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SOLGRAPH

A SOIL AND CLIMATE DATA PRESENTATION AND ASSESSMENT PROGRAM

J. Brunt & J.H. Kauffman

3rd version
October 1995

ISRIC

INTERNATIONAL SOIL REFERENCE AND INFORMATION CENTRE

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Note: Reference to keys of the PC keyboard are placed in square brackets.
E.g. [S], [Enter] etc.

Keys often used in SOLGRAPH

KEYS	Purpose
[Alt] and [S]	to start LOTUS macros
[Enter]	to confirm commands
[Q]	to quit applications
[X]	to leave the selection program

WHAT IS SOLGRAPH?

SOLGRAPH© is a program to enable the graphical presentation of soil and climate data. It has been developed for participants in the National Soil Reference Collection and Database project (NASREC). NASREC is a DGIS/UNEP[1] supported project with the objectives to establish pedon databases for soil reference profiles (or benchmark soils) and the development of dataprocessing techniques in developing countries. Since SOLGRAPH meets the wishes of many others, it was decided to make it available in ISRIC's Technical Paper series.

Staff members of ISRIC and of the Department of Soil Science and Geology of Wageningen Agricultural University (WAU), have developed a number of graphical presentations using Lotus or Symphony programs. SOLGRAPH version 1 was the first attempt to assembly these facilities and offer them to the user in a menu driven program. The graphical presentation of soil and climatic parameters offered in SOLGRAPH forms an introduction to easy data handling method facilities.
After testing the first version, useful comments and suggestions were incorporated, the number of diagrams increased and the single soil parameter assessment expanded. Two versions of SOLGRAPH were developed to support different ISIS[2] and dBase versions:

- SOLGRAPH version 2 is for ISIS version 3 using dBase III or dBase IV
- SOLGRAPH version 3 is for ISIS version 4 using dBase IV only.

The users of SOLGRAPH are encouraged to make comments and suggestions for improvement. New applications sent to ISRIC may be incorporated in a later version of SOLGRAPH and proper reference to the author will be made.

Major contributions have come from:

J. Brunt	dBase and Lotus programming	ISRIC
J.R.M. Huting	Multi pF-curve diagram	ISRIC
J.H. Kauffman	Soil parameters with depth diagrams Climatic diagrams	ISRIC
E. Meijer	Texture triangle	WAU

Suggestions for improvements on SOLGRAPH were received from: A.W. Vogel (ISRIC), J. Quispe (INRENA, Peru), and G. Paredes Arce (UNAP, Peru).
The editing of the text by H. van Baren, E.M. Bridges and A.E. Hartemink (ISRIC) and the secretarial assistance of M.B. Clabaut are much appreciated.

[1] DGIS = Directorate General for International Cooperation of the Netherlands.
UNEP = United Nations Environmental Programme

[2] ISIS = ISRIC Soil Information System

1 INTRODUCTION

SOLGRAPH© is a soil and climatic data presentation and assessment program. It offers automatic graphical presentations of soil data, such as a texture triangle, pF curves and various soil parameters with depth diagrams. In addition, it offers an automatic assessment of single soil parameters in a tabular format, linear regression and the determination of the CEC as a function of soil organic carbon and clay content.

The program consists of two modules. One module is related to database activities and programmed in dBase; the other module is related to spreadsheet operations and programmed in Lotus, making use of Lotus macros. The major manipulations in SOLGRAPH are summarized in the flow chart of Figure 1 (p.3).

The dBase module selects the required soil and climate data from seven data files. These can be files of ISRIC Soil Information System (ISIS), but also other database files can be used if identical file names and field names are used as listed in Appendix 2. The single soil parameter assessment utility is also programmed in dBase.

The Lotus spreadsheet program will process the selected data and a serie of graphical and tabular options are offered. The automatic procedures for these options are made with the Lotus macro language. For each option a separate spreadsheet has been developed and the required Lotus macros are situated in the relevant spreadsheets.

Once installed, SOLGRAPH can be used without thorough knowledge of dBase or Lotus. However, working knowledge of these two programs gives the user a greater autonomy and a wider field of applications. It allows the user to include a selection of data from other files, to select own diagram titles instead of the SOLGRAPH standard titles, etc. In addition, with programming knowledge of dBase and Lotus, the SOLGRAPH programs can also be modified and new modules incorporated.

2 INSTALLATION

Required software

SOLGRAPH is available on one 3½", 720 Kb diskette (or if requested on two 5¼ inch, 360 Kb diskettes), and contains 24 PRG, 21 DBF, 5 NDX, 15 WKS, 11 WK1, 1 BAT and 1 EXE file. A list of these files is given in Appendix 1.
The following software should be present on the hard disk:

1. dBase IV version 2.x
2. Lotus 123 version 3.x
3. Soil and Climatic database files according to ISIS version 3 or other dBase files corresponding to file names and field names as given in the data dictionary in Appendix 2.

Installation of SOLGRAPH

1. Create a sub-directory SOLGRAPH on your hard disk.

2. Copy the files from the SOLGRAPH diskette(s) to the SOLGRAPH sub-directory.

3a. ***For ISIS database users:*** Copy the files ISISCHEM.DBF, ISISPHYS.DBF, CLIMDATA.DBF, ISISCLST.DBF, ISISMORP.DBF, ISISSITE.DBF and CLIMSTAT.DBF to the sub-directory SOLGRAPH

3b. ***For non-ISIS database users:*** Organize your soil and climate data in dBase 3+ or dBase IV according to the file name and field names given in Appendix 2. Please note that missing values should be entered as a minus 1(-1) value.

4. Place both dBase and Lotus programs in the path. In case you are not familiar with the "path" command, please refer to your DOS manual.

5. Make the sub-directory SOLGRAPH the default Lotus Directory (this is the Directory where Lotus finds its worksheet files). To do so, start Lotus and strike the keys [/], [W], [G], [D] and [D] referring to: / (=menu), Worksheet, Global, Default, Directory. Type the full directory path name, including drive letter e.g. C:\SOLGRAPH and press the [ENTER] key. Strike the [U] and [Q] (Update and Quit). Leave the Lotus program.

Start SOLGRAPH

6. Go to the SOLGRAPH sub-directory and type SOLGRAPH and press the [ENTER] key in order to start the SOLGRAPH application program.

3 HOW TO USE SOLGRAPH

3.1 Utility and data selection menu - dBase module

The major actions in SOLGRAPH are summarized in the flow chart given in Fig. 1.

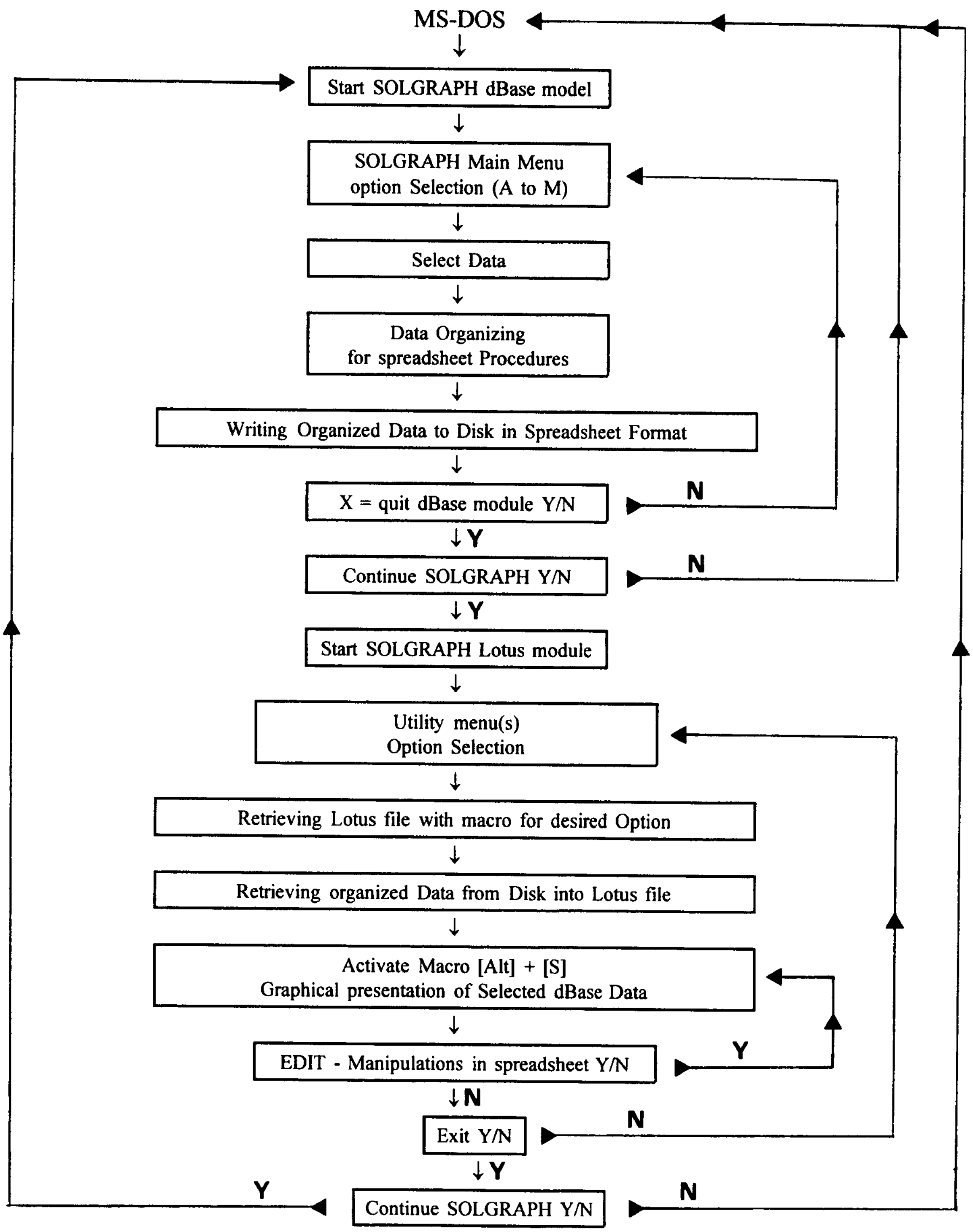

Fig. 1 Flow Chart of SOLGRAPH

The program is started by typing SOLGRAPH at the dot prompt, followed by pressing the [ENTER] key, and the following message appears:

```
                              SOLGRAPH
                  Soil & Climate Data Utility Program

                             Version 3.0
                                                        Wageningen
 1995                          ISRIC                    Holland

                       Press any key to continue
```

Strike a key to continue the program and the following main menu appears:

```
SOLGRAPH MAIN MENU
```

```
 G R A P H I C S                          C A L C U L A T I O N S

 A. Texture Triangle                      J. Linear Regression
 B. Depth - vs - Sand,Silt,Clay           K. CEC, Clay and Org. C
 C. Depth - vs - Sum Bases, etc.
 D. Depth - vs - Two Parameters
 E. Multi-Profiles
 F. Precipitation & Evaporation
 G. Temperatures                            OTHER / EXIT
 H. pF-Curves
                                          L. Log file
                                          M. Reindex
 E V A L U A T I O N                      X. Exit (start Lotus)

 I. Single Parameter Ratings              Date: Wednesday 20 April 1994
                                          Free Space on Hard disk 2645192

               Enter Your Selection: [A] to [M] or X to EXIT
```

The menu aims at the selection of dataprocessing utilities and required data. The utilities are grouped in three applications:

- GRAPHICAL applications [keys A to H]
- EVALUATION application [I]
- CALCULATION applications [J and K]

Other Utilities are found in the lower right part of the screen [L, M and X], as well as the date and available disk space. It has been found useful to keep track of all options chosen by the user during one SOLGRAPH working session and option L provides a list summarizing this information. In some cases, reindexing of the database is required which can be done by selecting option [M].

Detailed information on applications [A] to [M] is given in Chapter 4.

Data selection for a utility is started by typing the corresponding letter. Each utility will start by asking the user to select profile(s) and samples for dataprocessing. On the screen, the following questions will appear:

Which profile(s) do you select?

Type the required profile code number.

Note: *For ISIS users:*
In ISIS version 3 the profile code is composed of a maximum of 3 letters and 2 digits (e.g. BRA01, CR 01, S 01, referring to Brazil No.1, Costa Rica No.1 and Spain No.1 etc.). In ISIS version 4, the profile code is composed of a maximum of 2 letters (the ISO country code) and 3 digits, indicating the number of the soil.

For non-ISIS users:
You may use any code composed of maximum 5 characters (including spaces).

For the Texture Triangle and the Multi-Profile options two more questions will appear on the screen:

More profiles?
Do you want to specify one horizon/sample?

This means that you may construct a texture triangle from more than one profile and/or of one horizon/sample or of all samples (of the selected profiles).

When option [D], Depth-vs-Two Parameters, is chosen a selection has to be made of physical and/or chemical parameters and one of the two following menus will appear on the screen:

```
Depth  -vs- Two Parameters
```

```
PHYSICAL PARAMETERS

[A] Gravel                     [M] Bulk Density
[B] Sand 2000-1000µm           [N] pF 0.0
[C] Sand 1000-500µm            [O] pF 1.0
[D] Sand 500-250µm             [P] pF 1.5
[E] Sand 250-100µm             [Q] pF 2.0
[F] Sand 100-50µm              [R] pF 2.3
[G] Total Sand                 [S] pF 2.7
[H] Silt 50-20µm               [T] pF 3.4
[I] Silt 20-2µm                [U] pF 4.2
[J] Total Silt                 [V] Spec. Surface
[K] Clay
[L] Disp. Clay

[Enter your selection (A - V) or X to eXit: ]
```

```
:::::::::::::::::::::::::::::CHEMICAL PARAMETERS::::::::::::::::::::::::::::::::
::                                                                         ::
::  [A] pH-water                  [M] CEC Soil                             ::
::  [B] pH-KCl                    [N] CEC Clay                             ::
::  [C] Calcium Carbonate         [O] CEC Org. Matter                      ::
::  [D] Organic Carbon            [P] Effective CEC                        ::
::  [E] Organic Nitrogen          [Q] Base Sat.                            ::
::  [F] Exch. Calcium             [R] Aluminium Sat.                       ::
::  [G] Exch. Magnesium           [S] Elec. Conduct.                       ::
::  [H] Exch. Potassium                                                    ::
::  [I] Exch. Sodium                                                       ::
::  [J] Sum of Bases                                                       ::
::  [K] Exch. Acidity                                                      ::
::  [L] Exch. Aluminium                                                    ::
::                                                                         ::
:::::: [Enter your selection (A - S) or X to eXit: ]::::::
```

After parameter selection the programme automatically returns to the main selection menu.

Quit selection menu
The utility and data selection menu can be left by pressing the [X] key and the following question appears:

```
Do you want to continue
SOLGRAPH application Y/N?
```

By striking [Y], the Lotus module will start (see paragraph 3.2).
By striking [N], you will quit SOLGRAPH.

Error
In case of error, dBase will respond with the error message on screen 'Cancel, Suspend or Ignore'. Use [C] Cancel and type (from the dBase dot prompt) **DO SOLMENU** and press the [Enter] key. SOLMENU is the name of the first program which starts the SOLGRAPH program.

3.2 Utility menu - Lotus module

After the selections from the main menu are made, and the [X] key is pressed, the dBase selection module is left and the Lotus utility module starts automatically. The following menu appears at the upper part of the Lotus spreadsheet screen:

```
Texture  Sand,Silt,Clay  Bases  Other Parameter  pF-Curves  More  Exit
```

Make your choice with the cursor keys and press [ENTER]. Detailed information of all applications is given in Chapter 4.

The option <Exit> will terminate the Lotus utility menu, while option <More> will offer you the following applications:

```
Depth  Precipitation  Temperature  Regression  CEC/Clay/Org_C  More  Exit
```

Depending on the selected application, you either see a graphical presentation or be requested to strike the keys [Alt] and [S] simultaneously to start a Lotus macro for automatic graph presentation.

PRESS ALT and S KEYS SIMULTANEOUSLY TO SEE GRAPH

ISIS_IHORI		TOP	BOT	CLAY	TSI	TSA	average depth between top and bottom layers			
NG029	1.0	0	28	6.5	3.1	90.3	-14	-14	-14	X + 0
NG029	2.0	28	53	4.7	7.2	88.0	-40.5	-40.5	-40.5	X + 0
NG029	3.0	53	106	8.5	6.3	85.2	-79.5	-79.5	-79.5	X + 0
NG029	4.0	106	155	6.5	6.5	86.9	-130.5	-130.5	-130.5	X + 0
NG029	5.0	-1	-1	14.8	6.0	79.0	1	1	1	X + 0
NG029	6.0	-1	-1	13.4	6.8	79.6	1	1	1	X + 0
NG029	7.0	-1	-1	14.7	8.8	76.5	1	1	1	X + 0

Fig. 2 Example of a Spreadsheet in the Edit Mode

3.3 Selected Lotus instructions

For users not acquainted with Lotus, a summary of Lotus information is given here. For detailed Lotus instructions and information, reference is made to the Lotus user manual.
Lotus commands can only be realized in the spreadsheet and to enter the spreadsheet, use the <Edit> option of SOLGRAPH.

Modifying data
It may be necessary to make some modifications in the data before constructing and saving a diagram.
After seeing the graphical presentation or activating a macro, you may enter the spreadsheet by choosing the option <Edit> in the menu.

```
Edit   Quit
```

Select <Edit> and move the cursor to where you need to modify the data. After the changes, activate the macro by striking the [Alt] and [S] keys simultaneously, and a new diagram appears in which the modifications are incorporated.

Note: *Each application requires a series of Lotus macros, which are located in the relevant spreadsheets. When modifying your data, it is advisable not to use the* <u>*Delete*</u> *row or columns command as this may also affect the macros. Instead, the* <u>*Erasing*</u> *of a range of cells should be used. In Chapter 4 the exact location of the Lotus macros for each application is given.*

An example of a macro for the graphical presentation of precipitation and evapotranspiration is given in Fig. 3.

```
\0\a      /reoud~
input     {goto}a3~{down 2}/fccetriangle.wks~/cc6~b599~{calc}   ncncnc
\s        /red2~{if @count(olddata)>1}{goto}a600~/wdr{down @count(oldda
          {if @count(clay)<>@count(silt)}{branch glp}
          {if @count(silt)<>@count(sand)}{branch glp}
          {if @count(clay)<>@count(sand)}{branch glp}
          {if @count(sand)+@count(silt)+@count(clay)=0}{branch nodata}
insert    {calc}{goto}b600~
          {if @count(sand)=1}{branch grafiek}
          {if @count(sand)=2}{branch dotwee}
          /wir{down +b1}~
          /ctotaal~~
          {goto}e599~/c{right 2}~.{down @count(sand)-1}~{goto}a2~{goto}


grafiek   {calc}/g{windowson}vq{menubranch z22}

  dotwee  /wir~
          /ctotaal~~
          {goto}e599~/c{right 2}~.{down}~{goto}a2~{goto}c6~{grafiek}
```

Fig. 3 Example of a Lotus macro

Modifying diagrams
Standard SOLGRAPH titles can easily be modified, which is especially required in the "other parameters" diagram.
Press the keys [/], [G], [O], [T], [F], referring to Menu, Graph, Titles and First commands. Then modify the content of the first title. Press the [Enter] and [Q] keys (Quit command).

The automatic scaling offered in SOLGRAPH is modified by striking the [/], [G], [O], [S] keys, select [Y] or [X] (referring to Menu, Graph, Titles, Scaling commands and selection of Y or X axis). Follow the manual scale instructions with Upper and Lower Limit, instead of the automatic scale option.

Adding new data
After inspecting the first graphical presentation, adding new data may be required. This can easily be done by typing the data directly in the spreadsheet (after having selected Edit from menu). Data can also be appended from other files by the regular Lotus files combine procedures. For this, press the [/], [F] and [C] keys (referring to Menu, File and Combine commands).

Save diagram
The diagram is saved by using regular Lotus 'save picture' commands. For this, strike the [/] [G] and [S] keys (referring to Menu, Graph and Save keys). Type a filename defined by the user (and if required a sub-directory) followed by [Enter] and [Q] keys for quitting the saving procedure. The file automatically has the .PIC extension.

Save spreadsheet
It is also possible to save the spreadsheet containing the extracted data from the database files although it is not recommended to store identical data twice on the disk. In case you decide to save the spreadsheet data in a separate file, two conditions should be met:

a. The spreadsheet should not be saved under its original name, because if a macro was accidentally corrupted, the original macro will disappear.
b. The initial macro in the spreadsheet (the \0 macro) should be erased in the saved spreadsheet (when this is not done, the saved data will be overwritten by other data).

The \0 macro can be erased by striking the following keys: / (=menu) [R] [N] [D] [\0] [Q] (referring to Range, Name, Delete, \0 and Quit).

Quit Lotus application module
When working directly in the spreadsheet (e.g. modifying or adding data), a return to the main menu is achieved by the Lotus macro (strike [Alt] and [S]), which shows you the graph. Then select the option <Quit> and subsequently <Exit> from the pop-up menus and the following question appears:

> Do you want to continue
> SOLGRAPH Application Y/N?

By striking [Y], the dBase selection module starts and the SOLGRAPH main selection menu re-appears on the screen.
By striking [N], you will quit SOLGRAPH.

3.4 Further processing of SOLGRAPH results

Diagrams produced by SOLGRAPH and saved as .PIC files can be used directly in word processing programs (such as WordPerfect). Further manipulation of diagrams in other graphical programs (such as Harvard Graphics and Coral Draw) is possible. This can be realized by using the "save spreadsheet" file. The saved spreadsheet file can then be loaded in an other graphical program.

4 EXAMPLES AND BACKGROUND INFORMATION

4.1 Texture Triangle

The texture triangle shows the sand, silt and clay percentages in an equilateral triangle. Each side represents the percentage of sand, silt or clay. The texture triangle can be used to visualize the shifts in texture composition of one or more profile(s). It enables the user to derive in a graphical way the texture class name. An example of a texture triangle is given in Figure 4.

Texture triangles can be made of:

- One or more profiles, by typing the required profile codes (e.g. MLI01) followed by specifying if one ore more horizons should be selected (by typing the horizon number (1 = top horizon, 2 = second horizon, etc.)).
- All profiles of a country, by typing the country code (e.g. MLI) and of one or all horizons.
- Specific selections made by the user, by adding the new data directly in the spreadsheet (this can only be done in the Edit mode). Add the new data manually or append new data sets in the spreadsheet with the File Combine procedure by striking the keys [/][F] and [C]).

Modification/addition of data
After the first graphical presentation and/or modification, adding more data can simply be done by the Lotus procedures given in Chapter 3. In summary: select <Edit> in the menu, modify or add data in the columns SAND, SILT and CLAY. Then press the keys [Alt] and [S] simultaneously to show the new texture diagram. Any other new data can be added to the columns SAND, SILT and CLAY or appended from other files by the regular Lotus File Combine procedures.

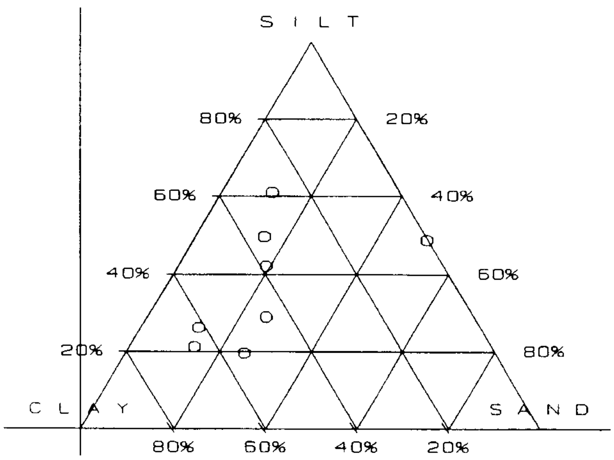

Fig. 4 Texture triangle of a soil profile

Save diagram
Saving of the final graph is executed according to regular Lotus procedures as explained in paragraph 3.3 'selected Lotus instructions'.

Quit application
Strike again the [Alt] and [S] keys simultaneously and select the option Quit.

Spreadsheet information

- texture data are stored in the cell range C6 to E6
- the Lotus macros for the texture triangle application are stored in the spreadsheet in the cell range Y1 to AN24.
- the graphic parameters are located in the range A595 to J649.

4.2 Sand, Silt and Clay diagram

In the sand, silt and clay diagram the percentages are plotted against depth. Such diagrams are useful to analyze soil processes (e.g. clay illuviation), to detect abrupt texture changes due to stratification or sedimentation, a transition from solumn to weathering rock, etc. An example of a sand silt and clay diagram is given in Figure 5.

Modification/adding of data
After the first graph presentation and/or modification, adding data is done following the procedures given in Chapter 3 and 4.1. In summary: select <Edit>, modify or add data in the columns CLAY, TSI AND TSA. When adding data, the mid-depth formula and the resulting depth values in the soil depth columns need to be copied.

Please note that it is necessary to put the cursor on the first code number in the column CODE before starting the automatic graphing. Pressing the keys [Alt] and [S] will activate the Lotus macro and the new sand, silt, clay versus depth diagram will be shown.

Save diagram and quit application
According to the procedures given in 4.1

Spreadsheet information
- Lotus macros are located in the cell range A1 to B22.
- The spreadsheet data are located in columns A102 to H102. The calculated mid-depth of horizons and legend symbols are located in columns I102 N102.

An example of such a diagram is given in Figure 6.

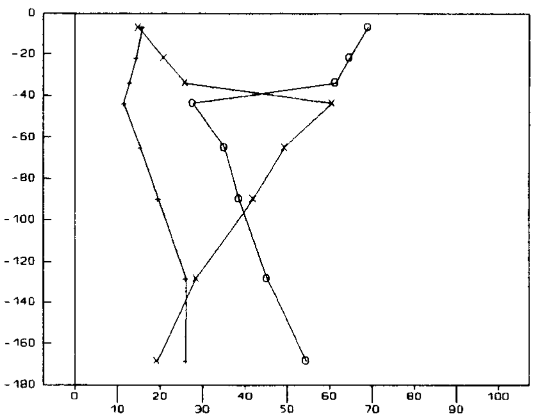

Fig. 5 Percentage of sand, silt, and clay versus depth of soil BR 4

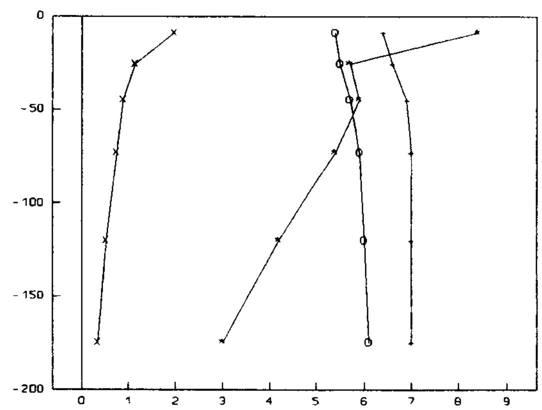

Fig. 6 Sum of bases ($cmol_c$ kg^{-1} soil) (*), pH-H_2O (+), pH-KCl (-) and organic carbon (×) versus depth (cm) of soil BR 4

4.3 Sum of Bases, pH-H_2O, pH-KCl and Organic Carbon diagram

Frequently used soil chemical properties are pH, organic carbon (%) and the sum of exchangeable bases (Ca+Mg+K+Na), the latter is shortly indicated in the diagrams and the spreadsheet by SUM BASES. The presentation of these parameters with depth in one diagram, facilitates the verification of possible correlations, anomalies and shows the relation between topsoil and subsoil.

Scale and Units modification

In many cases, the automatic scaling of the four soil parameters gives satisfactory results. However, in case of much higher values as in Sum of Bases or organic carbon (e.g. Histosols) exceeding 10 ($cmol_c$ kg^{-1}) adaptation may be required. Too high values may simply be reduced by dividing all the values by 10 and subsequent modifications in the legend of the diagram. These modifications can be made by working directly in the spreadsheet with the Edit mode.

Spreadsheet information

- Lotus macros are located in the cell range A1 to B22
- The spreadsheet data are located in row A97 and downward.

4.4 Other parameter diagram

In addition to the fixed parameter with depth diagrams offered in paragraphs 4.2. and 4.3, the user may construct other diagrams for any combination of two soil properties available in the chemical and physical data sets. An example of such a diagram is given in Figure 7.

Modify title

Especially in this diagram the standard title "Soil Depth Graph" can be easily changed using regular Lotus commands to a new title referring to the two selected parameters.

Spreadsheet information

- Lotus macros are located in the cell range A1 to B27.
- The spreadsheet data are located in row A97 and downward.

4.5 Soil moisture retention (pF) curve

Graphical presentation of the pF-curves for different depths allows a visual interpretation of the moisture retention determinations and a quick verification of their correctness. An example of pF-curves is given in Figure 8.

The interpretation of a pF-curve aims at 3 derived parameters: Air Capacity (AC), Available Moisture (AM) and physically Inert Moisture volume (IM). For details on the definitions, reference is made to ILACO (1981).
These parameters are shortly defined as:

AC = Φ (pF 0-pF 2) = volume % between saturation point and field capacity
AM = Φ (pF 2-pF 4.2) = volume % between field capacity and wilting point
IM = Φ (pF 4.2) = volume % of moisture held by the soil at wilting point.

Please note that the Field Capacity definition may vary from the moisture content held at pF values between 2.0 to 2.5.

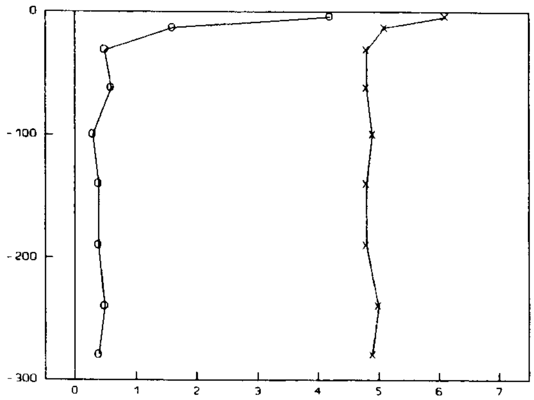

Fig. 7 Distribution of two soil parameters with depth (in this case the pH-H_2O (x) and Sum of Bases (o)) of soil BR 11

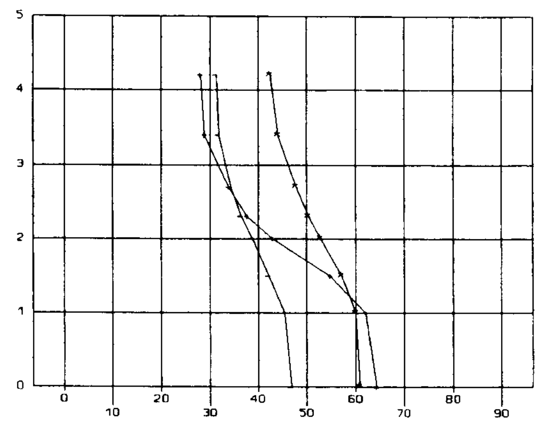

Fig. 8 pF or moisture retention curves (water content in vol % versus suction). The symbols +, - and * refer to the sampling depth

Besides a visual interpretation in figure 9, the calculation and assessment of AC and AM is also given in Table 1 on page 15.

Spreadsheet information:
- Lotus macros are located in the cell range A1 to V26.
- The spreadsheet data are located in row A98 and downward.

4.6 Multiprofiles-vs-Depth diagram

In the utilities explained in paragraphs 4.2 to 4.5, soil property diagrams are made for one profile. The present option provides the user with the possibility to present data of one soil parameter from several soil profiles versus depth in a graphical form. An example of such a diagram is given in Figure 9. The graph symbols a,b,c to z can be modified by changing the data labels in the Edit mode (see paragraph 3.3)

Spreadsheet information

- Lotus macros are located in cell O13 onwards.

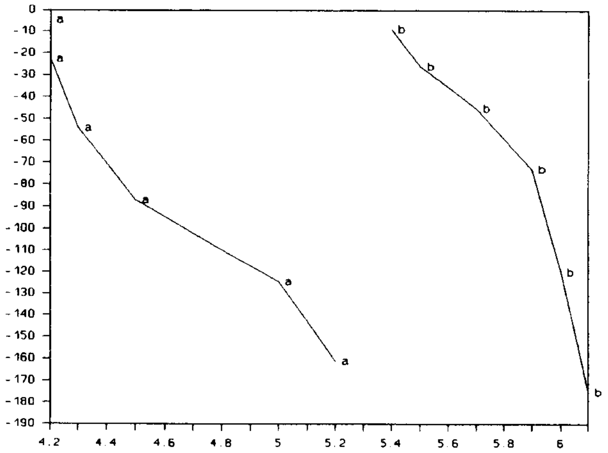

Fig. 9 Multi pH-KCl curves versus depth

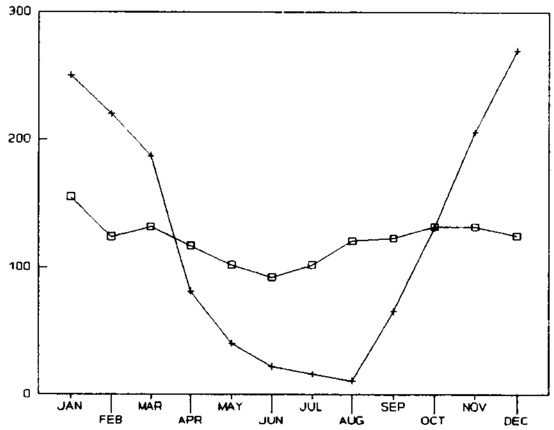

Fig. 10 Precipitation (+) and evapotranspiration (□) in mm at site of profile BR 24

4.7 Precipitation & Evapotranspiration diagram

The presentation of monthly precipitation and (potential) evapotranspiration data in one diagram allows a visual assessment of the length of the growing period divided in wet, intermediate and dry periods (if temperature is not a limiting factor).

An example of interpretation of such a diagram is given in Figure 10. From this diagram the start of the growing period is from about mid September (precipitation ≈ half potential evapotranspiration). The end of the growing period is around early April, although this also depends on the quantity of moisture stored in the soil. The period September to April is characterized by a surplus, in which precipitation exceeds the evapotranspiration. A surplus may contribute to increase the moisture stored in the soil, percolation to the subsoil, and/or run-off. The period of May to the beginning of September, is characterized by very low precipitation and high evapotranspiration.

Spreadsheet information:
- Lotus macros are located in the cell range T1 to V10.
- The spreadsheet data are located in row A1 to N7.

4.8 Temperature diagram

The range of temperatures relevant for crop production can be illustrated with a diagram showing the average monthly values of the Maximum, Mean and Minimum temperatures. An example of such a diagram is given in Figure 11. Where necessary, the absolute values of maximum and minimum temperatures can be added to the spreadsheet. These modifications can be included in the Lotus graph setting /(menu), G(graph), S(setting).

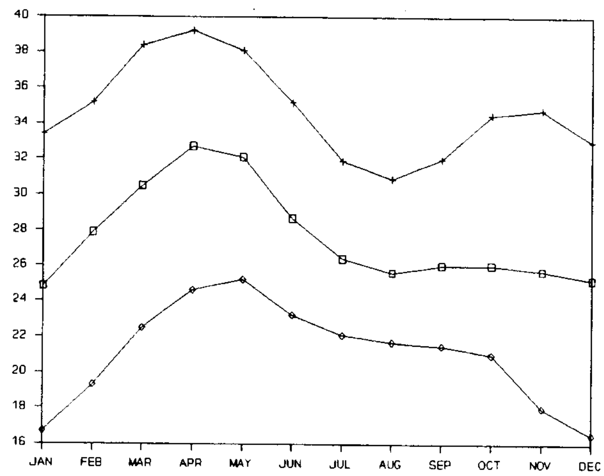

Fig. 11 Distribution of the Maximum, Mean and Minimum temperatures of meteorological station Bamako, representative for soil ML 1

Spreadsheet information:
- Lotus macros are located in the cell range Q1 to V15.
- the spreadsheet data are located in row A1 to N6.

4.9 Single soil parameter assessment

An automatic single soil parameter assessment for all sampled soil horizons is available in SOLGRAPH. Results of this assessment can be viewed on screen or sent to a printer. The results are given in tabular form and an example of a profile in Mali is given in Table 1. In most cases, 5 quantitative classes are used: very low, low, medium, high and very high. Criteria for these classes are given in Appendix 3. The single soil parameter assessment is available for the following characteristics:

ECe	Electrical Conductivity (m Siemens cm^{-1})
pH-H_2O	Soil reaction in a 1:2.5 soil-water extract
CEC	Cation Exchange Capacity, buffered at pH 7 ($cmol_c$ kg^{-1} soil)
	Base Saturation (%)
	Sum of exchangeable cations Ca, Mg, K and Na ($cmol_c$ kg^{-1} soil)
	Exchangeable Aluminium (%)

	Organic Carbon (%)
	Total Nitrogen (%)
C/N	Carbon - Nitrogen ratio
	Exchangeable Sodium Percentage for soil structure
	Exchangeable Sodium Percentage for crops
	Air capacity, Φ (pF0-pF2) (%)
	Available moisture Φ (pF2-pF4.2) (%)
	Bulk density (kg dm^{-3})
	Textural class (FAO,1992).

The criteria for the 5 classes were developed to suit the interpretation of ISRIC's collection of soil profiles. Major sources consulted for these criteria were Landon (1991) and ILACO (1981). Additional information on the single soil parameter assessment is given ISRIC (in prep.).

Table 1 Single parameter ratings of soil profile ML 1

Hori-zon	Depth	ECe	pH-H_2O	CEC	Base Saturation	Sum of Bases	Exchangeable Aluminium
0		Very Low	Neutral	Low	Very High	Medium	Very Low
1		Very Low	Slightly Acid	Low	High	Medium	Very Low
2		Very Low	Slightly Acid	Low	High	Medium	Very Low
3		Very Low	Slightly Acid	Low	High	Medium	Very Low
4		Very Low	Neutral	Low	Very High	High	Very Low
5		Very Low	Neutral	Low	Very High	Medium	Very Low
6		Very Low	Neutral	Low	Very High	Medium	Very Low
7		Very Low	Neutral	Low	High	Medium	Very Low
8		Very Low	Slightly Acid	Low	High	Medium	Very Low
9		Very Low	Neutral	Low	Very High	High	Very Low

Hori-zon	Depth	Organic Carbon	Total Nitrogen	C/N	ESP Soil Structure	ESP Crops
0		Very Low	No data	-	Very Low	Very Low
1		Very Low	No data	-	Very Low	Very Low
2		Very Low	No data	-	Very Low	Very Low
3		Very Low	No data	-	Very Low	Very Low
4		Very Low	No data	-	Very Low	Very Low
5		Very Low	No data	-	Very Low	Very Low
6		Very Low	No data	-	Very Low	Very Low
7		Very Low	No data	-	Very Low	Very Low
8		Very Low	No data	-	Very Low	Very Low
9		Very Low	No data	-	Very Low	Very Low

Hori-zon	Depth	Air capacity (pF 0 - pF 2)	Moisture Availability (pF2 - pF4.2)	Bulk Density	Textural Class
0		Medium	High	Medium	silt loam
1		No data	No data	No data	silty clay
2		Medium	High	Medium	silty clay
3		No data	No data	No data	silty clay
4		Low	Medium	Medium	silty clay
5		No data	No data	No data	silty clay loam
6		No data	No data	No data	silty clay loam
7		No data	No data	No data	clay loam
8		No data	No data	No data	silty clay loam
9		No data	No data	No data	clay loam

Note: if message "can not classify" appears, the sum of the clay, silt and sand fractions is not 100%

4.10 Linear regression diagram

There are a large number of powerful statistical programs available, and SOLGRAPH was originally not meant to include statistical facilities. However, the linear regression for two parameters was included as it is frequently used in soil science. In addition, the calculation of CEC clay and organic carbon is given (see paragraph 4.11).
The statistical equation for the linear regression is: $y = a \times + b$. The resulting graph shows the scatter of observations allowing a visual interpretation whether a linear regression method is suitable. When non-linear methods are needed, it is recommended to use other statistical packages.

In Figure 12 the linear regression of Sum of Bases and the pH-H_2O of profile BRA11 is given.

Spreadsheet information
- Lotus macros are located in cell range K4 to R8.
- The spreadsheet data are located in row A1 to F3 and downward.
- Regression is located in K15 to L20, X and Y data in cell range E1 and F1 downward.

4.11 CEC as function of Clay and Organic Carbon content diagram

This application offers an automatic calculation of the Cation Exchange Capacity (CEC) of the clay and organic carbon components. The method was developed by Bennema in Brazil (FAO, 1966).
The assumptions on which the procedure is based are:
- the Cation Exchange Capacity of the clay fraction is similar throughout the profile
- the cation exchange capacity of the soil organic carbon fraction is similar throughout the profile.

In summary, the calculation procedure involves the following steps:

1. Calculation of the Organic Carbon and CEC data from content per 100 g soil to content per 100 g clay indicated in the graph as CEC (per 100 g clay) and Organic Carbon (per 100 g clay). See note below.
2. Determination of the linear regression of the CEC and Organic Carbon (per 100 g clay).
3. Judgement whether the linear regression is applicable.
4. Determination of CEC of 100g clay and CEC of 1g Organic Carbon (in the graph or from the equation).

Note:

Analytical data are generally expressed as quantity per 100 g soil. In the recalculation procedure, quantities of organic carbon and CEC (per 100 g soil) are recalculated to quantities per portion of soil containing 100 g clay.

An example of a CEC, clay and organic carbon diagram is given in Figure 13. The resulting CEC-clay and CEC-organic carbon are an estimate of the Cation Exchange Capacity of the two soil components. The method generally gives good results for very deep homogeneous soils such as Ferralsols (Oxisols), Acrisols and Lixisols (Ultisols). In soils where the assumptions are not valid, e.g. shallow soils and heterogeneous soils, there is no satisfactory outcome. This can be deduced from the graph which then will show a large scatter and a poor fit.

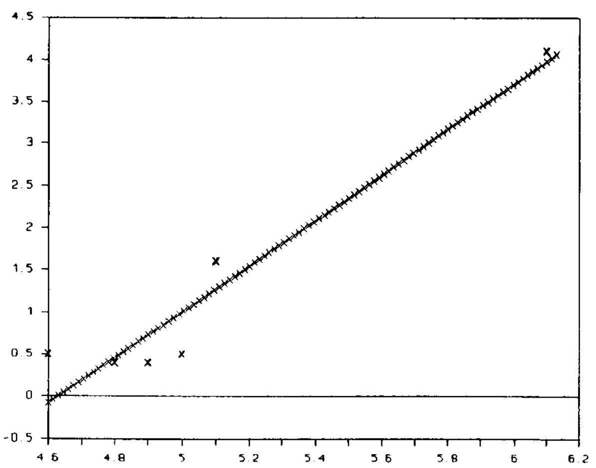

Fig. 12 Relation between the sum of bases and the pH-H_2O of soil BR 11

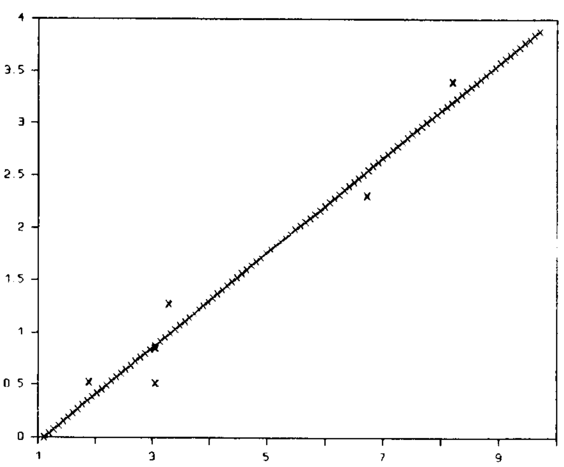

Fig. 13 Linear relation between CEC clay and organic carbon of soil profile BR 3

Spreadsheet information

- Lotus macros are located in cell range K4 to L13.
- The spreadsheet data are located in row A1 to I9.
- Regression calculations are located in A14 to M23, with X and Y data in cell range O16 to P124.

The regression equation, the number of observation, r^2 and other regression statistics are presented in the spreadsheet, just below the data series. See Figure 14

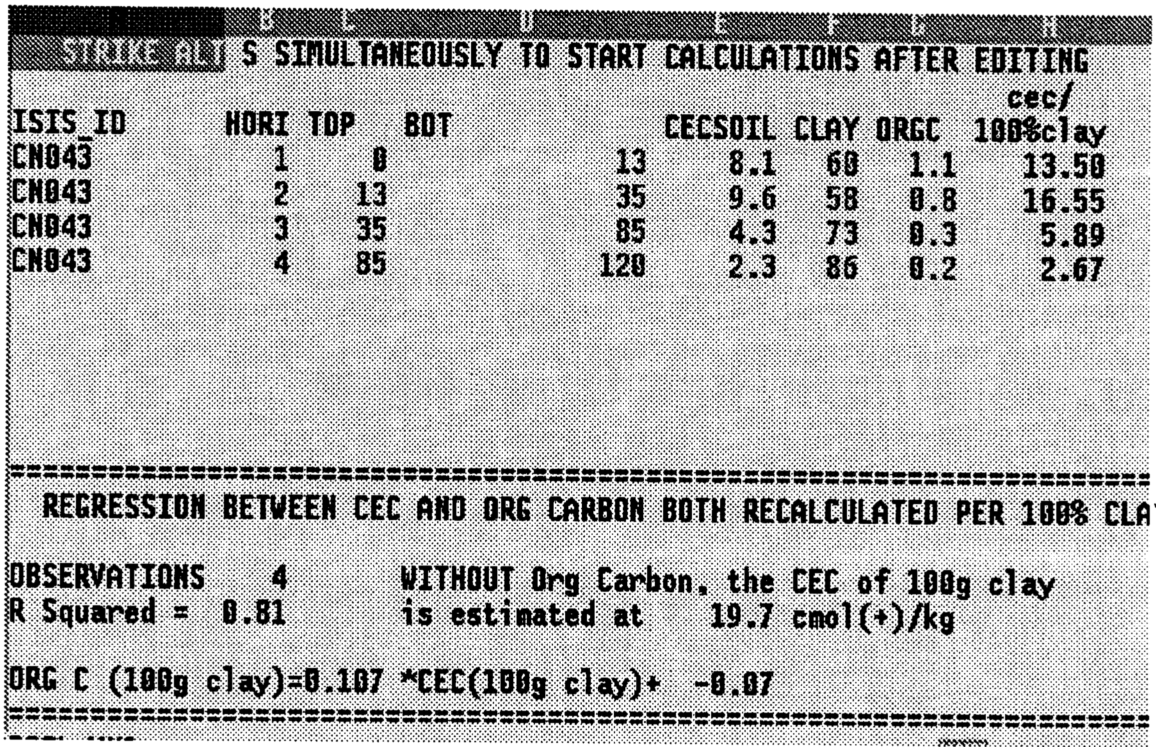

Fig. 14 Spreadsheet window of CEC as function of clay and organic carbon content.

The results of CEC per 100 g clay is given in the spreadsheet (lower right corner of Figure 14). The results of CEC per 1 g organic carbon is obtained from the slope of the line.

4.12 Others / Exit

In the lower right part of the SOLGRAPH main menu, three options can be chosen.
The option L ("Log file") displays all options which were chosen for the main selection menu during the SOLGRAPH session. Press <ESC> to return to the Main Menu.

The option M ("Reindex") can be chosen if data were edited in (or appended to) the data files, without using the ISIS program.

Finally you Exit the dBase module by striking X and will be asked if you want to continue with SOLGRAPH.

REFERENCES

ILACO (1981). Compendium for agricultural development in the tropics and subtropics. Elsevier Scientific Publishing Company.

FAO (1966). Classification of Brazilian soils, Appendix 2. Report to the Government of Brazil. Nr. EPTA 2197. (Available at CNPS-EMBRAPA, Rio de Janeiro, FAO, Rome and ISRIC, Wageningen)

FAO (1992). Guidelines for Profile Description, 2nd edition. FAO, Rome

ISRIC (in prep.). A rapid assessment of soil/land qualities to identify major stress factors. ISRIC Working Paper and Preprint.

Landon, J.R. (1991). Booker tropical soil manual: a handbook for soil survey and agricultural land evaluation in the tropics and subtropics. Longman, Harlow.

Lotus (1990). Manual, Release 3.1

Meijer E.L. (1989). Plotting triangular diagrams in Symphony. Internal document. Soil Science and Geology Department, Wageningen Agricultural University.

APPENDIX 1 List of SOLGRAPH files

Utility	dBase PRG files	Spreadsheet files
Main module	SOLMENU.PRG	AUTO123.WK1
Texture Triangle	TRIANGLE.PRG	TRIANGLE.WK1, TRIANGLE.WKS
Sand Silt Clay	SASICLAY.PRG	PARTSIZE.WK1 PARTSIZE.WKS
Sum of Bases, pH-H_20, pH-KCl and Organic Carbon	CEC.PRG	SUMBASES.WK1 CEC.WKS
Other parameters	CHEMPHYS.PRG SOILPHYS.PRG SOILCHEM.PRG SOLDEPTH.PRG	SOILDEPT.WK1 SOILDEPT.WKS
Soil moisture retention curves	PF-CURVE.PRG	PF_CURVE.WK1 PF_CURVE.WKS
Multi Profiles Option	MULTIPRO.PRG	MULTIPRO.WK1 MULTIPRO.WKS PROFILES.WKS NUMBER.WKS
Precipitation and Evapotranspiration diagram	PRECIPIT.PRG	PRECIPIT.WK1 PRECIPIT.WKS CODE.WKS
Temperature Diagram	TEMPERAT.PRG	TEMPERAT.WK1 AVGTEMP.WKS MAXTEMP.WKS MINTEMP.WKS CODE.WKS
Single Soil Parameter Assessment	SINGRAT.PRG TEXTURE.PRG	
Linear Regression	CHEMPHYS.PRG SOILPHYS.PRG SOILCHEM.PRG SOLDEPTH.PRG	REGRES.WK1 REGRES.WKS
CEC as function of Clay and Organic Carbon	CECORGCL.PRG	CECORGCL.WK1 CECORGCL.WKS
System Information	REINDEX.PRG LOGFILE.PRG	

Data and other files

123CLIM.DBF	TEMPCHEM.DBF	CLSTCODE.NDX
AVGTEMP.DBF	TEMPPHYS.DBF	CHEMCODE.NDX
CLIMDATA.DBF	TEMPCHPH.DBF	MORCODE.NDX
CLIMSTAT.DBF	ISISPHYS.DBF	PHYSCODE.NDX
CODE.DBF	ISISSITE.DBF	TEMP2.NDX
ISISCHEM.DBF	CHEMPHYS.DBF	SOLGRAPH.BAT
MAXTEMP.DBF	WHATDONE.DBF	ASK.EXE
MINTEMP.DBF	MULTIPRO.DBF	PRINTER.PRG
ISISCLST.DBF	NUMBER.DBF	REINDEX.PRG
ISISMORP.DBF	PROFILES.DBF	CONTINUE.PRG
		KOP.PRG

APPENDIX 2 Dictionary of required soil and climate data files

Field names and structure of the ISISPHYS.DBF dBase file containing physical parameters

Field Name	Type	Description
CODE	Character	Profile Code
TYPE	Character	Horizon Number
TOP	Numeric	Top of Horizon (cm)
BOTTOM	Numeric	Bottom of Horizon (cm)
GRAVEL	Numeric	Gravel %
S1	Numeric	Sand 2000-1000μ %
S2	Numeric	Sand 1000-500μ %
S3	Numeric	Sand 500-250μ %
S4	Numeric	Sand 250-100μ %
S5	Numeric	Sand 100-50μ %
TSA	Numeric	Total Sand %
SI1	Numeric	Silt 50-20μ %
SI2	Numeric	Silt 20-2μ %
TSI	Numeric	Total Silt %
CLAY	Numeric	Clay %
DISPCL	Numeric	water-dispers. clay %
BULK	Numeric	Bulk Density
PF0	Numeric	pF0
PF1	Numeric	pF1
PF15	Numeric	pF1.5
PF2	Numeric	pF2
PF23	Numeric	pF2.3
PF27	Numeric	pF2.7
PF34	Numeric	pF3.4
PF42	Numeric	pF4.2
SPECS	Numeric	Specific Surface

Field names and structure of the ISISCHEM.DBF dBase file containing chemical parameters

Field Name	Type	Description
CODE	Character	Profile Code
TYPE	Character	Horizon Number (cm)
TOP	Numeric	Top of Horizon (cm)
BOT	Numeric	Bottom of Horizon (cm)
PHH2O	Numeric	pH-water
PHKCL	Numeric	pH-KCl
CACO3	Numeric	$CaCO_3$ %
ORGC	Numeric	Organic Carbon %
ORGN	Numeric	Organic Nitrogen %
CA	Numeric	Exch. Ca ($cmol_c kg^{-1}$ soil)
MG	Numeric	Exch. Mg ($cmol_c kg^{-1}$ soil)
K	Numeric	Exch. K ($cmol_c kg^{-1}$ soil)
NA	Numeric	Exch. Na ($cmol_c kg^{-1}$ soil)
SUM	Numeric	Sum of Bases
EXACID	Numeric	Exch. Acidity ($cmol_c kg^{-1}$ soil)
EXAL	Numeric	Exch. Aluminium ($cmolckg^{-1}$ soil)
CECSOIL	Numeric	CEC Soil ($cmol_c kg^{-1}$ soil)
CECCLAY	Numeric	CEC Clay ($cmol_c kg^{-1}$ soil)
CECORG	Numeric	CEC Org. matter ($cmol_c kg^{-1}$ soil)
ECEC	Numeric	Effective CEC ($cmol_c kg^{-1}$ soil)
BS	Numeric	Base Saturation %
ALS	Numeric	Aluminium Saturation %
EC	Numeric	Electrical Conductivity

Field names and structure of the CLIMDATA.DBF dBase file containing climatological data

Field name	Type	Description
STATCODE	Character	Meteo Station Code
TYPE	Character	Type of Data
YEAR	Character	Year of recording data
ANNUAL	Numeric	Annual Data
JAN	Numeric	January Data
FEB	Numeric	February Data
MAR	Numeric	March Data
APR	Numeric	April Data
MAY	Numeric	May Data
JUN	Numeric	June Data
JUL	Numeric	July Data
AUG	Numeric	August Data
SEP	Numeric	September Data
OCT	Numeric	October Data
NOV	Numeric	November Data
DEC	Numeric	December Data

The fieldname "Type" registers the type of numeric data stored in the other fields. "Type" should be as follows:

T for mean temperature in degrees C
Ti for minimum temperature in degrees C
Ta for maximum temperature in degrees C
P precipitation in mm
E potential evapotranspiration in mm

Field names and structure of the CLIMSTAT.DBF dBase file containing Meteorological Stations

Field name	Type	Description
STATCODE	Character	Station Code
STATION	Character	Station Name
COUNTRY	Character	Country

Fieldnames and structure of ISISSITE.DBF

Fieldname	Type	Description
CODE	Character	Profile Code
SODE	Character	Soil Depth Class
STON	Character	Stoniness Class
SLP	Character	Slope Class

Fieldnames and structure of ISISMORP.DBF

Fieldname	Type	Description
CODE	Character	Profile Code
TYPE	Character	Horizon Number
TOP	Character	Top of Horizon (cm)
BOT	Character	Bottom of Horizon (cm)
CONM	Character	Consistency (when moist)
FORM	Character	

APPENDIX 3 Criteria for the single soil parameter assessment

Organic Carbon (%)

<	0.4	very low
0.5 -	0.9	low
1.0 -	1.9	medium
2.0 -	5.0	high
>	5.0	very high

Sum of exchangeable bases
[Ca+Mg+K+Na] (cmol$_c$ kg^{-1} soil)

<	1	very low
1 -	3.9	low
4 -	7.9	medium
8 -	15.9	high
>	16	very high

Bulk density (kg dm^{-3})

<	0.9	very low
0.9 -	1.1	low
1.1 -	1.4	medium
1.4 -	1.6	high
>	1.6	very high

Soil Acidity (pH-H_2O)

<	4.0	extremely acid
4.0 -	4.9	strongly acid
5.0 -	5.4	acid
5.5 -	5.9	slightly acid
6.0 -	7.5	neutral
7.6 -	8.4	slightly alkaline
8.5 -	9.4	alkaline
>	9.5	strongly alkaline

Base saturation
[CEC pH7] (%)

>	80	very high
50 -	79	high
30 -	49	medium
10 -	29	low
<	10	very low

Air capacity Φ
[pF0 - pF2] (%)

<	5	very low
5 -	10	low
10 -	15	medium
15 -	20	high
>	20	very high

CEC [pH7] (cmol$_c$ kg^{-1} soil)

<	4	very low
4 -	9.9	low
10 -	19.9	medium
20 -	39.9	high
>	40	very high

Exchangeable aluminium
[CEC pH7] (%)

<	5	very low
10 -	24	low
25 -	49	moderate
50 -	79	high
>	80	very high

Moisture availability
Φ[pF2 - pF4.2] (%)

<	5	very low
5 -	10	low
10 -	15	medium
15 -	20	high
>	20	very high