	29.00	15.08	234.57	8.28	43.89
1987	31.5	68.90	37.80	27.28	13.88	267.66	9.88	46.56
1988	110.4	69.18	40.23	27.19	13.30	220.33	8.66	38.28
1989	180.5	69.47	33.21	24.19	12.10	259.50	7.44	44.70
1990	21.3	64.20	37.10	26.35	13.25	217.71	7.41	49.48
1991	116.3	80.76	32.00	26.47	11.42	165.44	7.39	44.52
1992	138.9	52.23	34.80	28.04	15.65	188.41	7.34	49.24
1993	40.6	51.04	40.28	26.66	13.67	170.83	6.91	41.07
1994	33.1	61.66	36.52	26.00	11.94	215.57	7.36	47.02
1995	71.9	62.66	37.19	26.18	12.15	200.99	8.70	43.42
1996	100.6	68.67	36.42	24.90	10.84	195.22	7.27	36.92
1997	164.0	75.32	32.69	24.61	9.73	165.35	7.70	25.25
1998	**	**	**	**	**	**	**	**
1999	6.7	54.33	36.71	26.23	13.99	196.9	8.14	46.91
2000	141.6	74.92	30.06	22.53	6.58	223.47	7.92	59.23
	X1	X2	X3	X4	X5	X6	X7	Y

Table 3. Correlation and regression of climate with germination/yield.

Variables	Correlation coefficient
Total Rainfall (mm)	-0.458*
Relative Humidity (%)	-0.491**
Mean Max. Temp.	-0.294
Mean Min. Temp.	-0.427*
Mean Evaporation (mm)	0.762***
Mean wind Vel. (km)	- 0.078
Mean sunshine (hrs)	0.353

* Significant at 90% Probability ** Significant at 95% Probability *** Significant at 99% Probability

Regression equation.

$Y = 110 - 0.0682 X_1 - 0.223X_2 - 1.86X_3 + 0.13X_4 + 0.525X_5 + 0.167X_6 - 3.01X_7$, where; S = 6.948 R-sq = 86.4% R-sq (adj) = 76.9%

at 5% confidence level. The finding agree with the works of Clements and Kubota (1942) in Humbert (1963) who offered explanation for the necessity of high evaporation at germination as being, “relevant because transpiration of large quantities of moisture is necessary in order to enable the cane plant to safely project itself into a high energy environment of sun- light and air temperature .”

This is necessary for rapid photosynthesis and growth. The regression equation ($Y = 110 + 0.525X_5$) also showed a positive effect in the sense that a unit increase in the mean of evaporation will lead to a yield increase of about 0.525kg/ha. The coefficient of determination (R^2) shows that mean evaporation alone accounts for 58.1% of yield variation at the germination stage. This relationship is significant at

1% confidence level. The result of the regression of climatic variables on sugarcane germination also shows that in all, climatic parameters used in this study accounts for 86.4% of sugar cane germination in the study area while the regression residue of 13.6% can be attributed to edaphic and cultural factors.

CONCLUSION

The result of the correlation analysis between sugarcane germination and climatic elements presented and discussed above have shown that in order to optimize technological applications and advances in the method of crop husbandry on crop production, the beneficial effect of climate on crop germination must be optimized

while the negative influences must be minimized if not completely avoided. Thus for Numan the present planting period of between February – May should be maintained, since the influence of the harmattan winds are mostly felt between (Nov. – Jan.). Consequently, temperatures between that period (Nov-Jan) falls within the critical stage whereby germination is either slowed down or stopped completely.

This study has given further evidence of the dominating influence that climatic factors have on crop germination/yield with special regards to sugarcane. The result has shown that actual evaporation and relative humidity are the most critical climatic factors affecting the variation in the germination and subsequent yield of the crop in Numan. This preliminary work on climate/sugarcane germination and yield relationship is not exhaustive. More could still be achieved in further studies geared towards understanding the interplay between climate and the dynamics of cane germination.

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