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GENERAL TEMPERATURE ZONES FOR LAND EVALUATION IN JAMAICA

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SUMMARY

Fluctuations in air temperature are shown to be highly correlated with height (P<0.001). Four general temperature zones have been delineated on the map of Jamaica using linear regression functions of mean air temperature against height. Climatically adapted crops for each of these zones have been identified. The results are used in the computerized 'Jamaica Physical Land Evaluation System'.

1 INTRODUCTION

Specific environmental conditions of climate and soil are needed for optimum crop yields. Temperature and water are the major climatic factors that regulate the climatic adaptability and distribution of crops. In combination with solar radiation these factors determine the net photosynthesis and thereby the production rate of organic matter.

In general temperature determines the growth and development of a crop. It may also determine whether a particular developmental stage will begin, the time it will, the rate of development, and the time the process will take. In conjunction with day length, temperature often determines the time when the plant will flower. Temperature may also influence the percentage of seedsetting and the quality of the product.

In addition to the temperature and day length requirements, the crop's possible growing season is determined by a continuous period with rainfall and soil moisture supply exceeding the water requirements of the crop. IICA (1983) has prepared two maps that show the probable beginning and the probable length of the growing season in Jamaica. This study in conjunction with the present one forms the basis of the agro-climatic analysis in the computerized 'Jamaica Physical Land Evaluation System' which is being developed at the Rural Physical Planning Division of the Ministry of Agriculture, Jamaica (see Batjes, Bouwman & Sinclair, 1986).

This Technical Bulletin presents a map showing general temperature zones for Jamaica. Each zone is defined on the basis of the range in mean daily minimum, mean daily, and mean daily maximum air temperature as related to the range in elevation. The relationship between air temperature and height has been studied with linear regression functions (Section 2). Climatically adapted crops for each temperature zone are given in Section 3.

2 MATERIALS AND METHODS

Figures for daily mean minimum (DMIT), daily mean (DMT), and daily mean maximum (DMAT) air temperature, that have been listed on a monthly basis for 22 stations for the 1931 to 1960 period by JMS (1973), are used for this study. The stations are evenly distributed over the island and occur at elevation ranging from 0.9 m (Montego Bay) to 1520 m (Cinchona).

Air temperature readings at all stations are taken in conformity with international standards. Thermometers are located in an adequately ventilated double slatted, louvered screen at about 1.40 m above ground level which is usually under short grass. Under these conditions all temperature readings should be representative of the free air circulating in the locality.

Air temperature in the tropics is generally well related to elevation. The temperature figures for each station have, therefore, been correlated against height using linear regression functions. The linear regression of temperature (Y in Celsius) on elevation (X in meters) is:

$$Y = a + b*X$$

in which a and b are approximated by the 'least squares' method (see e.g. Walpole & Myers, 1978).

The closeness of the linear relationship between the variables X and Y follows from the size of the coefficient of linear determination squared (r-squared). If this coefficient is close to unity a good linear relationship can safely be assumed. In such a case general temperature zones can be derived from the regression functions provided that they have good predictive value, that is that the confidence interval on a future observed response is narrow.

3 RESULTS

3.1 Regression functions

The linear regression functions of DMIT, DMT, and DMAT (Y variable) on elevation (X variable) have been calculated on a monthly basis and yearly basis for a 30 year period (see Appendix

II).

R-squared values for the regression of DMAT on elevation range from 0.876 for January to 0.957 for October. On a yearly basis the r-squared value is 0.940. In the case of DMIT, the coefficients of linear determination range from 0.590 for February to 0.758 for September. On an annual basis the r-squared value is 0.713. The coefficients of linear determination vary from 0.868 for February to 0.929 for September, and is .917 on a yearly basis for DMT. The above relationships are all highly significant as the test for r=0 is always rejected at the 1% level of confidence.

The linear regression equations for DMIT (a), DMT (b) and DMAT (c) against height, expressed on a yearly basis, are respectively:

- (a) Y= 20.86 + 0.0052*X (r-squared= 0.713; P<.001)
- (b) Y= 25.61 + 0.0054*X (r-squared= 0.917; P<.001)
- (c) Y= 30.34 + 0.0054*X (r-squared= 0.949; P<.001)

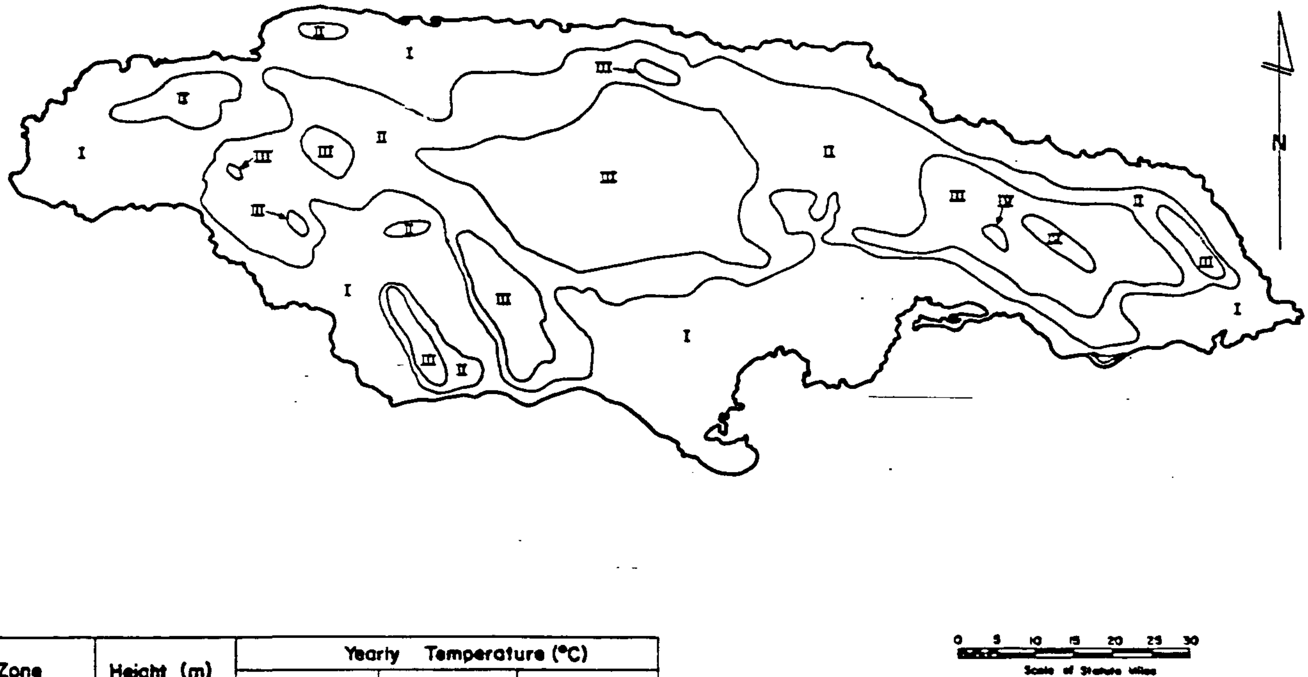
The predictive value of equation a though lowest is still acceptable. From calculations it followed that the 80% confidence interval on a future observed response is 7 C wide (for the testing procedure see Walpole & Myers, 1978). In case b and c the predictive value of the models is good, the width of the '80% interval' being at most 2 C.

From equation b it follows that DMT drops by about 0.54 C for every 100 m raise in elevation, which is in accordance with the commonly used 'rule of thumb' for the tropics (see ILACO, 1981).

No linear relationship could be found for the mean daily air temperature 'difference' as a linear function of altitude. The r-squared values for these functions are close to 0 (P >>0.1). Such functions could have been used to assess the soil temperature regime had the r-squared value been close to unity.

3.2 Temperature zones and climatically adapted crops

Equations a to c have been used to delineate Jamaica into four broad temperature zones(Fig. 1), namely:



Zone	Height (m)	Yearly Temperature (°C)		
		Mean Minimum	Mean	Mean Maximum
I	< 300	> 19	> 24	> 29
II	300–600	17–19	22–24	27–29
III	600–1500	13–17	17–22	22–27
IV	> 1500	< 13	< 17	< 22

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Figure 1: General temperature zones for Jamaica.

- Zone I: height below 300 meters

- Zone II: height from 300 to 600 meters

- Zone III: height from 600 to 1500 meters

- Zone IV: height above 1500 meters

The four elevation zones, with their specific range in air temperature, relate well to the optimum temperature requirements of the major crops. For example, coconut in Zone I, cocoa in Zone II, arabica coffee in Zone III, and timber in Zone IV.

Appendix I shows the optimum, sub-optimum and marginal to non-suitable temperature range for a wide range of crops commonly grown in Jamaica. The information shown in Appendix I is derived from Barker (1985), ILACO (1981) and FAO (1979), and should be used with the understanding that most crops offer varieties which vary in their specific and general environmental requirements and in their period of growing from seeding/planting to harvesting. This variation allows the crop to grow well under a wide range of environmental conditions. It should also be appreciated that many different micro-climates occur in the island.

4 CONCLUDING REMARKS

Four general air temperature zones for Jamaica have been delineated on a map on the basis of linear regression functions with air temperature as the dependent variable and height as the independent variable. The zones have been interpreted in terms of their climatic suitablity for specific crops. Detailed information about daily air temperature fluctuations during the growing season of given crops can be derived from the regression equations for the corresponding months (Appendix II).

The above named equations and resulting map form the first stage of the Jample Physical Land Evaluation System which matches the crop's climatic and soil requirements with the environmental characteristics of the land. The computerization of this system is in an advanced development stage at the Rural Physical Planning Division of the Ministry of Agriculture, Jamaica.

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APPENDICES

APPENDIX I: Climatic suitability of 59 crops for four temperature zones in Jamaica.

Crop type	General temperature zone No: I	II	III	IV	File No
Ackee	+	+	*	–	52#
Avocado	+	+	+/*	–	55
Banana	+	+	*	–	3
Beetroot	–	*	+	*	31
Breadfruit	+	+	*	–	48
Broccoli	–	*	+	*	39
Cabbage (white)	–	*	+	+	37
" (chinese)	–	+	+	*	38
Carrot	–	*	+	+	30
Castor	+	*	*	–	56
Cassava	+	*	–	–	21
Cauliflower	–	–	+	+	40
Celery	–	*	+	+	32
Chilly pepper	+	+	*	–	35
Chocho	–	+	+	–	42
Citrus	+	+	*	–	49
Coconut	+	*	–	–	10
Cocoa	+	+	*	–	11
Cof. (arabica)	–	*	+	+	12
Cof. (caneph.)	*	+	*	–	13
Cotton	+	*	–	–	6
Cow pea	*	+	+	–	16
Cuccumber	+	+	*	–	41
Dasheen	*	+	*	–	25
Egg plant	+	+	*	–	36
Ginger	–	+	*	–	26
Grapes	+	*	–	–	57
Green peas	–	*	+	*	20
Guava	*	+	+	*	50
Irish potato	–	*	+	+	23
Lettuce	–	*	+	*	27
Lima bean	+	+	*	*	18
Maize (corn)	+	+	*	–	9
Mango	+	+	*	–	53

APPENDIX I (cont.)

Okra	+	+	*	-	29
Oil palm	+	*	-	-	47
Onion	*	+	+	*	28
Passion fruit	*	+	+	*	58
Paw paw	+	+	*	-	51
Peanut	+	*	-	-	14
Pigeon pea	+	+	*	*	15
Pimento	+	+	*	-	54
Pineapple	*	+	*	-	59
Pumpkin	+	+	*	-	45
Red pea	-	*	+	-	17
Rice	+	+	*	-	1
Squash	*	+	*	-	44
Sorghum	+	*	-	-	5
Soya	+	+	*	-	8
Sugar cane	+	+	-	-	2
Sunflower	*	+	-	-	7
Sweet pepper	+	+	*	-	34
Sweet potato	-	*	+	*	22
Tobacco	+	+	*	-	4
Tomato	+	+	*	-	33
Watermelon	+	*	-	-	46
Winged bean	+	+	*	*	19
Yam	*	+	+	-	24

Key: + optimum temperature range for the specific crop.
* sub-optimal temperature range.
- marginally and non-suitable temperature range.
crop file number in the CROBASE computer disk file.

APPENDIX II: Regression functions of Daily Mean Maximum Air Temperature (DMAT), Daily Mean Mininum Air Temperature (DMIT), and Daily Mean Air Temperature (DMT) in Celsius against height (Y-variable) in meters.

JANUARY:
1) Y = 28.93 - 0.5887*DMAT R^2= 0.876
2) Y = 19.06 - 0.4957*DMIT R^2= 0.631
3) Y = 23.90 - 0.5294*DMT R^2= 0.885

FEBRUARY:
1) Y = 29.04 - 0.5882*DMAT R^2= 0.900
2) Y = 18.69 - 0.5066*DMIT R^2= 0.590
3) Y = 23.86 - 0.5453*DMT R^2= 0.868

MARCH:
1) Y = 29.49 - 0.5406*DMAT R^2= 0.906
2) Y = 19.14 - 0.5139*DMIT R^2= 0.627
3) Y = 24.14 - 0.5081*DMT R^2= 0.878

APRIL:
1) Y = 30.06 - 0.5164*DMAT R^2= 0.888
2) Y = 20.11 - 0.5157*DMIT R^2= 0.665
3) Y = 25.06 - 0.5126*DMT R^2= 0.900

MAY:
1) Y = 30.41 - 0.5340*DNAT R^2= 0.943
2) Y = 21.44 - 0.5226*DMIT R^2= 0.706
3) Y = 25.91 - 0.5251*DMT R^2= 0.903

JUNE:
1) Y = 30.94 - 0.5554*DMAT R^2= 0.955
2) Y = 22.10 - 0.5237*DMIT R^2= 0.689
3) Y = 26.53 - 0.5412*DMT R^2= 0.902

JULY:
1) Y = 31.45 - 0.5324*DMAT R^2= 0.931
2) Y = 22.07 - 0.5291*DMIT R^2= 0.719
3) Y = 26.82 - 0.5348*DMT R^2= 0.878

AUGUST:
1) Y = 31.61 - 0.4982*DMAT R^2= 0.909
2) Y = 22.09 - 0.5191*DMIT R^2= 0.746
3) Y = 27.15 - 0.5385*DMT R^2= 0.878

SEPTEMBER:
1) Y = 31.32 - 0.5385*DMAT R^2= 0.949
2) Y = 22.15 - 0.5336*DMIT R^2= 0.758
3) Y = 26.73 - 0.5307*DMT R^2= 0.929

OCTOBER:
1) Y = 30.95 - 0.5773*DMAT R^2= 0.957
2) Y = 21.81 - 0.5207*DMIT R^2= 0.747
3) Y = 26.53 - 0.5629*DMT R^2= 0.869

APPENDIX II (cont.)

NOVEMBER:

1) $Y = 30.23 - 0.5812*DMAT$ $R^2 = 0.927$

2) $Y = 21.16 - 0.5179*DMIT$ $R^2 = 0.745$

3) $Y = 25.87 - 0.5670*DMT$ $R^2 = 0.865$

DECEMBER:

1) $Y = 29.46 - 0.5927*DMAT$ $R^2 = 0.904$

2) $Y = 20.19 - 0.5197*DMIT$ $R^2 = 0.707$

3) $Y = 24.87 - 0.5642*DMT$ $R^2 = 0.912$

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