AGENCY FOR INTERNATIONAL DEVELOPMENT
WASHINGTON, D. C. 20523

BIBLIOGRAPHIC INPUT SHEET

FOR AID USE ONLY

1. SUBJECT CLASSIFICATION

A. PRIMARY: Agriculture — AF25-0000-0000

B. SECONDARY: Soil fertility,fertilizers,and plant nutrition

2. TITLE AND SUBTITLE

Systematic forms for manual or mechanized data collection processing and reporting for use in soil fertility evaluation and improvement programs

3. AUTHOR(S)

Waugh,D.L.; Cate,R.B.

4. DOCUMENT DATE	5. NUMBER OF PAGES	6. ARC NUMBER
1968	17p.	ARC 631.42072.W354

7. REFERENCE ORGANIZATION NAME AND ADDRESS

N.C.State

8. SUPPLEMENTARY NOTES *(Sponsoring Organization, Publishers, Availability)*

(In Prelim.rpt.no.2)

9. ABSTRACT

10. CONTROL NUMBER	11. PRICE OF DOCUMENT
PN-RAA-434	
12. DESCRIPTORS	**13. PROJECT NUMBER**
Data processing Forms	
	14. CONTRACT NUMBER
	CSD-287 Res.
	15. TYPE OF DOCUMENT

AID 590-1 (4-74)

8

PAM

AID/csd-287
Agr. N

DECEMBER 1968

INTERNATIONAL SOIL FERTILITY
EVALUATION & IMPROVEMENT SERIES

PRELIMINARY REPORT NO. 2

SYSTEMATIC FORMS
FOR
MANUAL OR MECHANIZED DATA COLLECTION PROCESSING AND REPORTING FOR USE IN SOIL FERTILITY EVALUATION AND IMPROVEMENT PROGRAMS

DONOVAN L. WAUGH AND ROBERT B. CATE, JR.

CONTRACT AID/csd-287
NORTH CAROLINA STATE UNIVERSITY
RALEIGH

SYSTEMATIC FORMS FOR MANUAL OR MECHANIZED DATA COLLECTION PROCESSING AND REPORTING FOR USE IN SOIL FERTILITY EVALUATION AND IMPROVEMENT PROGRAMS

Donovan L. Waugh[1/] and Robert B. Cate, Jr.[2/]

As the number of soil samples being analyzed by a soil fertility evaluation and improvement program becomes larger and larger, it becomes increasingly important that efficient techniques be employed to process the data. Computer data processing techniques are currently being employed by a number of soil fertility evaluation programs, and many schemes have been tried in the past few years. In general, modern computer data processing is employed for two main purposes or phases of the program: (1) Summarization of soil fertility evaluation data and simple correlation work, and (2) Computation of fertilizer and lime recommendations based on soil analyses with simultaneous or subsequent printing of the soil fertility evaluation report. Phase (1), summarization of soil fertility evaluation data, is very straight forward and is actually within the scope of every soil fertility evaluation and improvement program since data which are collected on the proper forms can readily be forwarded to a computer center for processing. Even the more sophisticated phase (2), computations of fertilizer and lime recommendations and report printing, should strongly be considered as soon as computer equipment becomes operative in the vicinity of the laboratory. Of course, the time spent in organizing and implementing the proper forms for a suitable computer data processing program is very worthwhile.

Two approaches to computer processing are in pilot study status in South America under the guidance of a North Carolina/AID Contract, International

1/ Regional Director (Bolivia, Ecuador, Peru), International Soil Fertility Evaluation and Improvement Program.
2/ Regional Director (Brazil), International Soil Fertility Evaluation and Improvement Program.

Soil Fertility Evaluation and Improvement. Both of these approaches provide a means for organizing the data for phase (1) summarization and for phase (2) computation and printout of results and recommendations. The distinction between the two approaches involves nothing more than the mechanics of collecting the data to be punched on computer cards. The card punching and the data processing (summary and soil test reports) are the same for each system. The actual "program," that is the operational manipulations of the input information and resultant computations and report printout, are subject to and determined by the kind of computer employed as well as the specific end product desired. Such information cannot conveniently be covered in the scope of this preliminary report. However, it is essential that step-by-step handling of input information be well organized and that the design of data collection and report forms be well in mind before such programming begins. This report has been prepared as an aid in such initial planning and organizing, and either of the approaches outlined could be used as a guide for soil fertility evaluation programs in preparing for mechanized data processing. It is noteworthy that systems such as these will usually improve the efficiency of manual data processing within the labs as well as provide a means for mechanized computer processing.

The General Laboratory Approach

The simplest kind of data collection forms (as those currently employed by the IPEANE Laboratory in Recife, Brazil) are shown in Figure 1. These forms are especially well suited to laboratories which receive most of their samples from the individual farmer, the fertilizer dealer or company. In this case, the

DATA COLLECTION SHEET NO. 1 - Information required for identification and for printing recommendations for fertilizer and other amendments on a soil fertility evaluation report form.

PROJECT CODE	COUNTRY	LABORATORY	SAMPLE NO.	DATE			FARMERS SAMPLE IDENTIFICATION	FARMER'S NAME	FARMER'S ADDRESS BOX NO.	DISTRICT/TOWN	COUNTRY MUNICIPALITY	STATE/PROVINCE	SOURCE of SAMPLE
				MONTH	YEAR								
1	2	3	4	5	6	7	8	9	10	11	12	13	14

DATA COLLECTION SHEET NO. 2 - Laboratory analyses and more specific information regarding the origin of the sample.

PROJECT CODE	COUNTRY	LABORATORY	SAMPLE NO.	DATE			LABORATORY DATA													BLANK		CROP	SOIL ASSOCIATION
				MONTH	YEAR		N	P (ppm)	K (ppm)	pH	Ca	Mg	Ca+Mg	Al	O.M. %	ELECTRICAL INDUCTIVITY mhos/cm	COLOR	TEXTURE					
											me/100cc Soil												
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24

NOTE: The column numbers in Figure 1 and Figure 2 do not always coincide. This is because the specialized form in Figure 2 required some rearrangement for consistency of order with the remainder of the procedure.

FIGURE 1. Forms of a type suitable for collection of soil sample data which can be transferred to computer punch cards for processing

information concerning the soil sample is usually recorded on the sample box and/or a separate questionnaire which accompanies the sample to the laboratory. The information required for identification and for printing recommendations for fertilizer and other amendments on a soil fertility evaluation report form is placed on Data Collection Sheet No. 1 as shown in Figure 1. The laboratory analyses and more specific information regarding the origin of the sample are placed on Data Collection Sheet No. 2 shown in Figure 1. All information is transferred to these sheets from the sample box (or questionnaire) when it is checked into the lab and from the laboratory result sheets following the analyses. Coding is used where needed. One computer card is punched for each sample using the data from one line of the Data Collection Sheet No. 1, and another computer card is punched using the data from the Data Collection Sheet No. 2. Then, one or more copies of the report form (Figure 4) can be printed out by computer using the computer cards or can be typed out manually using the information from the two data collection sheets. Summarization of soil test data is accomplished entirely from the information on the Data Collection Sheet No. 2, Figure 1. If the data sheets shown in Figure 1 are printed with 33 horizontal lines, space is sufficient for three sets of ten samples with one line for the control sample in each set. (Computer summarization of control sample results can be useful.)

One advantage of this approach is the ease of recording and key punching the entries which are constant for a group of samples received from the same individual. (Once the entry is made on a line, the corresponding subsequent lines can be left blank on the data collection sheet, and the key punch

operator can repeat the original information.) Also, the data collection sheets provide a compact means of filing all data for future reference.

The Internally Coordinated Field Office/Central Laboratory Approach

In those cases where a soil fertility evaluation program is controlled on a national, a regional, or an organizational basis, and is operated as a coordinated system between a number of outlying field offices and a central laboratory, it is advantageous to employ an internal control approach for the shipping and receiving of soil samples as well as the collection of the soil analysis data. In this system, the field office acts as a collecting station for the soil samples and the accompanying information. The field office then sends the soil samples and information by groups to the laboratory for analysis and for partial recommendations. The importance of transporting the samples to the laboratory and getting the results back to the field office as rapidly as possible makes it highly desirable to incorporate a shipment control scheme into this system. In many parts of the world, a direct freight shipment (air or land) is faster and less expensive than government mail service; and the approach presented here is designed to take advantage of this fact for shipment of both soil samples to the laboratory and the somewhat bulky report forms (along with new sample cartons) back to the field office. Shipment is probably best accomplished with special boxes designed to accommodate a group of samples together; for example, ten samples.

The National Soil Testing Service of Peru, operated within SIPA of the Ministry of Agriculture, has coordinated 150 extension offices with the

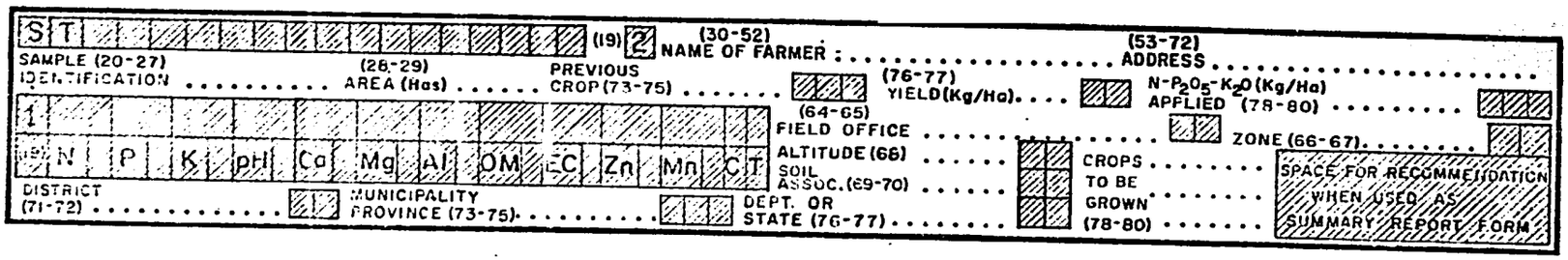
laboratory center at La Molina to form a field office/central laboratory system. Shipment control and data collection worksheets are made up by inserting the desired number (i. e., ten--if samples are shipped in groups of ten) of data collection blocks as shown in Figure 2 into the designated area of the shipping control form as shown in Figure 3. The resulting worksheet serves to accomplish the following interrelated goals and functions.

1. Control of Shipment of Samples to the Laboratory

Soil samples are collected by the field office, and the information concerning the sample (which has been recorded on the sample box) is entered in the white spaces of the data collection blocks (Figure 2). One sample is recorded per block until all the blocks on the shipment control and data collection worksheets are used.

The appropriate spaces of the shipment control portion of the worksheet are then filled in (the dispatch number is simply a coded number which identifies the field office and the shipment number).

Triplicate copies of the worksheet are made, the original of which is mailed immediately to the laboratory. The second copy is packaged inside the multiple sample shipping carton, and the samples are dispatched to the laboratory by the most rapid and reliable method. The third copy is retained by the field office until the analytical results and recommendations are returned. With this system, if the samples are lost or misplaced in shipment, the mailed copy of the worksheet informs the laboratory that the samples have been sent and provides information for locating them.



NOTES: (1) All information for the white spaces is filled in at the field office; whereas the information for the shaded spaces, including the coding of the field office information is filled in at the central laboratory. The information in one collection block pertains to one sample. As many of these units as desired may be inserted in the space indicated on the shipment control form shown in Figure 3 to make up the shipment control and data collection work sheet. These work sheets serve as the laboratory work copy, the file copy, the summary report form, and the accounting control copy.

(2) Information for punching the first eighteen columns of the computer card of both Card #1 and Card #2 is obtained from shaded spaces in the upper left hand corner. Card #2 continues with the information on the lines immediately under and to the right according to column number. Card #1 continues with the soil analyses and then with the remaining information on the lower half according to column number.

FIGURE 2. The data collection block portion of the shipment control and data worksheet suitable for computer processing in conjunction with the field office/central laboratory system

CONTROL FOR SHIPMENT OF SAMPLES AND RESULTS ___

1. ORIGIN OF SAMPLES — FIELD OFFICE IN: / AGRARIAN ZONE: — OTHER:

2. RETURN RESULTS: SEND TO: ..... VIA TRANSPORT AGENCY: .....
OTHER: .....

DATA COLLECTION BLOCK UNITS (FIGURE 2) ARE INSERTED HERE

WHITE - TO LAB WITH LETTER
BLUE - TO LAB WITH SAMPLES
ROSE - COPY FOR FIELD OFFICE

ANALYSIS REQUESTED BY:		DISPATCH NO.	ZONE	AG.	NO.

SPACE FOR LAB OR PROGRAM IDENTIFICATION

TRANSPORT COMPANY

AIR	LAND	DISPATCH NO.	ZONE	AG.	NO.

PLACE OF ORIGIN: ..... DATE: .....

SENDER: .....

CONSIGNED TO: .....

DESTINATION: .....

NO. OF PARCELS	CONTENTS	WEIGHT (Kg)	COST PER Kg.	AMOUNT
.....	SOIL SAMPLES FOR ANALYSIS			
	RESULTS, RECOMMENDATIONS			
			TAXES	
			TOTAL	

CHARGE TO ACCOUNT OF:

..... SIGNATURE OF SENDER

..... AUTHORIZED BY - TRANSPORT COMPANY

DELIVERY RECEIPT

DISPATCH NO.	ZONE	AG.	NO.

FROM .....

TO .....

NO. OF PARCELS .....

RECEIVED .....

FIGURE 3. Shipping Control Form suitable for use in the Field Office/Central Laboratory System to facilitate smooth flow of samples to the laboratory and results back to the field office

2. Laboratory Worksheet

When the samples arrive at the laboratory, they are recorded, assigned a laboratory number, and analyzed. The analytical data is recorded in the data collection blocks of the worksheet which accompanied the samples. The necessary coding of the information received from the field office is done so that computer cards can be punched.

3. Computer Printout or Manual Processing

The data collection blocks contain all of the information needed for punching the two computer cards mentioned under the general laboratory approach. The desired number of copies of the soil fertility evaluation report form shown in Figure 4 can be prepared manually or by computer using the information from the blocks or the computer cards.

Figure 5 illustrates an additional portion of the soil fertility evaluation report form used in Peru for the field office/central laboratory system. In this system, the central laboratory makes a partial recommendation of the nutrients or soil amendments needed, and the field office makes the specific recommendation based on local conditions and information.

4. Control of Returning the Soil Fertility Evaluation Results to the Field Office

In Peru when the sample analysis is completed, another set of shipment control and data collection worksheets containing all of the information is made in triplicate. The original copy of this set of worksheets is mailed immediately to the field office. The other two copies are retained at the laboratory for use in summarizing the data and for processing the shipping accounts.

One copy of the soil fertility evaluation report form mentioned in item 3 above is retained by the laboratory and is filed under the heading of the field office from which the samples originated.

•RESULTS OF ANALYSIS

3	50	2.3	8.6	0.0	6.5	0.3	4.5	10.0		
P	K	Mg	Ca	Al	pH	E.C	Zn	Mn		
(ppm)	(ppm)	(m. e./100 g)				mmhos/cm	(ppm)	(ppm)		

•INTERPRETATION OF ANALYSES[2/]

	DANGER	SAFE
EXTRACT ACIDITY		XX
ALKALIN REACTIC		
SOIL SALINIT		XXX

	LOW	HIGH
PHOSPHORUS(	XX	
POTASSIUM (		
MAGNESIUM(M	XX	XXXXXXXXXXXX
CALCIUM (C	XXXX	XXXXXXXXXXXXXX
ZINC (Z	XXX	XXXXXXXXXXXXX
MANGANESE(M	XXXX	XXXXXXXXXXXXXXXX

•RECOMMENDATIONS

1/ Modified from Color-Bar-Graph report form presented by Pennsylvania State University at the ASA Meetings in Washington, D. C. 1967.

2/ Interpretation of results based on analytical methodology and critical levels employed by National Soil Testing Service (SIPA) in Peru.

FIGURE 4. Model of soil test report form with the recommended uniform units for reporting results of analyses and the Color-Bar-Graph interpretation scheme. (The portion of the report involving fertilizer recommendations is shown in Figure 5.) 1/

	CROP 1			CROP 2			CROP 3		
LABORATORY RECOMMENDATIONS FOR LIME AND FERTILIZER IN CROP PROGRAMS									
LIME NEEDED (T/Ha)									
SPECIAL NUTRIENTS									
MAJOR NUTRIENTS NEEDED	N Kg/Ha	P_2O_5 Kg/Ha	K_2O Kg/Ha	N Kg/Ha	P_2O_5 Kg/Ha	K_2O Kg/Ha	N Kg/Ha	P_2O_5 Kg/Ha	K_2O Kg/Ha
MINIMUM									
MAXIMUM									

FIELD OFFICE ADAPTATION 2/

FERTILIZER RECOMMENDATION	AT OR BEFORE PLANTING TIME			
	SIDEDRESS OR TOPDRESS			

1/ Format employed by National Soil Testing Service (SIPA) in Peru.

2/ Field office adapts laboratory recommendations as follows: (a) Select minimum or maximum nutrient recommendation based on farm management in general; (b) Transpose nutrients into fertilizer grades and amounts according to supply available on market; (c) Indicate timing of application in accordance with crop grown, general cultural practices, and equipment to be employed.

FIGURE 5. Portion of the soil fertility evaluation report form involving recommendations for lime and nutrients by the central laboratory and for fertilizer grades, amounts, and timing of application by the field office. (The portion of the report for analytical results and interpretation is shown in Figure 4.) 1/

The remaining copies of the report form are packed inside a new multiple sample shipping box (which contains new sample cartons), and this is shipped to the field office by the most efficient way available. Upon arrival at the field office, one copy of the report form is given to the farmer, one copy is filed in the field office, and other copies may be given (upon request) to fertilizer company representatives, bank representatives, or others working with the farmer.

If the sample shipping box containing the report forms should be lost in transit, then the mailed copy of the worksheet can be used to trace the shipment. This worksheet also contains all of the analytical data and other information concerning the samples, and it could be used temporarily by the field office for making recommendations.

Processing Accounts

In Peru, a charge is made for the analysis of the soil samples. There are also certain costs for transportation of the samples to the laboratory and costs for the return of the results, the new shipping boxes, and the soil cartons to the field office. The remaining copies of the control and data collection worksheets are used to facilitate payment and balancing of these accounts.

The advantage of this system is that it provides a high degree of internal control of sample and report shipments. Loss of either samples or results (or even undue delay) will detract from the acceptance of the soil fertility evaluation and improvement program. Therefore, this approach is very important to the successful operation of the field office/central laboratory system.

Soil Test Report Forms

Considerable variability in the kinds of forms used for reporting soil analyses and for making suggestions on the use of fertilizers and other soil amendments

exists between laboratories. No doubt, some variation is desirable; but also some degree of uniformity will be advantageous in order to facilitate comparisons of data originating from different states, countries, or even continents.

A primary requisite of any report is that it be easy to read and interpret. Furthermore, from the standpoint of individual field records and from the standpoint of using soil test recommendations as a basis for fertilizer loans, it is advantageous to report results and recommendations of each soil sample on a separate report. W. W. Hinish, M. R. Heddleson, and D. E. Baker of Pennsylvania State College have introduced a red-green color-bar-graph scheme for interpretation of the data. The resulting report is attractive, easily read, and understood by laymen as well as soil technicians. Moreover, this type of approach to soil fertility evaluation reporting offers promise as an effective way of communicating to farmers in any areas where illiteracy is prominent since red is universally recognized as an unfavorable condition (or danger) and green recognized as a favorable condition (or safe zone).

A soil fertility evaluation report form based on color-bar-graph interpretation is presently being tested in Bolivia, Brazil, Ecuador, and Peru (Figure 4). Other countries cooperating with the North Carolina/AID Contract, International Soil Fertility Evaluation and Improvement Program, have indicated an interest in adopting at least the uniform units of reporting results of analysis and the color-bar-graph interpretation scheme. Beyond these basic components of the report, each laboratory can adjust the form to suit the particular needs and liking of that group.

Suggested Guide for Preparing the Color-Bar-Graph Report

The color-bar-graph report (Figure 4) is comprised of two main blocks: (1) the interpretation of the soil reaction and salinity, and (2) the interpretation of the nutrient status of the soil. The solid red zone indicates, for the first block, an acidity condition requiring lime or an alkaline reaction requiring acidification and/or a salinity condition requiring treatment. In the second block, the solid red zone indicates nutrient deficiency requiring corrective amounts of fertilization. The green zone in both blocks indicates a desirable operating range.

The following criteria are used to fill in the graphs:

Extractable Acidity, Alkaline Reaction, and Soil Salinity

1. If pH is 7.0 or lower, place "XXX" opposite the heading of "Extractable Acidity" as follows:

   XXX - in the red if a sufficient amount of aluminum or extractable acidity is reported that lime is being recommended.

   XXX - in the green if the amount of aluminum or extractable acidity indicates no need for lime at present.

   ___ - make no entry opposite "Alkaline Reaction" category.

2. If pH is 7.1 or greater, place "XXX" opposite "Alkaline Reaction" as follows:

   XXX - in the red if soil acidification is being recommended.

   XXX - in the green if no soil acidification is being recommended.

   ___ - make no entry opposite "Extractable Acidity."

3. If electrical conductivity indicates soil salinity and treatment is being recommended, place "XXX" in the red; if no special treatment is recommended, place "XXX" in the green.

NOTE: If a borderline case occurs in any of the above mentioned categories, "XXX" could be placed so as to straddle the separation between red and green. While this is not really a strict application of a normal bar-graph technique, it will serve as an indicator to the reader that treatment of the condition may or may not be warranted, depending on the various technical and managerial factors involved.

***

Soil Nutrient Status

1. If the status of the nutrient in question is below the critical level which indicates that there is a high probability of obtaining a large yield response (of sound economic proportions) to the added nutrient, the "X's" will appear in the red zone. These start on the left side and extend to the right side on a linear scale.

2. If the status of the nutrient indicates that there is a low probability of obtaining a large yield response to the added nutrient, the "X's" will extend into the green zone increasing to a maximum of about three times the critical level. It is recognized that in the green zone it is difficult to separate zones of significance. Therefore, the shading merely implies the extent to which the present nutrient status exceeds the critical level.

NOTE: The "Critical Level" referred to above is considered to be that as defined by Cate and Nelson (Technical Bulletin No. 1 of ISTP Series, N. C. State University, Raleigh. July 1965) and is the junction between the red and green zones.

Agronomic and economic considerations would be used to determine the desired nutrient status level to which the soil should be raised or at which it should be maintained. Fertilizer recommendations would be made accordingly.

***

Handling Fertilizer Recommendations in the Field Office/Central Laboratory Approach

The field office/central laboratory approach to soil analysis offers an additional advantage in that it provides for an especially effective way to interpret and make recommendations to farmers in areas where they need help in following the recommendations. Figure 5 shows the bottom half of the report form employed by SIPA in Peru. The central laboratory makes fertilizer recommendations in terms of nutrients (in the shaded area), giving a minimum-maximum range based on the guide sheets prepared through experimentation. The field representative (extension agent) then selects the part of the minimum-maximum range that best fits the farmer's program and management level, and he transposes the recommendations into fertilizer formulations which are available locally--indicating how and when to apply the fertilizer. Training field representatives to properly handle this important part of the soil testing program is essential, and this training assures the smooth operation of the program in the long run.