Technical Soils Bulletin No. 5

MATMOD
Matching Model

Jamaica Physical Land Evaluation System

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Table of contents

INTRODUCTION

The Jamaica Physical Land Evaluation (JAMPLES) of which this Matching Model (MATMOD) forms a component, is a computer software package for the assessment of the limitations of land for the cultivation of specific crops. JAMPLES is a specially designed system for planning purposes at a semi detailed scale, but it may also be used at smaller scales.

The soil and crop data base can greatly increase the working speed and the computer model MATMOD can simplify and standardize the procedure of land evaluation. Furthermore, the storage of data in computer files (data base) enables the user to apply the system for any number and type of crops and for any number of soils occurring on any (defined) slope class.

During the development of JAMPLES it became clear, that on the basis of the available data on soils and because of the lack of data on the crop-responses to variations in soil conditions, no predictions in terms of the yields of crops could be made. Therefore, MATMOD's output is limited to the degree and type of limitation of the land for cultivation of specific crops, and it does not specify a suitability class. It is the author's opinion, that a suitability class implies a statement on the potential yield of crops. If desired, the user of MATMOD can draw such conclusions on the basis of the specified degree of limitation(s) of the land.

The programming language used for MATMOD is Microsoft's BASIC (release 1982), which is also used for all other models in JAMPLES. Listings of this programme are available for internal use at RPPD.

THE CROP DATA BASE

The crop requirements were stored on a computer file. This file is divided in records, whereby each record represents one crop. Each crop record contains a set of 28 different fields (variables). Each record has a field for the temperature requirements of the crop and one for the crop factor. The crop factor indicates the average coverage of the land's surface provided by the crop during its growth and is used in the Universal Soil Loss Equation. Furthermore, every crop record has fields that define the crop requirements, that match with soil conditions which cause no limitations, requirements that are equivalent to soil conditions which would cause slight limitations and fields that correspond to conditions of strong limitations.

The original data used in preparing these crop requirement records were extracted from international and Jamaican literature and Jamaican research data (see Barker, 1985). From these original 'crop profiles' the relevant data were translated into the classes and ratings of land qualities and land characteristics (see Appendix 1) and stored on computer files. Prints of these files are available for internal use at R.P.P.D.

THE SOIL DATA BASE

The soil data based data is created by the subroutine ENTERMOD (see Figure 1). ENTERMOD is a programme, which is based on the ratings of land qualities and land characteristics. ENTERMOD has been made 'user friendly' by simplifying the procedure of entering data and by incorporating 'error traps' where necessary.

Besides data required for the matching procedure, ENTERMOD stores other data important for identifying and differentiating the soils, such as their name, map code, USDA classification, mineralogy class, and data required for the use of the soil degradation model (SODEMOD). A complete list of required data for ENTERMOD is presented in Appendix 2. ENTERMOD translates the entered data into the above mentioned ratings and stores them on file.

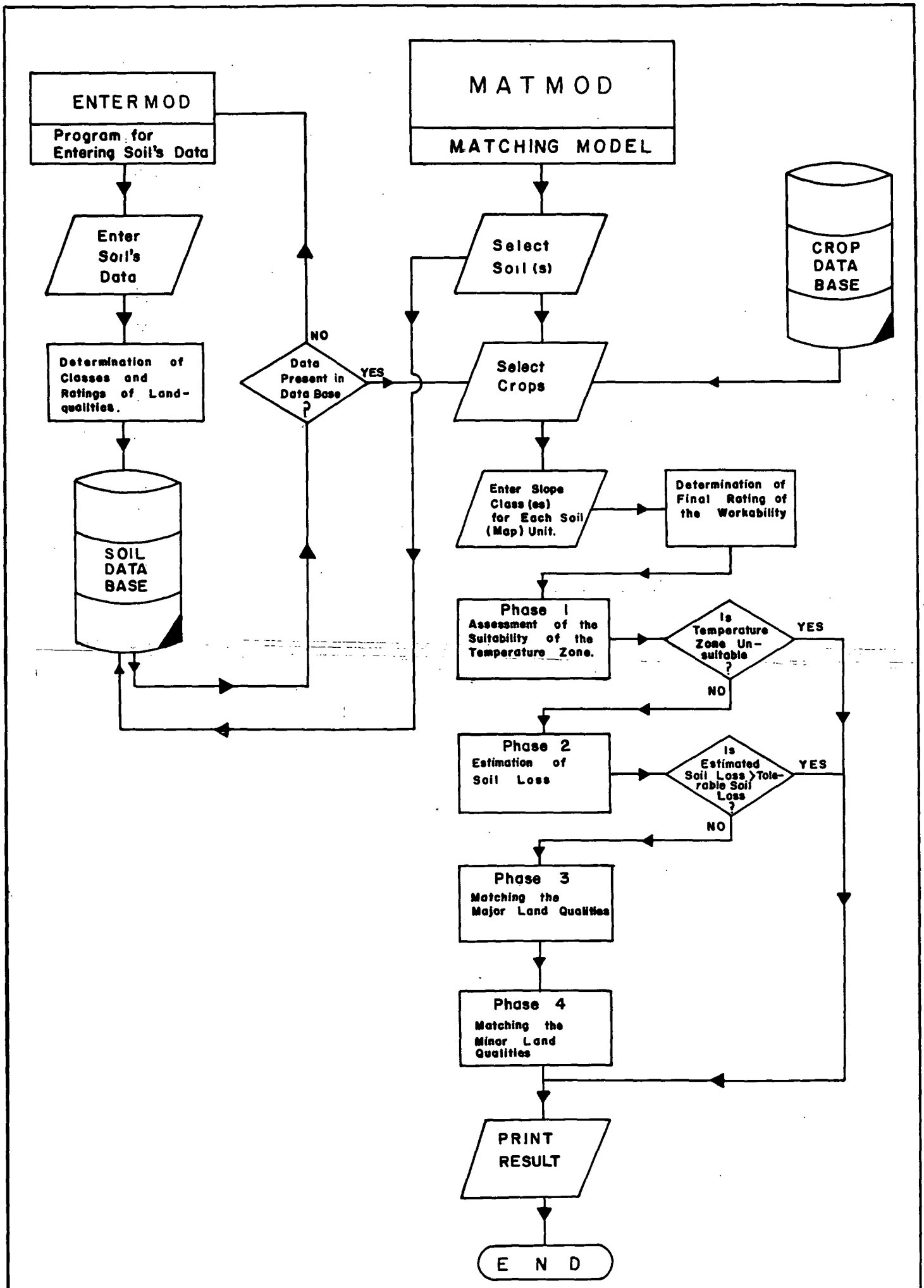
From Appendix 2 and Figure 1 can be read, that the slope class(es) typical for the considered soil (map) unit are entered while using MATMOD. The slope class is used in the first place to assess the resistance to erosion of the land-crop combination, and secondly to compute the final rating of the land quality 'workability'. The rating of the workability is based on the subratings of the topsoil's consistence, the stoniness and slope.

THE MATCHING PROCEDURE

The matching is carried out in 4 separate phases (see Figure 1).

1. In the first phase the crop's temperature requirements are compared with the temperature range of the land (map) unit. If the temperature range is strongly limiting for the considered crop, the other three phases of MATMOD are omitted. In that case further matching is not necessary since the crop cannot be grown.

2. Secondly, the soil loss from a land-crop combination is calculated with the Universal Soil Loss Equation (see Bouwman,


ENTERMOD
Program for Entering Soil's Data
Enter Soil's Data
Determination of Classes and Ratings of Land-qualities.
SOIL DATA BASE
NO
Data Present in Data Base ?
YES
MATMOD
MATCHING MODEL
Select Soil (s)
CROP DATA BASE
Select Crops
Enter Slope Class (es) for Each Soil (Map) Unit.
Determination of Final Rating of the Workability
Phase 1
Assessment of the Suitability of the Temperature Zone.
Is Temperature Zone Un-suitable ?
YES
NO
Phase 2
Estimation of Soil Loss
Is Estimated Soil Loss > Tole-rable Soil Loss ?
YES
NO
Phase 3
Matching the Major Land Qualities
Phase 4
Matching the Minor Land Qualities
PRINT RESULT
E N D

1985). In this equation a value of the management factor P is used, which corresponds to the most effective soil conservation practice that is feasible on the considered land (map) unit. The tolerable quantity of soil loss is determined in this model by the soil depth. If the so estimated soil loss exceeds the tolerable soil loss the third and fourth phase of the matching model are by-passed.

3. In the third phase of the matching procedure the 'major' landqualities and land characteristics are compared with their equivalent crop requirements. Major landqualities and land characteristics are essential for plant production and generally cannot be improved by simple management practices. The major landqualities are the control section textural group, the pH-H2O of the topsoil, the availability of oxygen, the availability of foothold for plant roots, the salinity hazard and the sodicity hazard.

4. During the fourth phase all 'minor' land qualities and land characteristics are matched with their corresponding crop requirements. Minor landqualities include those, that can be improved through proper soil and water management or with the use of certain simple agronomic techniques or modern inputs. The landqualities which are considered in the fourth phase are the nutrient retention (or the capability to store nutrients and prevent them from being leached), the availability of nutrients (chemical fertility), the workability considered for manual labour and the workability considered for mechanization.

THE OUTPUT OF MATMOD

As was stated before, the matching model does not produce a suitability class, but instead, it determines the occurring limitations and the degree of the limitations of the land for cultivation of specific crops.

In the printed output of MATMOD each crop-soil combination has been assigned three lines on which limitations can be presented. The first line corresponds to the first and second phase in the matching procedure. The second and third line in the output-table correspond with the third and fourth matching phase respectively.

There are two circumstances, which cause the model to abort the matching procedure, because further matching would not be necessary. In the first place, the matching is stopped if the temperature zone of the land causes strong limitations for the growth of the considered crop. Secondly, when the estimated soil loss exceeds the tolerable level, the phases three and four are omitted. In the above two cases only the top line is used and

lines 2 and 3 remain blank. In all other cases the complete matching procedure is carried out and printed.

For each soil (map) unit the slope class(es) have to be entered. The slope classes are similar to those used by the Jamaica Soil Survey. MATMOD carries out the matching for any number of land (=soil + slope) map units and with any number of crops present in the data base.

Because of the limited line width of the computer-printer, the output is divided in tables in which the rows correspond to the land units and the columns (with a maximum of 10 per table) to the crops. After completing a table, the model continues automatically with the printimg of the next table. An example of such a table is presented in Appendix 3.

DISCUSSION

It is understood that computers and computer software must be made to serve man and should not be a goal in itself. MATMOD can carry out at a high speed, what could be done manually using the ratings and classes of land qualities and land characteristics as listed in appendix I. The advantage of carrying out a land evaluation exercise manually is, that the user can apply his personal knowledge and experience of crops and soils to check the data and the outcome of the matching, while in the event of using a computer model like MATMOD, there is no control over the matching procedures and the danger exists that the user has no insight in the basic crop data and ratings.

Personal input in the matching process has the disadvantage, that in many instances the results of the land evaluation are biased. By comparison, there is greater objectivity using the computer, since it assesses all factors similarly, based on certain assumptions (ratings and classes) and data (crop requirements).

The computer software discussed should be used in conjunction with the other components of JAMPLES. A complete evaluation of the physical factors of crop production also should include a thorough climate analysis (see climate models) and an assessment of the soil degradation and soil conservation practices (see SODEMOD). The evaluation of the economic viability of the proposed crops is carried out with the MULBUD software package.

Acknowledgements

Thanks are due to the staff members of the Soil Survey Unit and Rural Physical Planning Division for their participation in the composition of the list of ratings and classes of land qualities and land characteristics. I would like to thank in particular Miss H. Hylton for editing the text of this technical bulletin and Mr. N.H. Batjes for his valuable, positive comments and his technical assistance during the designing of the computer program.

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List of ratings and classes of land qualities and land characteristics for land evaulation

Prepared by Soil Survey Staff
R.P.P.D.

A. Textural group of control section (usually 20-100cm): T

class	textural class *
1. fine	sandy clay, silty clay, clay
2. mod.fine	clay loam, sandy clay loam, silty clay loam
3. medium	very fine sandy loam, loam, silt loam, silt
4. mod.coarse	sandy loam, fine sandy loam
5. coarse	sand, loamy sand
6. strongly contrasting particle size classes	

* Source: USDA(1984)

B. Soil reaction (pH-H2O,soil/water ratio 1:2.5): pH

a. Soil reaction of the topsoil (0-30 cm)
b. Soil reaction of the subsoil (30-100 cm)

No classes and corresponding ranges of the pH-H2O are used since all crops have very specific requirements of soil reaction. The average values of the pH of the topsoil and of the subsoil (0-30 cm and 30-100 cm or 30 cm to a shallower depth if soil is shallower than 100 cm) is used to match against the crop's pH requirements.

C. Nutrient retention: NR

The classes of this land characteristic are formed by the ranges of the cation exchange capacity of the topsoil (0-30 cm). The cation exchange capacity (CEC) is measured with 1M NH4OAc at pH7.

Class	CEC(me/100 g of soil)
1	>25
2	10-25
3	<10

D. Nutrient availability: NA

The availability of nutrients is determined on the basis of subratings of three land characteristics, each having its subrating as shown below. The three land characteristics refer to the topsoil (0-30 cm).

Organic matter content (O.M.):

subrating	O.M.(%) *
1. high	>3
2. medium	1-3
3. low	<1

* O.M.(%)= O.C.(%)/0.58

Available phosphate (Truog):

subrating	available P(ppm P205)
1. high	>100
2. medium	50-100
3. low	<50

Base saturation (B.S. at pH7, 1M NH4OAc)

subrating	B.S.(%)
1. high	>50
2. medium	35-50
3. low	<35

Final rating of the nutrient availability:

rating	sum of subratings for organic matter content, available P and base saturation
1. high	3-4
2. medium	5-6
3. low	7-9

E. Content (in %) of finely divided CaCO3 in the control section (usually 25-100 cm): CC

1. low	0-3
2. medium	3-15
3. high	>15 *

F. Salinity hazard: SA

The rating for this land quality is determined by the electrical conductivity of the soil material measured in a saturated paste (ECe in mmhos/cm at 25 C) and the depth of occurence. The proposed ECe ratings are derived from salinity surveys by RPPD. The depth to the saline layer is introduced in the key to the salinity classes.

subrating	range of ECe (mmhos/cm, 25 C)
a. non saline	0 - 4
b. slightly saline	4 - 8
c. moderately saline	8 -13
d. strongly saline	>13

Key to salinity classes:

depth(cm)	salinity class *				
	1	2	3	4	5
0- 20	a	a	a	a-b	b-d
20- 40	a	a	a-b	b-c	b-d
40- 60	a	a	b-c	b-d	b-d
60- 80	a	a-b	b-c	b-d	b-d
80-100	a	b-c	b-c	b-d	b-d

* Source: salinity surveys, RPPD (1985)

The salinity classes are:

1. no salinity hazard
2. low salinity hazard
3. moderate salinity hazard
4. high salinity hazard
5. very high salinity hazard

G. Sodicity hazard: SO

The sodicity is expressed as the exchangeable sodium percentage (ESP) in the subsoil (below 30 cm).

rating	ESP(%)
1. low	<15
2. high	>15

H. Availability of oxygen for plant roots: O

The rating for this landquality is determined by the drainage condition of the soil.

rating	drainage class *
1. high	well drained, somewhat excessively drained, excessively drained
2. medium	moderately well drained, imperfectly drained
3. low	poorly drained, very poorly drained

* Source: FAO(1977)

I. Availability of foothold for plant roots: F

The rating of this land quality is determined by the soil depth (in cm) or the depth to any layer which limits the root growth.

1. high availability	>100
2. medium	50-100
3. low	25- 50
4. very low	<25

J. Workability: W

The rating of this landquality is determined by the land characteristics consistence of the topsoil, stoniness/ rockiness/ shallowness. The classes of these land characteristics have to be determined first. The rating of this land quality is taken

integrally from Nyandat et al (1978) who designed the system for Kenya.

- subrating for the topsoil's consistence:

dry consistence	moist consistence
1. loose	1. loose
2. soft	2. very friable
3. slightly hard	3. friable
4. hard	4. firm
5. very-extremely hard	5. very firm/extremely firm

- subrating of the consistence:

1. sum of dry consistence and moist consistence = 2 or 3
2. sum of dry consistence and moist consistence = 4 or 5
3. sum of dry consistence and moist consistence = 6 or 7
4. sum of dry consistence and moist consistence = 8 or 9
5. sum of dry consistence and moist consistence = 10

- subrating of stoniness/rockiness/shallowness:

1. non stony, non rocky and not shallow
2. fairly stony, fairly rocky and/or shallow
3. stony, rocky, and/or shallow
4. very stony, very rocky and/or very shallow
5. exceedingly stony and/or very rocky

- subrating of the topography (average slope gradient):

1. 0 - 8 % nearly level
2. 8 -16 % rolling
3. 16 -30 % hilly
4. 30 -50 % steep
5. >50 % very steep

- final rating of the workability:

To determine the final rating of the workability, the land quality is considered for:

- cultivation by hand only
- cultivation with mechanization (tractor and pulled implements)

For each of these land qualities *the most limiting subrating* will determine the final rating.

WH final rating of the workability considered for cultivation by hand only.

rating	consistence	stoniness/etc.	topography
1. no limitations	1-2	1-2	1
2. slight limitations	3	3	2
3. moderate limitations	4	4	3
4. strong limitations	5	5	4
5. very strong limitations	5	5	5

WM final rating of the workability considered for cultivation with mechanization.

rating	consistence	stoniness/etc.	topography
1. no limitations	3	1	1
2. slight limitations	4	1	1
3. moderate limitations	5	2	2
4. strong limitations	5	3	3
5. very strong limitations	5	4-5	4-5

List of required data for ENTERMOD (for creating the soil's data base)

APPENDIX 2

Data required	ENTERMOD transforms to:
1. soil name	- _____
2. soil (map) code	- _____
3. profile number	- _____
4. maximum elevation of map unit	- temperature zone (see Batjes, 1986)
5. minimum elevation of map unit	- temperature zone (see Batjes, 1986)
	- _____
6. USDA-classification	- _____
7. USDA-mineralogy class	- _____
8. textural group of the control section	- _____
9. pH-H2O of topsoil (0-30 cm)	- _____
10. pH-H2O of subsoil (>30 Cm)	- _____
11. CEC (NH4OAc/pH-7)	- rating of nutrient retention (NR)
12. organic matter content of topsoil (0-30 cm)	}
13. available phosphate	} rating of the availability of nutrients
14. base saturation	}
15. salinity class 0-20, 20-40, 40-60, 60-80 and 80-100 cm	- rating of the salinity hazard (SA)
16. exchangeable sodium %	- rating of sodicity hazard
17. CaCO3 content (%)	- rating for CaCO3-content
18. soil drainage class	- rating of availability of oxygen for plant roots
19. soil depth	- rating of availability of foothold for plant roots
20. topsoil dry consistence and moist consistence	- subrating of topsoil consistence
21. stoniness class	- subrating of stoniness
22. rainfall erosivity index	- _____
23. textural analysis data of topsoil, topsoil structure soil's permeability	} these data are used with the organic matter content to compute the soil's erodibility factor K.

Appendix III.1

Example of print out of MATMOD

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**********JAMAICA PHYSICAL LAND EVALUATION SYSTEM**********
**********************MATCHING MODULE**********************
**************************by A.F. Bouwman******************
**********************September 1986**********************
******************RURAL PHYSICAL PLANNING DIVISION**********
******************MINISTRY OF AGRICULTURE, JAMAICA**********
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Explanation of the codes used in the print out of MATCHMOD

Slope classes are those applied by the Jamaica Soil Survey :

1. 0 - 2%	*4. 16-30%*
2. 2 - 8%	*5. 30-50%*
3. 8 -16%	*6. >50%*

Only the factors which are limiting are presented. If a land unit does not present any limitations for growing of a specific crop, it can be considered as highly suitable for the crop under consideration
The limitations are indicated with special symbols as specified below
Each code, except for E (=erosion hazard), has a suffix, which indicates the degree of limitation :

1. slight limitations.
2. strong limitations

The risk of soil loss is calculated, taking into consideration the most efficient and feasible conservation practice. If you wish to evaluate the erosion hazard in and required soil conservation practices and its costs, you can use the SODEMOD program.

Symbols for the limitations of the land are :
HT = Temperature regime of highest elevation in map unit
LT = Temperature regime of lowest elevation in map unit
E = Erosion hazard; no degree of limitation is indicated
T = Textural group of control section (usually 25-100 cm)
PH = Soil reaction of topsoil (0-30 cm)
O = Availability of oxygen in the rooting zone
F = Availability of foothold for plant roots
SA = Salinity hazard
SO = Sodicity hazard
CC = Presence of finely divided CaCO3
NR = Nutrient retention (CEC pH7)
NA = Availability of nutrients
WH = workability considered for manual labour
WM = Workability considered for mechanization

For each land unit three lines are available.
On the top line the limitations 'LT','HT' and 'E' are printed
On the second line, the major soil limitations 'T','PH', 'O','F','SA' and 'SO' are printed, while on the last line only the minor soil limitations 'NR','NA','WH', and 'WM' will be shown.

If the result of the matching is 'HT2','LT2' or 'E' further matching of crop requirement is stopped.

Appendix III.2 Example of print out of MATMOD

Soil	slope	c	profile	rice	sugar cane	Banana	tobacco	sorghum	cotton	sunflower	soya bean	maize
Flint River (50)	3	85/	/1	HT1;LT1; T2;PH2; NR1;WH1;WM2;	HT2;LT2;	HT1;LT1; T2; NR1;	HT1;LT1; NR1;WH1;WM1;	HT2;LT2;	HT2;LT2;	HT2;LT2;	HT1;LT1; T1;PH1; NR1;WH1;WM1;	HT1;LT1; T1;PH1; NR1;WH1;WM2;
	4	85/	/1	HT1;LT1; T2;PH2; NR1;WH2;WM2;	HT2;LT2;	HT1;LT1;E	HT1;LT1; NR1;WH1;WM2;	HT2;LT2;	HT2;LT2;	HT2;LT2;	HT1;LT1;E	HT1;LT1;E
Diamonds (34)	3	85/	/4	HT1;LT1; T2;PH2; WH1;WM2;	HT2;LT2;	HT1;LT1; T2;	HT1;LT1; T1; WH1;WM1;	HT2;LT2;	HT2;LT2;	HT2;LT2;	HT1;LT1; T1;PH1;F1; WH1;WM1;	HT1;LT1; T1;F1; WH1;WM2;
	4	85/	/4	HT1;LT1; T2;PH2; WH2;WM2;	HT2;LT2;	HT1;LT1;E	HT1;LT1; T1; WH1;WM2;	HT2;LT2;	HT2;LT2;	HT2;LT2;	HT1;LT1;E	HT1;LT1;E
	5	85/	/4	HT1;LT1; T2;PH2; WH2;WM2;	HT2;LT2;	HT1;LT1;E	HT1;LT1;E	HT2;LT2;	HT2;LT2;	HT2;LT2;	HT1;LT1;E	HT1;LT1;E
Union Hill (75)	2	85/	/1A	T2;PH2; NR1;WM2;	T2;PH1;F1; NR1;WM1;	T2;PH1; NR1;	T2;PH2; NR1;WM1;	HT1;LT1; T2;PH1;F1; WM1;	HT1;LT1; T2;F1; WM1;	T2;PH2;F1; WM1;	T2;PH2;F1; NR1;WM1;	T2;PH1;F1; NR1;WM2;
	3	85/	/1A	T2;PH2; NR1;WH1;WM2;	T2;PH1;F1; NR1;WM1;	T2;PH1; NR1;	T2;PH2; NR1;WH1;WM1;	HT1;LT1; T2;PH1;F1; WH1;WM1;	HT1;LT1; T2;F1; WH1;WM1;	T2;PH2;F1; WH1;WM1;	T2;PH2;F1; NR1;WH1;WM1;	T2;PH1;F1; NR1;WH1;WM2;
	4	85/	/1A	T2;PH2; NR1;WH2;WM2;	E	E	T2;PH2; NR1;WH1;WM2;	HT1;LT1; T2;PH1;F1; WH1;WM2;	HT1;LT1;E	E	E	E