Nonconventional Communication of Field Trial Data*

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Much data has been lost and the value of professional cooperators has gone unappreciated because of inadequate reporting procedures. It is often difficult to separate the data from the conclusions in reports submitted from many cooperators in remote locations. Monsanto's new field trial data system provides weather conditions, field or host conditions, pretreatment preparation, method of treatment, data and detailed results, along with a subjective conclusion reached by the investigator.

The computer program not only provides brief summaries of the data, but also provides specialized arrays organized to permit the scientists at the source to apply their structure and activity knowledge of chemicals to explain the results and make projections for further experiments from the accumulated data of hundreds of field trials annually.

Input Data.—There has always been controversy about the value, validity, and vagaries of chemical test data obtained outside of direct research supervision. Microanalytical laboratories have battled against distrust and delays for years. Some chemists never seem to trust someone else's analysis—particularly if it does not check with their precious "theory."

Delays in shipments and in scheduling of the various tests to be run have caused other chemists to be do-it-yourselfers.

The same problems of the microanalyst are certainly to be found in large-scale field testing, but the problems of field trials are more extensive and more inclusive. There is little wonder that each competing product on television can advertise that "independent laboratory tests show our products to be best 8 out of 10 times." Field testing of potential pesticides by independent cooperators throughout the country yields a wide variety of conflicting conclusions.

Although there may be problems with conducting research outside the chemical laboratory, the problems dealt with in this paper (and in my opinion the more important problems) reflect the dilemma of the "in-house" people to ask the right questions and to evaluate the results.

Though we are concerned primarily here with the field trials of pesticides, these comments reflect experience in several other fields of applied chemistry. Discussion with people in the pharmaceutical industry shows the problem to be widespread in the evaluation of new drugs. Many of the pharmaceutical people have seriously discussed this problem of clinical testing and have agreed that the problems of what questions to ask or what tests to have run and the evaluation of results are becoming critical because of the narrowing limits of tolerance and the increasing statutory requirements.

Pesticide problems are rapidly becoming critical for similar reasons. In the past it was sufficient to have outside cooperators report on a broadened spectrum of activity of pesticides, and to supply subjective remarks about odor or irritation, and off-hand guesses about reasons for unexpected lack of activity. The answers were as deviate as the differences among cooperators.

Today much more specific data are necessary to evaluate the potential of a new chemical before deciding to introduce it to the agricultural pesticide market.

It has been over five years now since the CBCC (Chemical Biological Coordination Center) went out of existence. One of the technical reasons given for its demise was the tremendously large number of variations in test methods, hosts, and organisms found in the literature to evaluate potentially active biocides of one sort or another from antibiotics to insecticides.

Our studies of this problem at Monsanto over a period of years led us to adopt what appears to be a very commonplace solution. It consists of a very carefully designed one-page form and a computer-based data processing system to provide intelligent and rapid evaluation of chemicals. Although the drug houses and others have been using this approach, so far as we know, this is the first time this technique has been applied to pesticide-field evaluation. As a matter of fact, it has resulted in an unexpectedly large amount of favorable comment from our cooperators and much greater concern with results, greater respect, and confidence in our field trial data.

The particular form used by our outside cooperators in agriculture experiment stations and elsewhere for the field evaluation of experimental herbicides is shown in Fig. 1. The form has provided us with much more quantitative data than we were ever able to obtain before, and it has permitted us to make some correlations of chemical activity *vs.* field conditions among widely separated geographical locations that were heretofore impossible. We now know that one of our candidate compounds is temperature sensitive. The compound works well regardless of moisture; too high a temperature, however, causes a serious drop in herbicidal activity. This conclusion was obtained from a study of the computer output after the data from hundreds of tests were stored and processed into an output format designed for convenient study.

The important factors in designing your own field test data storage and retrieval system are input and output forms design. Great care is necessary in posing questions on the form and to the computer.

The input form, that is the form that is sent to the

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1. CP Number ____________
2. Date of Application __/__/__
3. Experimenter's Name ____________
4. Location ____________
5. Plot Size ____ Acres/____ Sq. Ft.
6. No. of Reps. ______
7. Spray Volume ______ Gal/A/___ Or
8. Pounds Granular/A ______
9. CODED COMMENTS (Check No More Than Three)
□ 1. Poor Drainage
□ 2. Steep Slope
□ 3. Not Plowed
■ 4. Stubble
□ 5. Very Dry
■ 6. Very Wet
■ 7. Trashy
■ 8. Fall Plowed
□ 9. Other *(List in Special Section)
■ 0. Furrow Irrigation
□ A. Overhead Irrigation □ D. Poor Stand
■ B. Sub Irrigation ■ E. Soil Compacted
□ C. Flood Irrigation □ F. Invalid Test
10. SOIL DATA (Check one each, A & B)
A TYPE
□ 1. Clay
□ 2. Sand
□ 3. Silt
■ 4. Loam
□ 5. Sandy Loam
□ 6. Sandy Clay
□ 7. Silt Loam
□ 8. Silty Clay
■ 9. Other *(List in Special Section)
□ 0. Clay Loam
■ A. Silty Clay Loam
■ B. Rock □ D. Sandy Clay Loam
■ C. Heavy Clay ■ E. Peats or Muck
B ORGANIC %
■ 1. 0–0.5
□ 2. 0.6–2.0
■ 3. 2.1–4.0
□ 4. 4.0
SOIL NAME FOR LOCATION ____________
R-287

11. FINAL TILLAGE BEFORE APPL. (CHECK NO MORE THAN TWO)
□ 1. Harrow □ 9. Other # (List in Special Section)
□ 2. Disk
■ 3. Cultivator
□ 4. Not Pertinent
12. SOIL SURFACE AT TREATMENT TIME (CHECK ONE OF EACH GROUP)
□ 1. Fine □ 1. Wet □ 1. Loose
□ 2. Medium □ 2. Medium □ 2. Medium
□ 3. Coarse □ 3. Dry □ 3. Compact
13. APPLICATION EQUIPMENT (Check One)
■ 1. Airplane ■ 5. (2) Plus Planter
□ 2. Boom Sprayer □ 6. (3) Plus Planter
□ 3. Boomless Sprayer □ 7. (4) Plus Planter
□ 4. Granular Applicator
WEATHER DATA AFTER APPLICATION (Check One)

	Wind-MPH Zero	1–5	6–14	15+
14. During Appl.	(0)	(1)	(2)	(3)
15. First Week	(0)	(1)	(2)	(3)

	Humidity - % 0-15	16-40	41-60	61-100
16. During Appl.	(0)	(1)	(2)	(3)
17. 1st Week	(0)	(1)	(2)	(3)

18. Days to 1st Significant Rain ____, Amt. ______
19. Days to 2nd Significant Rain ____, Amt. ______
20. Total Rain, 1st 3 weeks ____ inches
21. Temp. During Appl. ____°F
22. Av. Temp 1st Week Higher Lower Av.
23. Av. Temp 2nd Week Higher Lower Av.
24. Total Annual Rainfall ______ inches
SPECIAL SECTION
A. Extra Comments From Section/e.g. 9. 11. 10. 28.
B. % Weed Control Code
0–50 = 0 86–95 = 3
51–75 = 1 96–100 = 4
76–85 = 2
C. % Injury to Crops Code
0–5 = 0 31–100 = 3
6–15 = 1 Thinned = 4
16–30 = 2

TEST RESULTS
25. Date of Observation __/__/__
26. Good Enough For Commercial Use? Yes __, No __
27. Type Test (Check One)
□ 1. Preseed Surface □ 5. Post-Over-Top
□ 2. Preseed Incorp. □ 6. Post-Directed
□ 3. Postseed Surface □ 7. Post-Crop-Preseed
□ 4. Postseed Incorp. □ 8. Lay By – Preseed
28. Coded Comments (Check up to Four)
□ 1. Band Application
□ 2. Broadcast
□ 3. Invalid Test
□ 4. Defoliation
□ 5. Delayed Emergence
□ 6. Crop Stunting
□ 7. Chlorosis
□ 8. Malformation
□ 9. Other *(List in Special Section)
29. Formulation (Check One)
□ 1. Emul. Conc.
□ 2. Granular
□ 3. Wettable Powder
□ 4. Dust
□ 5. Solution Conc.
30. Rate Units (Check One)
□ 1. Pounds/Acre
□ 2. Pounds/100 Gal.
□ 3. ppm.
31. Sheet No. For This Date

% WEED CONTROL — WEED NAME	RATE (Use one column for each rate tested)

NOTE: SEE SPEC. SECTION FOR CODES TO USE IN EACH CELL OF TABLE ABOVE, AND BELOW

% CROP INJURY — CROP NAME	RATE (Use one column for each rate tested)

Fig. 1.—Field test data collection form in current use for herbicide testing by Monsanto.

cooperator, must be a single page. Multiple page forms are sure to fray tempers, particularly if any of the data are to be taken out-of-doors. Naturally, the principles of good forms design are to be taken into consideration such as: adequate, but not too much space for the answers, unambiguous questions, fortified by space for the unexpected reply, clear printing, and an ample supply for each investigator. Terminology must be familiar and should lead to unambiguous and easy transcription for data-processing machines. Currently we employ skilled Ph.D's. However, we believe that it is preferable to pay for great care in the encoding rather than to ask each of the cooperators to master a coding system.

The key point in designing the questions on the input form for the cooperators is to obtain from them as much significant raw data as are available. To ask them to submit subjective evaluations of the conditions under which the experiment is being conducted is to negate the value of such a system. For example, it adds nothing to the system to ask the cooperators whether there has been adequate or insufficient moisture. The measurement of the rainfall is the important data that is required. As we have observed so many times in the past when reviewing laboratory data, it is most important that the data itself be stored in a retrievable form rather than the conclusions derived therefrom.

So many times we have seen that conclusions, valid at a given point in time, change through the influence of additional information. On the other hand, the data taken at a time in the past do not change. Furthermore, the conditions under which the data are taken are of critical importance. It is our ultimate objective to bring together all of these data and examine them at a time in the future, and unless the conditions under which these data are taken are also recorded, and readily available, false conclusions can be arrived at simply because of varying experimental conditions.

For example, we have noticed that it makes a material difference in the response of a plant to a chemical whether the chemical was incorporated into the soil at the time of application or merely applied to the surface. Speculations as to the reason for the difference of data between incorporated treatment and surface treatment may be of considerable interest at various times in the life of an experimental compound. However, these are speculations and should not be incorporated into the store of raw data. It may be assumed at one point that the difference may be due to volatility; at a later time it may be found that it is solubility which caused the difference in activity.

A very important point is to obtain all of the data. This presents a serious problem in forms design, because under no circumstances should more than one page be involved in the collection of data. It is obviously important for that reason that great attention should be given to exactly what data are requested, and certainly no unnecessary data should be accumulated. Supposing that we know that it is critical to have some knowledge of the soil type involved in these tests; how much detailed information is required? It is on points of this nature that the very best advice obtainable should be employed.

Output of Data.—In requesting a computer programmer to prepare the output from thousands of pieces of data stored, it becomes important now to select the kinds of questions that are most meaningful. When most of the cooperators submit rave notices about a new compound, a critical evaluation of the data may not be called for. This compound is doing a good job, and deep study of the variations in the effect of temperature, soil, etc., may not be pertinent unless failures begin to occur.

The greatest use of the data comes from failures. And the next most important use is where a variety of cooperators cannot agree as to its utility. The key question then to be asked of the stored data is: Why did the chemical fail? The question becomes more operational for computer searching when it is recast in the following form: What were the experimental conditions that were most common in the cases of failure? At this time it becomes helpful to eliminate the cases of misapplication. We have found a number of cases where the application was contrary to those recommended. We were not particularly surprised to find that the chemical failed in these cases.

Our research and development personnel are most concerned, however, with discovering the conditions which contributed to the failure. Many times it is possible to change the structure of a chemical, or the formulation in which it is prepared, to circumvent the deleterious conditions. There are so many factors, however, that influence the activity of a chemical in agricultural use that it takes a communication system of this nature to pinpoint the particular condition involved in a chemical's failure.

The output of our computer system is in several forms. First of all, we have a complete listing in numerical order of all data submitted. The data in this listing are all in code and are not easily read for purposes of making correlations, but they do provide at a glance a means of evaluating specific data which come out in other forms. For example, one might be led to the conclusion that a chemical performed perfectly in 100% of the cases tried. A brief glance at the listing may show that it was only tried in one case. As mentioned earlier, the opposite conclusions may also be misleading. Where it is found that in most of the chemical failed, examination of the listing will show that it was tried under conditions which were not optimum for its use. This listing is most important for the use of critical scientific discrimination. The computer does not draw conclusions, it leads scientists to draw intelligent conclusions by presenting data in the most optimum form.

There are several other forms of computer output from this system. They all depend upon carefully designed questions by the technical experts from the laboratories, with the guidance of the computer programmer. Compounds are listed in decreasing order of their activity against specific pests. Obviously the first consideration is the degree of activity against certain specialized pests both as to the chemical's widespread activity and its selectivity. Here again, where differences among cooperators exist, special examination can be made of the conditions under which the experiments were run. Currently we have several other kinds of arrays of the same data coming from the machine on request.

The individual conclusions from the cooperators are not overlooked, however. Their scientific conclusions are of greatest concern. It will be noted on the form (Fig. 1) that there is a place for the conclusion of the cooperator. One of the most interesting computer programs is the one that suggests reasons why the cooperator arrived at the conclusions recorded. Plainly the machine can not make subjective evaluations of the men doing the scientific work. We have instructed the machine to examine the most likely reasons for a cooperator to vote either yes or no on an experimental compound. His reasons are most important to us, even though we may not agree with them.

Our latest venture in the field of research data storage and retrieval just described has been through one complete cycle from input through output. The second cycle is in process. Data are currently being keypunched for submission to the machine. We expect with two years of field testing data in the machine that we will be able to make a much more intelligent evaluation of our field test data than heretofore possible.

The results of our first cycle gave us information no one had suspected previously about why one of our candidate chemicals failed. When all the data was processed in the computer, it was found that this chemical worked very well at temperatures of 80° F. or above. As a result this temperature-sensitive compound is being field tested again another year.

In another case there was mixed response to all weather conditions and various soil types. When the data were arrayed with all failures in one list and all the successes in another by weather and soil types, we found that we had failures under two sets of conditions—wet clay and dry high organic.

The convenience and accuracy of having all the compiling and arranging into various arrays done by computer makes feasible a thorough study of the 80 pieces of data per test in addition to the many different plant species tested at several different rates. Such a critical, thorough analysis by any manual approach would just never be done. By this technique we have new knowledge, a pinpointing of problem areas, that permits concerted rather than a diffuse attack on compounds that are in an advanced stage of development.

Finally it must be observed that we have had excellent cooperation from the men in the field. Some have offered constructive comments on the form. Most of them have used the forms as requested. It is evident, since these people are cooperators, that only a certain amount of arm-twisting to use the form is possible. We feel that simply because there has been a large amount of cooperation that there is a large amount of enthusiastic acceptance of this type of field test data reporting.

There is one common theme in the work that we have done with data storage and retrieval of laboratory as well as field work. It is: a written report should be a timely document; the data are timeless. The report loses its value with time. Data may gain value with age only if they are accessible.