AIRGRAM

DEPARTMENT OF STATE

UNCLASSIFIED
CLASSIFICATION

ACTION COPY

-KS-
001.4
5782

Copy 1 of 1 copies
2

AGENCY FOR INTERNATIONAL DEVELOPMENT

1963 OCT 25 AM 9 53

CABLE & AIRGRAM BRANCH

DATE REC'D.

DATE SENT

TO:		ACTION	INFO
	AID/W	POAID A - 69	X
	Bangkok	USAID A - 6	X
	Djakarta	USAID A - 7	X
	Manila	USAID A - 8	X
	Phnom Penh	USAID A - 9	X
	Rangoon	USAID A - 10	X
	Saigon	USAID A - 11	X
	Taipei	USAID A - 20	X
	Vientiane	USAID A - 31	X

DISTRIBUTION
ACTION
FTEC
INFO.
FROR
FE
HRSD
Res
SRD
WC

75W
OTHER AGENCY
State
AGRIC
PC

21
PN-ABI-054
71777

FROM - SEOUL

SUBJECT - Lectures on Research Methodology by E. V. Staker

Before departing for home leave earlier this year, Dr. E. V. Staker, Agricultural Research Advisor, delivered a series of four lectures on research methodology to the then current class of Korean technicians at the CRD Training Center, Suwon. In his presentation, Dr. Staker undertook to lead his audience through a step-by-step exposition on sampling methods, site selection, materials control, record keeping and the various other elements of field plot research.

Although most of the illustrations in these lectures are drawn from the Korean scene, the principles set forth in them have universal application. In the belief that this material has potential value elsewhere, USOM/K is forwarding five copies of Dr. Staker's lecture notes to AID/W and one copy to each of the Far Eastern AID Missions. A limited reserve supply of this paper is available for others who may be interested.

no copies needed
Has been sent
to FE/VSTIDs

MEDGER

Attachments: a/s
5 - copies to AID/W forwarded to FTEC-FROR-HRSD
1 - to others

PAGE 1 OF PAGES 1

DRAFTED BY:	OFFICE	PHONE NO.	DATE	APPROVED BY:
[illegible]	RDD	2452	10/22/63	Joe L. Kotheral, Chief, RDD

AID AND OTHER CLEARANCES

A.I.D.
Reference Center
Room 1656 NS

UNCLASSIFIED
CLASSIFICATION

(Do not type below this line)

AID-5-36 5-62

ACTION OFFICE - When ACTION completed, return this copy to OFFICIAL FILE STATION or appropriate OFFICIAL FILE.

NO ACTION NECESSARY

DATE 10/28 SIGNATURE

PRINTED 5-62

AID-5-16 (5-62)

Research methodology.

KS
001.4 USOM/Korea.
S782 Research methodology. E.V. Staker. Oct. 1963.
44 p.

1. Research - ~~KS~~. 2. Sampling (statistics) - ~~KS.~~
I. Staker, E.V. II. Title

RESEARCH METHODOLOGY

I. Planning Research Projects

This lecture is the first in a series of four concerned with research methodology. The other three discuss the subject: field, plot techniques, record keeping, and the preparation of a research manuscript for publication, respectively. While we are going to examine all these subjects in some detail, it is our purpose to do so in simple language that you can all readily understand. Time will be reserved near the end of each lecture for questions so that any statements you didn't understand can be clarified. We may not know all the answers but we will do our best.

Perhaps before taking up the subject of planning research we should attempt to define research itself. According to Webster, and we quote, research is "studious inquiry or examination; specifically and usually, critical and exhaustive investigation or experimentation having for its aim the discovery of now facts and their correct interpretation, the revision of accepted conclusions, theories, or laws, in the light of newly discovered facts, or the practical applications of such new or revised conclusions". In Korea, specifically, and as far as you technicians who are working in agricultural research are concerned, perhaps we can simplify this definition by saying that research is the process by which one gets the answers to practical farm problems. For example, determining which of a number of barley varieties is the best for a farmer in a given area to grow. Or, the grade and quantity of fertilizer for a farmer living near Sosa to apply for rice. These are examples of what we call in English applied research and is the type that I am sure most of you are or should be engaged in.

Now that we know what research is, lets turn our attention to the matter of how research, to be effective, should be planned. It is just as important to properly plan research as it is to get the answers, or once these are known, to get the information into the hands of farmers. The reason is that unless careful plans are made you could end up with the wrong answer. So one of the important reasons for thoroughly planning a project is the fact that you are more likely to obtain the correct answer. In other words, you have taken into consideration the factors likely to affect the results and attempted to control all of them except those being evaluated.

Adequate planning also provides continuity to your research program since research is a continuing process. What you do this year often depends on the results you obtained previously or on the data some other person obtained.

With proper planning you also have in document form - on paper - a project outline defining in general terms your responsibilities. It also protects you in that it virtually insures that no persons other than those listed in the outline will be working on the project. It, therefore, prevents duplication.

We should now turn our attention to a discussion of the essentials for satisfactorily planning research. At the present level of agricultural development in Korea, it is necessary that officials and technicians emphasize applied rather than basic, fundamental research. There may be occasions, however, when a very limited amount of basic research is required before the answer to an applied research problem can be obtained. When this happens, the basic research should be carried out first.

Not only is it essential that emphasis be given to applied research but it should be directed toward solution of the most important local farm problems. In most cases, I believe you technicians have a good idea of what these problems are in your particular locality. But just to make sure you haven't inadvertently missed any, it would be an excellent idea to consult with officials of the Rural Guidance Section in your province. Another source of information would be the Guidance Bureau of ORD at Suwon. The most important source of all, however, is the farmer; you should never hesitate to ask him. If there are several important problems in your field, you may have to give them a priority listing assigning your resources, time and funds to the one or two that are most pressing. Work on the others might have to be delayed.

Another logical requirement for a research problem is that it be part of or at least directly related to some phase of the 5-year plan for agricultural development. Without this, it could be difficult to obtain and use necessary funds. This plan originated from many conferences of ROKG and USOM officials and is probably the best appraisal we have of the agricultural needs of Korea. As I understand it, the plan can be modified from year to year if desirable and in the interest of the Korean farmer to do so. So one should check the latest version of this plan.

One of the most important considerations in deciding on a research problem concerns the availability of needed equipment and supplies. Sometimes one must plan ahead for at least a year to insure that equipment, parts, supplies or even labor are ready when required. I would like to emphasize the phrase "when required" because timing can be most important. A soils chemist would not agree to studying the exchangeable potassium in soils representing a number of soil types unless he had access to a flame photometer and this instrument available when needed.

A chemist must also have all of the reagents necessary for any approved method he plans to use. Neither would an animal physiologist want to study phosphorus levels in the blood of hogs without some device, usually a colorimeter, for readily making the measurements. And speaking specifically of timing, I am sure some of you have had the experience of being ready to plant a crop yet you could not do so because the fertilizer required had not yet arrived! Many examples of deficiencies in timing could be given.

Laboratory equipment must also be in working order. With self-contained items like a Model G Beckman pH meter, lack of batteries for replacement can put one of these out of use for months at a time. If the batteries required are not available locally, the problem is even more serious.

A few laboratories at the provincial offices of rural development and some at the ORD experiment stations are handicapped because they have insufficient water and electricity. Efficient laboratory work requirs a 24-hour supply of these.

So if you are thinking of attacking a laboratory problem, careful consideration must be given to all the things you will need. Planning ahead may be the only answer in some cases.

We have just spoken of some of the problems a chemist may have. An agronomist, especially one working at a provincial office of rural development, may have problems even more serious. Often these stem from the lack of a suitable plot of land on which a field experiment can be established. The total area of land at most provincial offices of rural development is so small relatively in relation to needs that serious trouble is experienced in obtaining a suitable tract for experimental work. The

individual fields have been cultivated for many years, have been fertilized many times with different kinds and different amounts of fertilizer, without any notations having been made as to the field history of these areas. Therefore, none of these fields is likely to resemble an average field owned by a farmer as far as its fertility status is concerned. For the agronomist, a very difficult situation is thus presented which we should examine a bit further.

Le Clerg, Leonard and Clark, specialists on the subject of field plot techniques, have this to say: "Because of the increased demand for field trials on experiment station plot land, the question of the need for using former sites of concluded experiments becomes of paramount importance. It should be apparent that, where treatments of previous experiments did not have a differential effect on soil conditions, such a practice is not objectionable. However, fertilizer or crop rotation experiments do materially alter soil conditions. In these situations, the plan of procedure is not so simple and should be approached with a great deal of caution. Disregard of this source of additional variability is likely to increase the experimental error of the new experiment. Consequently, the experimenter is confronted with: (a) growing a uniform crop for several years on the land, or (b) use of some form of grouping of plots from different parts of the field and subsequent statistical evaluation of yield data of the new experiment".

Even if one could obtain a field at a provincial institute where soil heterogeneity was at a minimum, the chances are that the fertility level of the soil with respect to phosphorus and potassium would be appreciably higher than that of a farmer's field on the same soil type. If this is true, great care will have to be exercised in making recommendations to farmers based on the experimental results from an experiment established on that field.

Access to suitable field equipment in good repair is just as important to the agronomist as good laboratory equipment is to the chemist. Even the plow is included because it must turn the soil over at a uniform depth across the whole field. But the plow is only an example. All of the required items including dusters, sprayers and small hand tools should be in good operable condition.

Speaking of equipment, there is one item, namely, a small Clipper - type cleaner that should be available and used at every experiment station where tests with the cereal grains are being carried out. These can do a much better job than can be done by hand and in less time too. With a little care, there is no danger either of contaminating one grain sample with another. Unfortunately, there are only a few of these small grain cleaners in Korea. However, it would not be difficult to build them here.

Limited but competent technical assistance and labor must be planned for, too. Of course that includes their supervision.

Of considerable importance are the funds required for your project which must be requested and justified several months in advance when the budget for the year in which the money will be used is being formulated. Your estimates must cover your needs but should not be in excess of those needs.

Usually, any specific problem under consideration as a project should be one the answer to which can be obtained within a year or less. A feeding experiment with animals or a chemical laboratory type problem are good examples of this. It is to the advantage of everybody concerned to obtain the answers to research problems as quickly as possible. This is especially the case when the information to be obtained is urgently needed by the farmer. Incidentally, it also enables the research investigator to follow through quickly in writing up the results and possibly publishing them.

Finally, the most careful consideration should be given to the methods used for obtaining the answers to a research problem. The methods should be appropriate, up-to-date and should have either been used successfully by other research workers or shown in previous studies by the Korean investigator to be effective. If reliable and proven methods are not used, the research worker is likely to obtain data of a questionable nature that may not be the answer to the problem and certainly data he would not want to publish under his own name. If this situation occurs time, funds, and materials have been wasted and it may be difficult to get them to repeat the experiment a second time.

Having already discussed the essentials to be considered in planning research projects, we can now turn our attention to the project outline. This, as most of you already know is an official document which in a sense legalizes your project. Before your proposed project has been accepted, you must supply the information wanted on the outline, attach your own signature and obtain the signatures of other appropriate officials. These include your section chief, the Director of the Provincial Institute or Experiment Station Director, and if the Office of Rural Development at Suwon is supporting your project financially, the project must be approved by the chief, Research Bureau, ORD.

We need not enter into a discussion of the first page of the outline, except to say that the title should clearly indicate the nature of the investigation proposed yet should be brief like the title to a research publication. Unless there are questions, no comment will be made regarding the remaining headings on the first page.

On page 2, however, a fine opportunity is available to the project technician to describe the importance of his project and its objectives. By importance is meant the value of the data to be obtained to Korea and particularly to the Korean farmer. For example, will the information you expect to get assist in giving the farmer a better crop variety and in what way? Or, will the results from the experiment indicate how much potash a farmer should apply to rice to give the maximum economical yield response to this nutrient? Or, is it expected that the data at the end of the growing season will indicate economical methods the farmer can use for improvement of his pastures?

Under objectives, specific rather than general information is desired. For example, an objective might be to determine the relative yielding ability of ten rice varieties. On the other hand, if it is a chemistry experiment, the objectives could be (1) to determine the nitrogen content of the grain of 12 rice varieties grown in replicated plots and (2) to determine in this experiment which varieties vary significantly from the standard variety in total nitrogen content. If one has clear cut objectives, conducting the experimental work and evaluation of the data are much easier.

After one has clearly in mind the objectives to be reached, the next step is to find out what experiments, if any, were carried out previously in Korea or elsewhere on the subject to be investigated. This is the reason for the next heading in the project outline referred to as "Resume of Previous Investigations". This part of the outline is one of the most important and while only a summary of previous work is to be given, should indicate to the person reviewing your outline that you are thoroughly familiar with the results of previous investigations carried out in this field. This is especially true if it is the first time at your station for research to be conducted on this problem.

You should ask yourself the question: "Has any research carried out on this problem at our station in years previously?" If so, the results should be briefly summarized. Then, what about other experiment stations or colleges of agriculture in Korea? Have they published any papers on the subject? If so, what did they conclude? Next, have investigators in Japan attacked this problem? And finally, can you find any recent literature on the problem from other countries in the world? It is emphasized that the project outline is not the place for an exhaustive review of the literature on your problem. In fact, apart from Korea and Japan one could just reference in the papers on the subject.

Under "Method of Procedure" it is also not necessary to describe the methods to be used in detail. However, it should be made perfectly clear in general terms how you plan to attack the problem. For example, if your problem involved in part determination of the total nitrogen in wheat flour, it is only necessary to say that the determination of this constituent will be carried out using the A.O.A.C. Methods of Analysis, Ninth Edition, 1960, if that is the method you expect to use. Or, if you are determining the phosphorus c ntent of lespedeza leaves you might refer to the method of Fiske and Subbarow Jour, of Biol. Chem. 66: 375-400, 1925, as modified by P.R. Gast of the Harvard Forest. Other comments of a general nature as to how you expect to proceed should, of course, be included.

With the conclusion of our discussion regarding the project outline, this lecture in the series on research methodology has been completed. If you have any questions, I'll be glad to try to answer them for you.

RESEARCH METHODOLOGY

II. Techniques Essential in Field Plot Investigations:

This lecture, the second in a series of four on research methodology, discusses some of the problems experienced in carrying out successful field plot investigations in Korea. In a lecture such as this it is impossible to thoroughly cover the whole field. In fact, books have been written on the subject without exhausting all the possibilities. The problem is further complicated in countries like Korea which grows not only a variety of upland crops, but paddy rice as well.

It is the purpose of this talk to discuss some of the important procedures to be followed in conducting field plot experiments. The experience of the writer in the United States, Burma, Thailand, and Korea will be drawn upon freely when considered useful to the discussion.

On the whole, good progress has been made in conducting field plot research since I came to Korea five years ago. This is particularly true in the Suwon area where a number of participants have studied different phases of the problem in the United States as well as third countries. However, the situation appears to be quite different at experiment stations outside this area where I have observed problems of a rather serious nature.

Today, I am assuming that a soil fertility experiment using paddy rice as the test crop has been carefully planned including the use of a complete block design, wherein the treatments have been randomized and replicated. I believe that Professor Lee, Tae Hyon of the Agricultural College at Suwon has already started discussions with you on the subject of experimental designs. If not, you will receive this training soon.

1. Limiting Factor Concept

Before discussing some of the details of field plot work it is essential that we understand one thing of vital and basic importance. It is simply this: All of the variables in a field experiment must be under as complete and effective control as possible except those being evaluated. For example, the soil on which a fertility experiment is to be established should be of only one type and reasonably uniform. The soil should be plowed to the same depth and in the same way all across the field. Lime and fertilizer should be uniformly distributed, disease and insect damage minimized, and all other operations carried out as precisely as possible. All of these jobs when carefully done have the effect of minimizing experimental error. Therefore, you get a better measurement of the factors under study, i.e. response of a rice variety to differential fertilizer treatments.

2. Selection of Site

The first step in establishing and conducting a soil fertility experiment is to locate a suitable area of land. As already indicated, this area should consist of only one soil type and that type should be a major one found on farms in the area represented by your station. This may should like asking for the impossible since soil survey work is hardly started in Korea. However, with the help of a soil surveyor, an approach to this ideal can certainly be made and the area selected will more likely be representative of a soil found of farmers' fields.

I remember one occasion here in Korea when I happened to be inspecting a replicated fertilizer experiment. Barley was the test crop. After checking the treatments I was sure the variation I noted was not the result of the differential treatments but caused by some other factors. After further observations, I decided the trouble has its origin in the soil. So I had a USOM soil survey advisor check the soil. He reported four soil types scattered over the test area. Obviously, such land should not be used for experimental work. This experience points up the importance of site selection.

As indicated in our discussion of research planning, the choice of a suitable site at a provincial institute is complicated by two factors: (1) insufficient area of crop land available and (2) the fact that most if not all the land has already received fairly heavy applications of both phosphorus and potash. There is still another factor that may add further to this unsatisfactory situation and that is the possibility that the land at your station is not representative of the major soil types cultivated by farmers. If this is true, it would be wise not to establish a soil fertility experiment here, but with the help of one skilled in soil survey select a suitable area on a farmer's field.

If the soil type or types found at your station are representative of what the farmer has, but have received heavy applications of fertilizer in past years, an area for future use should be set aside on which no phosphorus or potash will be applied for several years or until a uniformity trial and soil test data indicate that the fertility level is about the same as that on a farmer's field.

In choosing a specific site, check over the field history of the area under consideration. What fertilizers and in what quantities were applied last year, two years ago and up to five years ago? Also what crops were grown? In order to have the same carryover or residual effect of previous treatments, it is desirable that the area under consideration received in the past uniform soil treatments. Where soil variability of a field or series of plots has been increased through varietal or cultural tests, one or more uniform croppings should intervene before the area is used again. Sometimes it helps to arrange the plots at right angles to the direction of the farmer plots.

Select a slightly slopping, well-drained soil if upland crops are to be planted. If paddy rice is the crop, make sure the water level can be controlled within limits of the estimated rainfall or when using irrigation water. The area should not be subject to periodic flooding and should also not be near a farmer's house or other farmstead building.

In connection with choice of site, it is important to note that distribution of plots in blocks and analysis of variance does not eliminate the necessity for choosing as uniform a field as possible. The reason for this lies in the fact that if the heterogeneity of the field is large and with only a few plots in a block, the different parts of the block will vary so greatly that this fact will tend to obviate the possibility of measuring differences between treatments.

Regarding this matter Wishart and Sanders state: "Much care must be taken in choosing the site of an experiment. Some people have the impression that uniformity of soil over an experimental area is no longer important, because they imagine that soil inequalities will all come out in the statistical wash. This is not true. The great strength of modern methods is that they protect the experimenter from drawing wrong conclusions when differences are merely due to soil irregularities. But we want more than this negative assistance; we want to detect true differences when they do exist, and this is often prevented by soil patchiness. Two things make for significant results -- large differences between the yields from different treatments, and a low experimental error. The placing and design of an experiment do not affect the former, but they should reduce the error as much as possible; unfortunately, no design can give a low error where great soil heterogeneity exists."

The writer has seen a number of instances in Korea where failure to select a proper site nullified a portion or all of the results. For example, on one area selected for measuring the response of a fiber crop to nitrogen, phosphorus, and potassium, so much commercial fertilizer had been applied in previous years that no realistic measure of response to these three nutrients could possible be obtained; vegetative growth on all the plots was essentially the same. In another experiment located near a house in which people lived, the growth of barley on plots near the house was outstanding including even that of the check plot.

Once the site has been chosen, take a representative soil sample. If feasible, a technician from the soil testing laboratory should be present to assist with this work. He can tell by using his soil kit whether the fertility status of the soil is at a sufficiently low level to represent an average farmer's field. However, a soil sample must still be taken for future reference and for determination of the lime requirement if the need for lime is indicated by comparing the soil pH with the lime needs of the crop to be grown. At this time the soil should also be examined for depth of surface layer and for nature and drainage of the sub-soil.

It is important that the necessary preliminary work be carried out as promptly as possible. If tests must be made at the soil laboratory before a final decision is reached as to suitability of the area under consideration, it is essential that this work be given high priority. Recommendations from the laboratory technician should be received within a few days. This is necessary to avoid serious delays in getting the experiment started.

If it is known in advance that none of the land at an experiment station is available for a fertility experiment or that the fertility status of the fields at the station is not representative of the farming area it serves, then the experiment must be established elsewhere. In this case, the following approach is suggested: Based on your experience and on the appearance of the present crop on the land, select a site in a general farming area of economic significance to the community. It should represent a soil type, assuming a soil survey has been made, of major importance. You may already know something about the degree of response of the soil to fertilizer nutrients as well as the location of fields where little or none of either of the major plant nutrients (N.P.K.) has been applied.

Select a general area owned by a farmer known to be a good cooperator. This is important because there may be times when you will need his assistance or that of the members of his family. The farmer should and undoubtedly will supply you with reliable information on the cropping system he has followed on any field in which you may be interested and which he is willing to let you use. With the farmer's assistance try to locate an experimental site near but not necessarily adjacent to a well travelled road. This will make it readily accessible to you as well as to any farmer who later may be interested in seeing your experiment.

Speaking of farmer cooperation, it is just as necessary for the farmer not to interfere in any way with an experiment as it is for him to help you. Perhaps an example will make clear what I mean. I remember well of an incident in Thailand where great care had been exercised in laying out a fertilizer experiment. Rice was the test crop. The farmer became worried because the growth of rice on some of the plots was so poor. On his own, and he thought he was helping out - he proceeded to scatter commercial fertilizer on these plots. Of course the experiment was ruined. Furthermore, it could not be repeated until the next growing season so a whole year's time was lost. Farmer cooperation is desirable but it is just as important for you to tell him of things he must not do, as it is to inform him of any jobs you want done.

3. Application of Lime

Where lime is used in Korea it is applied almost entirely to upland crops. However, with attention now being given to the use of green manure and other crops in rotation with rice, considerable lime may be added in the future to some rice soils in order to insure the satisfactory growth of these crops.

Lime should be applied to farm soils according to the requirements of the plants to be grown. Considering upland crops, peanuts, onions, cauliflower and cabbage are examples of plants which grow best at a high active calcium content and slight acidity (i.e.,pH about 6.5). On the other hand, corn, soybeans, potatoes, tomatoes and watermelons grow well at moderate acidity (i.e.,pH about 5.5).

Fortunately, rice will grow well over a wide pH range (i.e.,4.0 to 8.0). The writer has seen good crops at the Rangsit Station in Thailand where the pH of the soil is approximately 4.0, and excellent crops on the clay soil at Mandalay, Burma, where the soil pH is slightly above 8.0. Grist in reviewing the literature on rice reports no general agreement among investigators. He states "---while paddy is tolerant of considerable variation in reaction, it does appear to show a preference for the acid types. Most of the highly productive paddy soils of China are either slightly or strongly acid".

Ground limestone (100 mesh or less) reacts slowly with acid mineral soils and should therefore, be applied to the soil several months prior to the time it is expected to establish an experiment. Late summer or fall is an excellent time for this if an experiment is to be started in the spring. Usually the lime is plowed under. Care should be exercised in purchasing ground limestone so as to obtain a good quality product. As suggested above, you should obtain the help of your chemist who will determine the calcium carbonate equivalent of a representative sample before purchase is actually made or at least before the lime is applied to the soil. He should also be capable of giving you a realistic estimate of the amount of lime needed.

The best way to apply lime for field plot work is to use a spreader that can be calibrated. These are hand-pushed and apply the lime near the ground so as to minimize air movement of the lime. However, if such a spreader is not available, it may be necessary to apply the lime by hand. In this case it is more convenient if the plots are small and have already been staked out. Weigh the quantity required for one plot into a large wash basin or bucket. Carefully spread approximately half the amount lengthwise of the plot. Spread the remaining half crosswise. Spade under or work thoroughly into the soil.

Lime should only be applied when the air is still. Otherwise, not all of the lime required will be retained on the plot. Such a situation becomes of critical importance if one is comparing a limed and an unlimed plot which are adjacent to each other. In this case great care must be used.

As a general rule in spreading lime by hand, the laborer should scatter it with his hand in a position quite near the soil.

4. Preparation of the Soil

Plowing of the land should present no serious problem especially if the test is located at an experiment station. Here tractor power is usually available for upland crops. To do the right kind of a job with a tractor plow requires the equipment to be in good condition and a Korean who has had training in the operation and maintenance of such equipment. Plow in the fall if possible and uniformly 7-10 inches deep. In the spring follow with a double disk (if available) and possibly a harrow. The work of preparing the seed-bed should be completed at least the day before the experiment is staked out. The surface of the soil should be as smooth as possible and free of depressions.

With paddy soils, it is often not feasible to use a tractor plow because of the small size of the area and the presence of dikes. In this case plowing can be done using an ox and a small plow. If you do not already have access to one of the improved "Jaekon" plows, your station should arrange to get one. These plow deeper with the same ox-power and actually turn the furrow slice over. This is of great assistance in the control of weeds. Further, it is possible by shifting the position and angle of the plow share to plow a paddy from one side doing a better job than can be done with an ordinary plow.

If the paddy selected for your experiment already has the dikes in place and the plots are small, preparation of the soil for planting may have to be done by hand. This, of course, is necessary if the experiment is being conducted over a period of years. Your laborers may have to be shown how to do a uniform job of spading and preparing the paddy soil.

5. Plot Size

Fifty or more years ago, field experiments in the United States were conducted on rather large plots and generally without replication. Because of this, soil differences between two adjacent plots were often too large to discriminate effectively between treatments.

It was Mercer and Hall (1911) who first studied the relation of plot size to experimental error. They observed that regardless of the uniform care exercised in cultural operations an experimental error due to many uncontrollable factors was involved in plot yields. As the plot size increased the error diminished, but after the size reached 1/40 acre, the reduction was small for plots greater than this area. The direct result of their work was a trend toward smaller plots with increased replication. At the present time in the United States, plots vary in size from 1/10 acre to 1/1000 acre.

It is interesting to note that plot size now is largely a matter of convenience. However, it is true that the size of plots in field experiments has much to do with the accuracy, value, and importance of the results. Experience, or comparative tests with different size plots for various crops, have determined the sizes in use at the present time.

In addition to accuracy of experimental results, several factors determine plot size, i.e., kind of crop, number of varieties or treatments, type of machinery to be used, land area, labor, and funds available for field trials.

Usually, larger plots are used for corn, sugar beets, hay crops, and pastures than those used for small grain variety trials. One requirement is the fact that the plots must be large enough to produce a representative sample of the crop concerned.

In general, more funds are required to conduct experiments on large plots than on small plots.

6. Relation of Plot Size to Accuracy

It has been shown that, in general, an increase in plot size decreases the variability of an experiment by an increase in the precision of a single-plot yield. However, an increase in plot size may also result in an increase in variability within the block or replicate because of an expanded block area. Thus, there are two opposite tendencies that affect the experimental error as the plot size changes, with the final result a balance between the two tendencies.

Many experiments have been conducted on plot sizes for various crops. Time will permit us to only review a few here. At the University of Minnesota, for example, 16 and 32-foot rows were compared using wheat, oats, and barley. The results showed no advantage for 32-foot rows, or for two rod rows per plot over one.

Under the soil and climatic conditions of Iowa, a state in the United States where corn is a major crop, a total of 48 hills (three plants per hill) was determined as being sufficient to represent a variety. Variability in plot yields decreased as the plot sizes increased from 8 to 16, to 24, and to 48 hills. Only about one-half as many plants or hills of hybrids were required as for open-pollinated varieties for an equal degree of precision.

In Alabama, another state, a uniformity trial was conducted with double-cross hybrids planted in 42-inch rows with 21 inches between hills. Where costs were disregarded, plots one to three rows wide and 10 to 15 hills long (one plant per hill) were the most efficient sizes. The results indicated that a minimum of ten hills was needed per plot.

Where sorghum is the test crop, errors have been found to decrease with an increase in plot size up to 1/20 acre. Increasing the plot size from 1/800 acre to 1/20 acre, with the same total area concerned, reduced the error about 60 per cent.

In the case of soybeans, computations from uniformity trial data in West Virginia, showed that 16-foot plots in single rows replicated three times were the most satisfactory taking into consideration both accuracy in results and land economy. At the Illinois Agricultural Experiment Station work with soybeans indicated that seed yield was 6 to 8 times more variable than were chemical characters like oil, protein and iodine number. Optimum plot size for unguarded rows, with cost apportioned among these characters, was 3.2 times the basic unit of 28 feet. At North Carolina investigations of plot size for soybeans involved guarded rows, i.e., 4-row plots with the two center rows harvested for yield. Under the conditions at this Station, the optimum plot size was estimated as 3.6 times the basic unit (38 feet). However, for all practical purposes plots of two basic units were as efficient as the estimated optimum from the standpoint of relative cost in manhours per unit of information.

Potatoes is another crop on which we have some information on plot size. At the West Virginia Experiment Station experiments were conducted with 220 rows of potatoes, 150 feet long. When harvested in 10-foot lengths there was a sharp reduction in error between row lengths of 10 and 40 feet. Beyond 60-foot lengths, there was very little reduction in error.

Ligon reported in working with cotton that nothing was to be gained by rows greater than 100 feet in length. Shorter rows were just as accurate when sufficiently replicated.

Li et al in studying plot sizes for millet determined that 2-row plots 15 feet in length were the most efficient, i.e., 113.9 per cent as compared with 100 per cent for one-row 15-foot plots.

One of the problems arising in laying out field experiments is that of plot shape. There appears to be incomplete agreement on this as some investigators have found that long narrow plots best overcome the effects of soil heterogeneity, whereas others believe that plots should be approximately square. In a few instances, it was determined that shape made little or no difference. In general, however, most technicians will concede that relatively long and narrow plots, with the long dimension in the direction of the greatest soil variation, overcome the effects of soil heterogeniety most effectively. In addition, linear plots are usually more economical for cultural operations.

A summary of the plot sizes and shapes used by experiment stations in the United States for yield tests of different crops is as follows:

A. Small grains

Three or four-row plots of various lengths from 10 to 20 feet. Single rod-row plots.

Nursery tests: Four 10-foot rows per plot harvesting the two center rows for yield.

B. Corn

Three or four-row plots each 10 or 12 hills long with center rows harvested for yield.

Two-row plots without the removal of borders.

Two-row by 10-hill and 4-row by 5-hill.

Two-row plots, 10 to 15 hills long (one plant per hill).

Rows: 36, 40 or 42 inches wide.

C. Soybeans

One to four-row plots in 16-foot rows spaced two to three feet apart.

D. Sorghum

Two-3 or 4-row plots 30 feet in length, discarding border rows in 3 or 4-row plots.

Two-row plots without border removal for combine types.

Rows: 36, 40 or 42 inches wide.

E. Sugar beets

Four-row plots two to four rods long, spaced 20 to 24 inches apart, and the plants thinned to about 12 inches in the row.

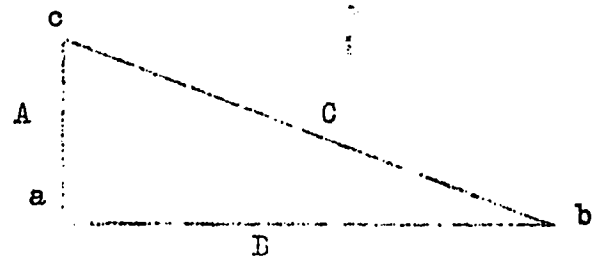
7. Number of Replications

The number of replications to use depends upon three things: the degree of soil heterogeneity, the degree of precision required, and the amount of seed. Another factor in Korea that may have to be considered is the amount of land available. For field plots the American Society of Agronomy suggests three to six replications. Corn variety trials are often designed for four to six replications.

8. Staking Out the Plots

Where an experiment is established for the first time and there are no markers to indicate the boundaries of former plots, it may be necessary to start from a right angle carefully indicating the two lines of direction. The first step is to position a corner stake where one of the corners of the experimental area will be located. From this stake, the two sides are measured out at exactly right angles to each other.

It is important to be sure the angle is a right angle if the detailed plan is to exactly fit the area selected. You will remember from your high school training that in a right triangle the square of the hypotenuse is equal to the sum of the squares of the other two sides.



In the above diagram $C^2 = A^2 + B^2$

and $C = \sqrt{A^2 + B^2}$

A stake is driven into the ground at a. If the distance ac is measured out exactly 6 meters and the distance ab to 8 meters, the angle cab will be a right angle when the distance bc is adjusted to read 10 meters. In practice a nail is driven into the top of the stake at a and two pieces of good quality string attached. These are marked at 6 and 8 meters, respectively, from the nail. Knots are tied in a third string and spaced exactly 10 meters apart. One man holds the string ac and one end of string bc. Another man holds the string ab and the other end of the string bc. A third man locates a stake along ac and one along ab.

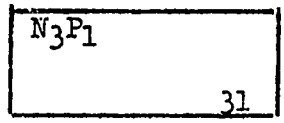
It is not intended that the above method will take the place of a transit. However, it can be helpful when one has to locate the four corners of an experimental area. The sides of the area must, of course, be measured off and any necessary adjustments made to insure that the parallel sides are the same length. One may have to slightly rotate the right angle to make one side of it line up with a tree or fence post marking the general direction of one side of the plot.

Following the experimental design, i.e., randomized complete block, the plots and alleys are marked off. From a practical viewpoints, it should be possible to go on to the area of any one plot without having to cross another to get there. As you well know, foot paths of uniform width but not over one meter wide and placed at appropriate places, are the solution to this problem. If land is scarce, space can be saved where there are four replications by placing the plots of two blocks back to back. One pathway then divides the two "double" blocks. All plots are still accessible without having to cross any other plot.

When the same plot layout is to be established at different locations, it is convenient to use marked wires. These should be soft wire of good quality and should be carefully used and stored in order not to get kinks in the wire. Plot boundaries are indicated by red paint marks at appropriate intervals along the wire.

It takes four wires to mark the boundaries of the plots next to each wire on the four sides. Another wire reaching across the plot area in one direction marks the inner plot boundaries on one side and a second wire running in the opposite direction marks the inner plot boundaries on the other side. The latter two wires are moved from place to place using the red markings on the outer wires as guide points. Stakes are placed at the corners of all individual plots. A precaution one may want to take is to check with a tape the dimensions of each plot.

A final job in laying out an experiment is to properly identify each plot with an appropriate sign. It is also desirable to show on another sign the number of each block. No two plots should have the same plot number as this may lead to confusion especially if laborers are sent to the field to work on a specific plot. In addition to the plot number, the sign should also show the treatment given. Such a sign is illustrated below.



The caption N_3P_1 indicates the treatment given the plot and the figure 31 the plot number.

In Thailand the plot inscriptions are usually painted on small sheets of galvanized iron. Wood is quite satisfactory but may not last as long. Even cedar shingles have been used. A convenient size is 12 x 20 cm. Such a sheet is attached near the top of a stake driven into the ground. It is best to place these signs outside the plot area, preferably midway of the side facing a food path. From here they are easily read provided they are tilted at an angle. It is also desirable to neatly arrange the signs so they are as nearly in a line in both directions as possible.

9. Application of Fertilizer

When broadcast, the same principles apply in spreading fertilizer on a field plot as in the spreading of lime: extreme care must be exercised. The writer has seen three types of errors which resulted in invalidating at least part of an experiment. These are listed below:

A. Fertilizer applied on the wrong plot.

B. Fertilizer unevenly spread over the plot area.

C. Fertilizer distributed while the wind was blowing so that a portion of it fell on a plot or plots for which it was not intended.

Fortunately, all these errors are easily prevented.

Fertilizer for any plot whether for upland crops or for rice generally arrives at the experiment site in bags. It may have been weighed out at Suwon or at the experiment station. Check the bags individually to be sure they arrived in good condition. It is customary to distribute the bags, one bag to each plot. A laborer may do this initially. After he has finished, an official taking the plot layout with fertilizer treatments, checks the treatment number and plot number on the bags, with the treatment and plot number on the diagram. Experience has indicated that using a design involving 60 or more plots, the laborer may make one or more errors. Checking by an official, however, always results in correcting such errors before it is too late.

The uneven distribution of fertilizer on a plot may result from carelessness on the part of a laborer or from the fact that he was not properly trained. However, some laborers seem incapable of doing a satisfactory job even though they have been trained. In such a situation it is best for the technician to carefully select his men; only those who have demonstrated previously their ability to do the job well should be chosen.

As with lime, the amount of fertilizer to be applied to a plot on upland should be placed in a large-sized wash basin or similar container and thoroughly mixed by hand. If the fertilizer is small in quantity, it should be diluted with some of the fine dry soil from the plot. After thoroughly mixing, the contents are divided in two parts using the side of the hand. One-half is then spread lengthwise and the other half crosswise of the plot. Air movement must be at a minimum. Raking the soil in both directions, completes the work and insures that the fertilizer is evenly distributed.

For plots to be transplanted to rice, it may be necessary to modify the above method of adding fertilizer. If the soil of the plots is already covered with water which cannot be drained off and the amount of fertilizer to be applied is small, a different approach is desirable. In this case the fertilizer may be dissolved or suspended in water and the water applied as uniformly as possible in small amounts by hand. Working the puddled soil before transplanting the rice insures adequate distribution of the fertilizer.

Where dry fertilizer or a mixture of fertilizer and soil is to be spread on a plot, the desirability of using great care cannot be too strongly emphasized. When an error is made, not one but at least two plots are affected as already pointed out under the discussion on lime.

In Thailand, the writer saw a very striking illustration of what happens when fertilizer is applied to plots while the wind is blowing. A plot which received a mixture of nitrogenous and phosphatic fertilizer was adjacent on the windward side to a check plot. During the spreading operation, only half the treated plot was covered as the wind blew considerable fertilizer on to half of the check plot. The growth of the rice crop was unmistakable evidence of what had happened. On both the treated and untreated plot, the growth was good on half of the area and poor on the other half. Research done in such a manner leads to none other than erroneous conclusions.

10. Seed Selection, Testing and Planting

Planting of seed or transplanting of rice logically follows the application of fertilizer. Like any of the other steps, this one must also be correctly done.

With upland crops such as corn, sorghum, soybeans, peanuts, etc., only pure seed of adapted and good yielding varieties should be used. For crops like corn, castor beans, and sesame where natural crossing occurs, seed increase plots must be grown in isolation and rogued if necessary throughout the season in order to maintain the original line. While such work is necessary it is the responsibility of the plant breeder rather than the soil fertility specialist.

About three weeks in advance of planting, a germination test is carried out. This is especially important where the facilities for seed storage are often inadequate and high air temperatures, high humidities and relatively high moisture content of the seed often cause a decreased germination percentage. The equipment, consisting of two tin plates and blotting paper, are readily available. A double layer of the paper cut to fit is placed on the bottom of one of the plates and saturated with water. After shaking the seed container thoroughly, 100 seeds are selected at random and placed on the paper in ten rows of ten seeds each. This arrangement is for convenience in counting to make sure that 100 seeds are used. A third piece of paper also moistened with water is placed over the seeds. Finally the second tin plate is inverted and used as a cover for the first one. If necessary the second plate can be held in place using a rubber band. The seed is then incubated for a week at a suitable temperature. At the end of this time those seeds which have germinated are counted, removed and their number recorded. Additional water is added to the filter papers to insure they are kept moist and the remaining seed incubated for another week when a final count is made. One hundred minus the number of unsprouted seeds gives directly the percentage germination.

The planting rate for any particular seed is now adjusted in accordance with its percentage germination. If planted in hills, usually an extra one or two seeds are added in addition to the calculated number to take care of the seed sampling error and thus insure the stand desired. Later any extra plants can be thinned out. Failure to plant a sufficient number of seeds to insure a stand can have disastrous results if your project involves farmer cooperation and the supply of seed for planting is limited.

For plot work, small seeds like sesame are best planted with a manually operated planter which has been calibrated to sow at the desired rate. The advantage of this tool lies in the fact that the seed is sown at uniform depth, covered, and the soil pressed firmly around the seed - all in one operation. Peanuts, corn and beans can also be planted this way and even sown in hills if desired. The Hansa planter is one that will sow seed in either rows or hills. It is of German make. Another excellent planter for small seeds is the Columbia. For planting corn in experimental plots the "corn jabber" is unexcelled.

Planting seed by hand using a hoe should not be carried out by inexperienced people especially if adequate supervision is lacking. The reason for this is the occasional failure of workmen to plant the same number of seeds per hill (if seed is planted in hills), tendency is toward too shallow or too deep planting, and the possibility of not properly covering the seed. Such errors have been noted many times. To correct them may seem like giving attention to unnecessary details. But these jobs must be carried out properly or a worthless experiment may well be the result.

The time of planting is also important. The approximate date which the experience of farmers in the locality has shown to be most suitable, should be adhered to as closely as possible unless the results from experiments have indicated otherwise. Planting of all the plots should be completed the same day.

Ordinarily replanting of an area will not be required if the suggestions given above are followed. But should it be necessary to do so, the whole experiment should be so treated. This must be done as soon as one can tell that the stand from the first sowing is unsatisfactory.

In the case of rice, the initial transplanting or the transplanting of additional plants should be promptly carried out. Again the laborers assigned the task should be carefully chosen as it is important that they plant in the same way as nearly as possible.

Much attention has been given to possible corrections for loss of stand. It should be pointed out that there is no entirely satisfactory method to correct for uneven stands. As far as possible they should be prevented. One method is to plant thick and thin the young plants to the desired rate. For example, where a corn stand of three plants per hill is desired, the experimenter may plant five or six. Later, the seedling plants are thinned to three per hill.

11. Protective Fences

If a soil fertility test occupies a farmer's field, it should practically always be fenced. This is the only sure way to prevent animals from grazing and leaving droppings on the plots. If the droppings are deposited after the first crop has been harvested, they are certain to cause uneven growth the second season, a condition not wanted by any responsible technician. The type of fence to use depends largely on the materials available and their cost.

Corrugated iron sheets ordinarily used for roofing have been suggested for keeping rats from the plots in areas where trouble occurs year after year. Their use is well worth trying. The sheets would be joined together lengthwise, set into the ground 4-5 inches to prevent the rats from digging under them and could be supported at intervals with stakes. Rats would probably have difficulty in climbing up the smooth metal sides.

12. General Care and Supervision

Most investigators will agree that it is much better to have a few experiments properly taken care of than to have so many they cannot be given the attention needed. The two factors which should largely determine the number of soil fertility experiments advisable are the availability of trained personnel and funds. An insufficient supply of either should result in a careful selection of only the most important tests - that is those which will provide answers to the most urgent farm problems.

When one is working with living plants as in a soil fertility experiment, it is essential that some trained person visit the test on an average of twice a week. This is necessary to keep a close check on damage which may occur from any one of several causes.

With upland crops, weeds appear about the same time the crop seedlings push through the soil. As soon as the planted crop can be seen in rows or hills it is time to do the first weeding. Most experiment stations in Korea have been provided with an effective tool for weed control of row planted crops. This is the Planet Junior type hand-operated garden cultivator. By using the two weeding knives, one placed on either side of the row, it is possible to take out all of the small weeds within 2-3 inches of the plants. Weeds within the rows must be removed by hand. However, if the plants are to be left in hills, a light garden hoe (not a grubbing hoe) can be used for blocking. This not only spaces the hills but reduces the weed population to those within the hill area.

As the plants become larger, the knives are spread farther apart. When the plants become so large that it is no longer possible to straddle the rows, the cultivator can be used to cut out the weeds between the rows by simply reversing the position of the knives.

Hand weeding may be required until the plants approach maturity. However, if the weeds were removed early in the life of the experiment, later weedings should not require much time. Weeds rob the cultivated crop of both nutrients and moisture and for these reasons will interfere seriously with any fertility experiment if their growth is allowed to proceed unchecked.

Weed growth must also be controlled in rice experimental plots or yields are certain to be reduced. Usually this is done by hand after the rice has been transplanted. Sometimes the weeds are simply pulled up then trampled back into the soil. But if present in large numbers, they must be carried from the plots.

Sufficient funds should be alloted in planning an experiment so that the labor necessary to insure effective weed control can be provided. Certainly, the presence of large weeds on the plots at harvest-time of either an upland crop or rice fertility experiment would indicate that sufficient attention had not been given to keeping the growth of weeds under control.

Another job for the field plot technician is to keep insect and plant disease attacks at a minimum or they will vitiate the results from a soil fertility experiment.

Dr. Harry Love, an outstanding research investigator who spent more than six years in Thailand, sums up the importance of effective field plot care as follows:

"From the time that the layout of the field has been completed to the final harvest the experimenter should be careful to keep in mind that the treatment of the entire set of plots should be as nearly the same at all times as is possible. That is, he should not permit anything to be done or to happen on part of the plots that may result in any way in their reacting differently than the other plots in the same field. There are many things that can happen to an experimental field if this is not kept in mind constantly, and some of these may seem so simple that they are apt to be overlooked. An example of such a case may be cited. Material harvested from plots was piled together at frequent spots in the field for convenience in removing. A period of very rainy weather followed immediately and it was some time before the piles could be removed. The effect of this could be seen in succeeding crops. It is important that the experimenter be constantly on guard to see that things of this sort do not occur, for if he permits something to happen that influences any part of his experimental field it may result in ruining the field and make it necessary to locate another area for continuing the test. This may present a problem at many experiment stations, since few, if any, stations have large areas of land available. It is necessary, therefore, that land assigned for experimental purposes should be carefully handled to make sure that experiments conducted on the field will be reliable."

13. Harvesting the Crop

Of all the operations in a soil fertility experiment, that of harvesting is one of the most important. Sometimes it happens that the other phases have been carried through successfully, but at or near harvest the experiment is lost.

While the writer was serving as an advisor in Thailand a good illustration of what may happen actually occurred. The ears of corn in a well-conducted experiment located at an agricultural school and adjacent to a main road, were in the soft dough or eating stage. Suddenly the students from the school began shucking the ears even though the experiment was under the supervisory care of the headmaster. Travellers passing along the road also took their share. Most of the losses occurred at night. When we visited the experiment, which a few weeks earlier had every appearance of being a successful one, we found it completely ruined.

But other things may happen that can detract from the value of an experiment. For example, with peanuts it may be failure to get all the nuts from the soil after the vines have been pulled. Or in the case of rice, it could even be the fact that the wrong label was attached to the bundle of harvested grain and the root never discovered until too late. Mistakes may even be made in weighing the threshed rice. Whatever the cause, it is apparent that all necessary precautions be taken to minimize such losses or errors.

In the case of a corn test where stealing of the ears is likely to occur, about the only thing one can do is to guard the experiment day and night during the critical ripening period. This will add to the expense, but it may well result in getting data that would not be obtained otherwise.

As the harvesting season for any crop approaches, the technician should begin checking on the labor and equipment that will be needed. Such standard items as sickles, tapes, hoes, baskets, string and weighing scale should not only be available but in condition to use.

In the harvesting operation, the guard rows of any plot are cut first and the material removed. Often this is done a day in advance of the actual harvest. The next step is to record the necessary field notes. If some of the hills in a test involving rice, peanuts or similar crops, respectively, were damaged by rats after the crop was already ripe, their number should be shown or the number of hills harvested recorded. On this basis the investigator or the statistician may be able to make a correction. If, however, a portion of the area - not exceeding half of it - were damaged early in the life of the experiment, a smaller portion of the plot can be harvested. In this case, plants next to the damaged zone should not be included but treated in the same way as those in guard rows. The record must clearly show the size of the harvested part as well as the weight of the product. On rare occasions it is necessary to discard a plot. In this case a note should be made in your book to treat the plot statistically as a "missing plot". Indicate why.

With most crops, the harvesting method used is quite well standardized; it is largely a matter of collecting and determining the weight of dried beans, corn, peanuts, etc., from the individual plots of the respective test area. In the case of rice, however, the method used in cutting the plants varies. In Southern Thailand, for example, it is customary to cut off the panicles instead of severing the plants near the ground. If the rice is uniformly ripe, there are no objections to this method. In fact, drying of the paddy may be facilitated. But ripeness is more or less a matter of degree and there are often some panicles that are not quite ripe. If this occurs and the rice is cut off near the ground, the moisture and nutrients in the long straw may help ripen any immature grains.

Once the rice crop is cut, it is best to remove the panicles or bundles to a concrete or hardened earth floor for drying. Sometimes they are placed on raised platforms which permit circulation of air from below. Care must be exercised in transporting the crop to avoid any mix up of samples or mechanical losses. If the straw was left attached to the panicles, it is convenient to tie the plot identification stake to the bundle before it is removed from the plot. This assumes, of course, that the plot is small enough to make it a practical operation. If not, identification labels written in pencil or India ink must be attached to each group of bundles from an individual plot.

After drying, the rice is threshed. This may be done in many ways. A method commonly used in some countries is to flail out the paddy on a canvas cloth or other covering. The writer has seen this done many times usually with small losses of grain. A better method is to use a small header properly protected by a canvas to prevent the rice grain from being scattered. A small thresher like those used at some experiment stations in the United States is even better.

Winnowing is often resorted to in order to remove the chaff and other lighter materials from the paddy. Here again it is difficult even for an experienced laborer to prevent small losses of grain. A laboratory type of "Clipper" cleaner turned by hand is ideal for this job. Unfortunately, only a few Korean stations have these although there is a good supply of the larger grain cleaners.

Whether the particular task at hand is the shelling of corn, peanuts, or even castor beans; whether it is the harvesting of sweet potatoes, sesame or rice, good judgement, care, and an appreciation for the importance of detailed work are essential. If laborers are to perform these operations successfully, they must not only be trained but supervised by the technician in charge.

The final step in field plot work is weighing the harvested crop. For this job a spring balance should never be used. Often these do not have the sensitivity necessary and after the first year, may not weigh accurately. It is much better to use a laboratory type balance with a beam, the balance having a capacity of 8-10 kilograms and a sensitivity of one gram.

When using the balance, it should be placed on a firm, level base and adjusted to read zero. If it has a double beam with a sliding tare weight, this can be adjusted to exactly balance the container. If the balance does not have a tare weight, the container must either be weighed or carefully balanced off using weights or solid objects placed on the right hand pan. If the container is weighed, the amount must be checked occasionally and always subtracted from the total. Air currents must also be avoided.

A Toledo balance on which the weight can be read directly is very convenient. This balance is also sensitive to one gram. Weighing are rapidly made.

To avoid weighing errors, it is best to assign two people to the job. One checks the other to make sure mistakes in reading are not made. The verified weights are then written in the field record book.

With the weighing of the harvested crop plot by plot, the experiment is brought to a close. A concluding quotation from Love's book "Experimental Methods in Agricultural Research" is particularly appropriate: "It is evident the experiments of the type discussed are not easy of accomplishment, yet under the direction of a careful investigator they can be successfully carried out. One who conducts agricultural experiments has a rare opportunity not only to advance the science of agriculture but to serve mankind in a practical way. If his experiments are well conceived, carefully designed, properly executed, and wisely interpreted, he will contribute something of value to this basic industry, agriculture."

RESEARCH METHODOLOGY

III. Methods for Keeping Current Records of Research Projects.

This the third lecture of the series discusses the subject of how to keep adequate research records. We will not concern ourselves with the various forms which the Korean Government requires in reporting research results officially. Rather, we want to talk about the records you as technicians keep from day to day of project plans, project activities and results. These records are very important because they are the original ones.

Observations made over a period of more than five years at various agricultural experiment stations in Korea have indicated the desirability of making changes in the methods used for keeping records of research in progress. Some technicians do very well in certain phases of this work but are weak in others. With technicians elsewhere, the reverse is true. In other words, needed improvements can be made at most research laboratories or experiment stations.

Aside from generalities which apply to the notes a technician may keep regardless of his activity field, detailed discussions will be confined to the chemical and agronomic fields. The reason is that these happen to be the two research fields which are most familiar to the writer because of his training and experience.

1. Necessity for Good Records

Let's begin our discussion by answering the question: Why in research are adequate and intelligible records necessary? I believe you will all agree that without such records you would really be in difficulty at the end of an experiment in trying to interpret the value of the data you obtained. It is a fact that even with good records an investigator may occasionally have difficulty in making sense out of his data. But without the benefit of detailed records, the situation would be hopeless.

At the conclusion of an experiment and regardless of the field of activity, the experimenter wants to know whether the results together with the observations made provide the answer to the problem studied and if the data justify statistical treatment. In the case of a field experiment, there could be "missing" plots. He also wants to know what parts, if any, of the experiment need to be repeated. Only detailed information can provide the answers.

There is another very good reason for having complete, understandable project records. You may need them for future reference, especially if you intend writing up for publication the results of your experiment. Even the calculations you made can again be checked if the original data were recorded in sufficient detail. In addition, when a similar experiment is planned in the future, it may be helpful to know what method or methods were used in a previous one. For example, if you are a chemist you might want to refer to your original records to know what method was used for determining the potassium content of lespedeza forage. This assumes, of course, that the data has not yet been published.

In Korea as in other countries of the world, it is customary to promote technicians when they deserve it and when there are openings elsewhere within an agency. This is fine and is especially commendable when the technician is still kept within his field of scientific training and experience. But when a technician at an experiment station is promoted and a replacement arrives, one of his first jobs is to become thoroughly acquainted with the details of the research undertaken at the laboratory prior to his joining the staff. Such a review is a decided advantage to both the station and its new employee. In doing this, the original records left by the departing employee can be of great assistance.

Finally - and I have purposely left this reason until the last - good records are one of the identification works of a capable scientist. He, as a matter of personal pride, has taken the pains to record the results of his researches in detail. He knows that someday some other technician will follow in his foot steps and that this man can do a better job if in the beginning he has access to the laboratory or field records of his predecessor.

2. Requirements for Record Keeping

Now that we know why complete records should be kept, let's turn our attention to some of the basic requirements for doing the job. As a matter of convenience, we can divide these requirements into two general groups - laboratory and field. We will discuss the laboratory records first.

In a chemical laboratory, records for the most part should be kept in notebook. It should have a cloth or other protective cover, open from the side, have ruled lines running horizontally, and contain about 100 pages. In size it should measure approximately 21 by 27 centimeters. The paper should be of good quality.

This writer is of the opinion that as a general rule, each laboratory technician should have his own notebook. However, he realizes that occasions may arise when it would be an advantage for another person to record data in this book, i.e., another laboratory technician substituting temporarily for the technician in charge. When this occurs, data recorded by another individual should be indicated by that person signing his name in the appropriate place.

For some specific chemical analyses which are done in large numbers and are routine in character, special forms with necessary printed headings may be used. For example, if a technician from the Analytical Chemistry Section, Institute of Plant Environment, ORD, were to make several dozen total nitrogen determinations per day over a period of 3 or 4 months, he might find well-planned and printed forms to be an advantage. It would save him time too. As each sheet was completed, it would be inserted between the covers of a ring or other type of notebook for safe keeping. It is emphasized that the case just described is a special one.

Field plot records should also be kept in some kind of notebook and never on sheets of paper. The notebooks available are of three general types: The ring, the spiral, and the ordinary notebook. Each has its advantages and disadvantages. In size, pages 22 cm wide and 24 cm long are about right. The book should open from the side, be well-bound and have a cover resistant to hard usage and wet weather. For field plot work it is an advantage to have lines on the pages running both horizontally and vertically.

One of the advantages of the three-ring notebook is the fact that the cover can usually be used for more than one year. Furthermore, the results from one experiment can be separated from those of any other experiments for filing or for processing of the data. When open, this book will remain that way until closed. Another advantage, is the fact that special paper with printed or typed column headings may be inserted as desired. In fact, before going to the field a technician can give the sheet on which he expects to record data to the typist and she can type in the column headings for him to use that day.

But this type of notebook also has its disadvantages. For instance, in field use, the individual pages are easily torn from the rings, especially the first several pages in the front and the last several pages in the book. However, gummed eyelets inserted around the holes where the rings go through will prevent this.

Another disadvantage of the ring notebook is the fact that not later than the beginning of the next season, the records for the last year's results must be removed from the book. These are loose sheets of paper which must be kept in order and held together in some way. Usually, the sheets are tied together with string and placed in file folders.

Finally, it may be difficult to purchase a suitable ring notebook in Korea. However, I assume that if there were sufficient demand, one meeting the requirements indicated could be made up.

The spiral type notebook with protective cover can also be used for recording field notes. The leaves from such a notebook are not easily torn out so any danger of loss of data from this source is minimized. This book will also lie flat when opened. Similar field experiments are easily kept together. If this book is used, it would be difficult to have any

column headings printed on the pages as these cannot feasibly be removed and replaced. For the same reason, the data for any one experiment cannot be removed conveniently from the book.

The ordinary notebook with cloth or plastic covers is rather commonly employed in other countries for recording field notes. For example, field men attached to the United States Department of Agriculture often use this type. The outstanding advantage of the notebook is the fact that rarely indeed are any of its pages lost. Without a doubt, arrangements could be made with a book agency in Seoul to make almost any kind of a notebook of this type desired including ruled pages of suitable design.

While taking field plot notes, one wants a notebook to stay open as a matter of convenience. One disadvantage of an ordinary notebook is its tendency to close when you want it to remain open. However, a rubber band placed across the width of the book will not only eliminate this difficulty but will solve the problem caused by wind blowing the pages.

Although a notebook is undoubtedly best for keeping field notes, a few technicians, for some reason, prefer loose sheets of paper kept either in a folder or on a clipboard. Admittedly, this is an inexpensive system but the grave danger of pages getting lost, far outweighs any financial advantage of the method. Korean technicians should not record their notes in this manner.

Before closing our discussion of requirements for good record keeping, it should be pointed out that once a decision has been made as to the type or types of notebooks desired, it is important to maintain a reserve supply of them. When a technician needs a new one, he is given a notebook just like the one he used before.

3. Methods for Keeping Records

Before citing examples of effective methods for keeping laboratory and field plot records, a few comments of a general nature should be made. The recording of original data should be done using a No3 pencil or its equivalent. A No1 or a No2 is too soft and a No4 or 4H too hard. A pencil is used realizing that sometimes a figure or a word will have to be erased. If a mistake is made while using a pen, this is difficult. Furthermore, if it begins to rain while taking field plot notes, any recorded data can soon become unreadable.

In some chemical laboratories, the original records are copied on sheets of paper or on a paper pad made by the technician and then re-copied in ink into a book. This is a sheer waste of time and may result in errors especially if the work is done by a typist or even by another technician.

It should also be remembered that any original research records made by a technician do not repeat not belong to him personally but are the property of the experiment station where he is employed. For that reason they must not be removed when the technician concerned leaves; neither should they be destroyed at that time. The reasons for this are obvious.

At the time a new record book is given a technician, he should record on the title page the general field covered by the data, the name of the experiment station and the year. At the bottom of the page and on the right hand side should appear the name of the technician. The examples given below are illustrative:

Total Nitrogen Content of Rice Grain Samples
Analytical Chemistry Section
Institute of Plant Environment
Office of Rural Development, Suwon
1963

Kim, Hon Soo, Technician in Charge

Barley Variety Yield Test
Crops Experiment Station, Suwon
1963

Chung, Hwan Ki, Technician in Charge

On the next page, and we will limit our discussion now to the first research project shown above, should be a brief statement about the nature of the project how it originated and the purpose of the work. Reference should also be made to the Project Outline indicating its number. The rest of that page and the next one should be left blank for any additional notes of a general nature that one might want to add later.

Turning over to the next double page, let's assume we are determining the moisture content, oven dry methods for a number of rice grain samples. In that case the headings and other information should be arranged as shown in enclosure 1.

There is nothing at all complicated about this arrangement. Any technician can do it. The important thing to note, however, is that sufficient detail is given so that the calculations can be checked for accuracy if desirable to do so. The brief statement at the head of the table also identifies the samples. In addition, the date the analysis began is also indicated. This is very important and should always be recorded.

Enclosure 2 is a suggested form for recording the results of total nitrogen determinations using the Kjeldahl Gunning method. Again the arrangement is simple but effective. It is logical, easy to follow and also easy to make necessary calculations. In this form, the date appears at the left for the reason that it may take several days to complete the analysis of this group of samples.

Field notes taken during the growing season are a necessary part of any soil fertility experiment. Their help is best appreciated after the crop has been harvested and the data are being prepared for statistical analysis. At this time they are especially of value in determining if or even how certain of the data are to be used.

Yet extensive field notes are not required nor are they necessary. Simple notes recorded at intervals during the season and which will be useful later in interpreting the data,are all that are needed.

The recording of information should begin as soon as the plan of the experiment has been decided by the experiment station technician or other person directly in charge. Taking his notebook, which can be either of a loose leaf or bound type, he "makes up" the experiment. When a yield test is involved, this activity consists in recording the treatments in such a way that the plots for each are grouped together. The treatments and plot numbers are typed or written in pencil on the left hand page of the book so that other data for any plot can be carried across the right hand page. The column headings for pages on the right side of the book are written on the last page of the plan. In addition, the tops of all except the first and last page, are cut off so that the column headings are visible in turning from one page to another.

Room is left at the bottom for recording general information concerning the experiment, such as date of plowing, date of planting, identification of treatment symbols used, etc. A double-page illustrating part of such a plan is shown in enclosure 3.

It is emphasized that these are field notes and do not necessarily represent the form on which a final report of the experiment is made to the agency concerned. The great advantage of such a system is the fact that all pertinent data are shown for plots on <u>an individual basis</u> throughout the growing season. It is further pointed out that the table is only illustrative of what might be done. Actually, a well-trained technician would not want to decide in advance the kind of notes to take except possibly at harvest time. Obviously, the information to be recorded depends on what happens during the growing season.

The width of the column needed for tabulating any particular data depends on the nature of it. If figures only are to be written down, the space alloted can be narrow; if observations or comments are to be noted, the column can be made wide enough to provide the amount of space needed.

At the bottom of each group of treatments one or two spaces are left for averaging any numerical data if such averages are desired. Brief remarks regarding any plot above can also be written here.

Additional notes too lengthy to be recorded in the table can be inserted at the end of the plan. A map of the plots, showing location of the blocks, treatment numbers,directions, plot numbers, etc., should also be included, preferably just ahead of the plot record. In practice not one but two sets of field data should be kept just as a precautionary measure in case one set is lost. But the notes written in a second book can be copied there at the convenience of the technician.

After an experiment has been completed, the results obtained and evaluated, how long should the records be kept? If the data are valid, the answer is until they have been published. There is nothing to be gained by retaining records beyond this date.

Enclosure 1. July 24, 1963

Moisture Content of Polished Rice Grain Samples

These were received from Mr. Choi, Hyun Ok, Paddy Rice Section, Suwon. They are representative samples from a variety test having four replications. Two-gram samples. Temp. 100° C. AOAC dry heat method used.

Variety	Rep No.	Bottle No.	Bottle Weight	Bottle & Dried Rice	Wt. of Dried Rice	Dry wt. per Gram	Percent Moisture
Paltal	1	10	21.4625	23.2368	1.7743	0.8871	11.29
	2	11	29.6785	31.4061	1.7276	0.8638	13.62
	3	12	29.7246	31.4095	1.6849	0.8424	15.76
	4	13	30.1475	31.8131	1.6656	0.8328	16.72

Enclosure 2

Total Nitrogen Content of Polished Rice Grain Samples.

Samples furnished by Mr. Choi, Hyun Ok, Paddy Rice Section, Suwon

N of H_2SO_4 = 0.20096 1 ml = 2.815 mgs. N
N of NaOH = 0.1176 1 Ml = 0.5834 mls of H_2SO_4

1 gram samples

Date	Lab. No.	Sample No.	Flask No.	Acid Added Ml.	Back Titer Ml.	Acid Used Ml.	Eq. Mgs. of N	Av. Mgs. of N	Dry Wt. of Sample	% N in Sample
6/25	63-1	1	1	10	10.10	3.94	11.09			
	"	"	2	10	10.00	4.00	11.26	11.18	0.8572	1.30
"	63-2	2	3	10	9.65	4.20	11.82			
	"	"	4	10	9.35	4.55	12.81	12.32	0.8455	1.46
	63-3	3	5	10	10.85	3.50	9.85			
	"	"	6	10	10.35	3.79	10.67	10.51	0.8550	1.23
	"	"	13R	10	10.55	3.68	10.36			
	63-4	4	7	10	10.20	3.88	10.92			
	"	"	8	10	10.40	3.76	10.58	10.75	0.8520	1.26

Enclosure 3

Illustration of a Method for Recording Field Plot Data
Paddy Rice Fertilizer Test. Iri Branch Experiment Station. 1963

(Page, left side of book) | Page, right side of book)

Treatment No.	Treatment Kind	Plot No.	Replants made 6/15	General Observations 7/10	General Observations 8/10	Rice neck blast panicles 8/30	Rat Damage 9/1	Loding 9/5	Date Ripe	No. Missing hills 11/15	Harvesting Data 9/22 Observations	Av. No. tillers/plant	Av. height cms.	Area Harvested M2	Wt. dried paddy gms.
7	$N_{12}P_6$	8	None	Good growth	Good. Rice dark green No heading	10	None	None	9/12	None	Uniform growth	5	100	12	2103
"	"	18	3	" "	"	12	None	Severe; culms not pinched	9/15	1	Panicles lodged but rice filled	6	94	12	2160
"	"	35	5	Fair	Fair. Rice dark green no heading	20	Severe on one corner	1/3 down	9/12	25	Uniform except damaged portion	8	92	9	2190 1/ for 12^2M
"	"	54	2	Good growth	Good. Rice dark green No heading	7	None	Slight	9/12	2	Uniform	7	96	12	2245
Average						12						6.5	95.5		2174
8	$N_{12}P_{12}$	10	4	Growth only fair 2/3 plot	Growth now quite uniform Starting to head out	5	Slight left side	None	9/12	2	Uniform except side	9	115	12	2832
"	"	20	6	Good growth	Good. Rice heading out.	8	None	Slight	9/10	None	Uniform	10	120	12	3036
"	"	37	5	" "	" "	11	"	None	9/10	"	"	12	111	12	3165
"	"	49	None	" "	" "	4	Severe plot possibly lost	"	9/13	Many	Treat as missing plot	-	-	-	-
Average						7						10.3 Av. of (3)	115.3 Av. of 3 plots		3011 Av. of 3 plots

1/ Wt. from $(9)^2$ meters was 1524 gms.

IV. Preparation of a Research Manuscript for Publication

In previous lectures we have talked about research planning, field plot techniques, and record keeping. It is logical at this time to assume valid data were obtained whether in the laboratory or in the field, and discuss how the results might be reported in the form of a manuscript for publication.

If the technician has worked hard and has data which he has every reason to believe are reliable, he should consider publishing them so that other scientists can benefit from the results of his experiments. This is especially true if the current year's tests round out a series of similar experiments carried out over a period of 3 to 5 years, i.e., yield test comparisons. However, it often happens that within a year or even less a research worker can obtain sufficient information on a specific problem to publish a paper.

Evidence indicates that with the possible exception of veterinary science and forestry, far too few papers are published by the research technicians of ORD. Some of you prepare brief articles that go in the annual Research Report, but to me these are more or less reports of research in progress and not bona fide research papers. In addition, reprints are not available.

A research investigation is not complete until the data are written up and published. The writing for publication of your results is just as much a part of your project as the planning and conducting of the research itself. I imagine that an actual survey of unpublished research data at ORD and the PORDs would be a real eye-opener. But to be more specific, what did you do with the research data you obtained in previous years? If it hasn't been published, why not? Why don't you do something about it?

It is my personal opinion as the result of many years experience that a successful research man publishes on the average one paper each year. If you really expect to progress in your speciality field, the results of your work must be published. How else, is anybody to learn of your ability and interests?

One of the first decisions to be made is how and where the author would like his material published. He might be satisfied, if he considers his data of a preliminary nature, to write it up as a mimeographed report. Or, if he intends to present his material at a scientific meeting, it could appear in the "Proceedings" of such a meeting. It might also be possible to publish the data in the form of a technical or special report of the Office of Rural Development. Further, the author may want to publish in a stateside journal and if so, he must decide which one.

Another decision will involve the language to be used even if the manuscript is to be published in Korea. If the decision is to publish the paper in Korean, it will be wasted effort to send the publication to the scientists of any other country with the possible exception of Japan. The reason, of course, is the inability of the people in other counties to read a mixture of Korean and Chinese. An apparent solution to this problem is to prepare an English copy. However, in this case, some western scientific journals are not very happy about accepting a manuscript if the paper has already been published elsewhere.

Since it is not possible in one lecture to discuss in detail how to prepare papers for different scientific journals, we are going to select one, the Agronomy Journal, and tell how we would proceed to prepare a paper for that. This journal is one of the publications of the American Society of Agronomy. It has an international reputation as a publication in the field of agronomy. Partly because of this, its standards are high and a paper must be a good one to be accepted. There is one restriction, however, which must be borne in mind. This is covered by the following quotation which appears on the first page of every issue:

"Articles concerned with the instruction, demonstration, experimentation, or research in agronomy will be accepted from active members of the society if deemed suitable by the Editorial Board. It is understood that articles submitted for publication have not been previously and will not be simultaneously published in any other scientific or technical journal without the consent of the Editor of this Journal. At least one author of a paper must be an active member of the American Society of Agronomy".

About 7-8 per cent of the papers submitted for publication are not accepted. Those refused are usually the ones which are not sufficiently concerned with the agronomic field. They could be fine papers, however, for journals in agricultural engineering, agricultural economics, or other related fields. According to the Editor of the Agronomy Journal, 70-80 per cent are returned to the authors for revision. After they are revised, they are accepted.

I belive there are a few Koreans at either the Crop Experiment Station or the Institute of Plant Environoment, who are members of the American Society of Agronomy and who might be interested in being a co-author with you should you like to publish a paper in the Agronomy Journal, or even in Crop Science. But an even better arrangement would be for you to join this Society. Regardless of what you answer may be, I'll say that it's still possible for you to do this.

The first step in w riting a paper is to organize it. You should study the style of papers that have been published in the Journal. This will save much revision of the manuscript when it reached the editor's office. In fact, if you will look in the index published in the December issue each year, you may find references to papers in the same field as yours. After you have examined some of these, make an outline of your own paper. An outline such as you would prepare will resemble the one below:

1. Title.
2. Introduction.
3. Review of Literature.
4. Experimental Procedure.
5. Presentation of Results.
6. Discussion.
7. Summary and Conclusions.
8. Literature Cited.
9. Synopsis.

The above headings are the broad, general ones. Under most of these you will indicate in more detail what you want included. For example, under Review of Literature, you would list the papers published by others that you want to refer to.

In general, clear, concise sentences are desired rather than long, involved statements. Also, an account of scientific work should be written in the third person. Use of the first person is permissible only when the personal views of the author are the point at issue rather than the facts themselves.

Now, lets discuss each of the headings in the above outline more detail. First, the title. This should be as brief as possible and yet convey an accurate impression of the contents of the paper. Avoid such expressions as "study of", "investigations on", "observations on" as these are not desirable parts of a title. Below are the titles of a few papers which were published in the May-June issue of the Agrohomy Journal for 1963:

1. Method and Rate of Applying Zinc Sulfate for Corn on Zinc Deficient Soil in Western Nebraska.

2. Water Use by Several Crops in a Weighing Lysimeter.

3. Alternating Strips of Corn and Soybean VS. Solid Plantings.

4. Root Distribution Patterns of Sorghum and Soil moisture Conditions.

Sometimes the author doesn't decide on the exact title of his paper until after he has completed writing it.

The documentation of a paper is important too, especially to readers of countries other than the United States where the Journal is published. As far as the paper itself is concerned, this is done by a footnote to the title. The following is an example:

[1]Contribution of the Department of Agronomy, Nebraska Agricultural Experiment Station, Lincoln, Nebraska. Published with the approval of the Director as paper No. 1279, Journal Series, Nebraska Agricultural Experiment Station Received August 13, 1962.

Documentation of the authors of the above paper is also accomplished by means of a footnote from the last author's name as follows:

[2]Associate Professors and Professor, Respetively Department of Agronomy, University of Nebraska, Lincoln.

"Details on the source of the article and the professional status of the author may seems superfluous to those closely associated with contemporary workers in given field, but for readers in more remote localities and for those who may consult the Agronomy Journal in years to come, this information will be an important part of the record". So says the editor of the Agronomy Journal and he is quite right.

The opening paragraph or the last paragraph of the introduction should state the problem to be dealt with. For example, the last sentance in the opening paragraph of the paper "Estimation of Optimum Plot Size and Shape for safflower Yield Trials", reads as follows:

> "Determining the optimum plot size and shape for safflower yield trials was the purpose of this tudy". In another paper on the irrigation of cotton, the last sentence of the introduction is the following statement: "The purpose of this experiment was to investigate the effects of the timing of a single irrigation on growth, fruiting, yield and quality of cotton under conditions of summer aridity".

The review of literature cannot be exhaustive in a journal publication. Only those references which have a direct bearing on the data to be published should be included. In citing a person's paper, his surname followed by a number referring to the literature cited at the end of the paper, is used. The following example will make this clear: "A different method of determining plot size was proposed by Smith (5)". This is followed by a brief comment of a few sentances describing the method Smith used. If a paper has three citations or less, these should be given as footnotes.

The experimental procedures used are printed in small type and follow the review of literature. A thorough job should be done in describing these methods. There should be sufficient detail so that if one were to use your method, he can get all the information required from your paper. If you modified some other persons method, it is essential not only to refer to the method, but to tell exactly how and in what ways the method was changed.

In presenting the results, tables are frequently used. Since the type setting of tables costs several times that of setting text matter, all tabular matter should be carefully organized and presented in the most concise manner possible. The heading used for the table should be brief but explanatory and should be complete in itself without reference to the text. An example of a good table heading is:

> Table 3. Size class distribution of peas as influenced by N concentrations of nutrient solutions.

An unsatisfactory heading would be:

> Table 3. Results of First Experiment.

A study of the forms used for tabular matter appearing in the Journal would seem to be most helpful in planning the layout of a table for presentation in this publication. And each table should be typed on a separate sheet regardless of its length. The reason for this request is that the tables are set in smaller type than the body of the text and are often set by a different operator in the printing shop.

Graphs are often more effective than tables in getting data across to the reader at a glance. These should be submitted as originals and not as photostatic copies. In the making of a graph it is not necessary to show all the coordinate ruling of specially designed graph paper. Much more satisfactory results will be obtained by using plain white paper of good quality or blue - line cross - section paper with the necessary vertical and horizontal lines drawn by hand so as to avoid obscuring the curves by an excessive number of grid lines.

If it is necessary to show all the coordinate ruling, it should be remembered that blue does not photograph for reproduction, and that paper should be used which has the ruling printed in green, brown, black or red.

Of even greater importance than the choice of paper is the use of black, indelible ink, such as india ink, for all lettering, curves, and lines that are to be reproduced. Typewritten figures and letters are not satisfactory.

Both photographs and graphs submitted with the manuscript should be larger than the printed copy will be. A size of from one half to the full width of a page is about right.

Ordinarily, an editor does not look with favor on both tables and graphs for illustrating the same data.

Care must be exercised in the selection of pictures for publication. Only those should be used that tell a real story. Unmounted glossy type photographs are preferred. Each photograph or drawing should carry on the back its number and the name of the author.

Discussion of the data should be direct following the tables or graphs in logical order. One not skilled in this technique is likely to do too much "thrashing over" of the data resulting in this part of his paper being too long. With a little experience, however, he soon learns how to do an acceptable job.

The summary of a paper is almost an abstract. It should include a statement of the problem and the conclusions drawn. Whilebrief, it should be sufficiently comprehensive to include every significant finding. Considerable care must be used in writing the summary because most scientists turn first to the summary and decide from their impression of it whether it is worth their time to read the paper in detail. In order words, interested technicians are more likely to read your paper if it has a good summary.

When there are more than three literature citations, they are grouped together and placed at the end of the paper under the heading "Literature Cited". Citations should be arranged with the names of the authors in alphabetical order and should then be number in parentheses, as for example Brown (1), with the Citation reading as follows:

1. Brown, B. A. The effects of fertilization on the chemical composition of vegetation in pastures. Jour. Am Soc. Agron, 24: 129-145. 1932.

Citations to "unpublished data" are not a part of the "literature" on a subject. Properly, such refrences belong in footnotes or as a statement in the text. This is also the case for references to personal correspondence which should properly appear in footnotes, not in a list of citations.

In recent years, the editorial staff of the Agronomy Journal have required at the time a paper is submitted for publication a short paragraph giving a synopsis of the paper. This is in small type and is inserted just a head of the opening paragraph. For example, such a paragraph for the paper "Effect of Nitrogen and Magnesium Nutrition on Pod and Seed Development in Canning Peas", reads as follows:

"SYNOPSIS. Numbers of pods and seeds were influenced by levels of nitrogen and magnesium. Low nitrogen early and high nitrogen late were detrime ntal to number of pods, seeds, and size. Deficient magnesium levels reduced both numbers of seds and pods, while a slight deficiency only reduced numbers of pods."

The synopsis can best be written after the paper has been completed in draft. When the final copy is made, the synopsis is placed in the position indicated.

For presentation to the American Society of Agronomy for publication, the manuscript should be typed on a standard weight white paper preferably $8\frac{1}{2}$ x 11 inches, and should be double spaced with ample margins at top and bottom and on both sides. Only the original or ribbon copy should be supplied; never a carbon copy.

In conclusion, let me emphasize again that a well-conducted research project has not been completed until the data have been written up for publication. There are many opportunities for publishing the results from research both in Korea and elsewhere in the world. Should you like to publish in an American scientific journal, contact, if possible one of the American advisors in your field. He may have time to assist you, particularly during the winter season. Translation of your paper into English is not an insurmountable problem.

And remember this, that your goal as a research worker should be an average of one publishd paper a year.