

ORGANIZATION OF INVESTIGATION IN AGRICULTURE¹

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The organization of investigation with a view to a larger measure of coöperation among institutions and workers, and greater attempt toward coördination, is at present perhaps the liveliest subject connected with scientific research. Hardly an address is delivered which does not touch upon this subject, and very many in the past year have dealt primarily with it. The idea is not new, as the work of this Association testifies, but it has been given new force and far broader scope in the past few years.

This association is well-nigh a pioneer in that field, and the systematic study it has devoted to the details and means of accomplishing the ends sought has made it one of the going agencies in this line. There is something stimulating in knowing that the idea the Association has stood for is gaining ground, and we may feel a new conviction that in this effort we are on the right track and in the line of progress. It may be interesting to reflect briefly on the recent growth of efforts in this field.

The war gave a great impetus to coöperative effort in all directions, including agriculture. It developed the National Research Council, which is founded in the idea of coöperative and coördinated effort. It gave so many illustrations of usefulness that the Council has been made permanent, and is now organized on a generous plan which embraces a division for the biological sciences and agriculture. The prime purpose of the Council is to afford opportunity for coöperation and to assist in bringing it about, without itself having part in the investigations. It aims to serve as a stimulating agency, rather than

¹ Read at the Atlanta meeting of the Association of Southern Agricultural Workers, February 26, 1920.

to build up within itself means for carrying on research or for subsidizing it. It does not purpose to centralize the administration of research but to popularize it, to direct attention to the need for it, and to democratize efforts at organization for specific lines of inquiry. As you have seen, the Council has recently received from the Carnegie Corporation a gift of \$5,000,000, one million of which is to be used for erecting a building in Washington as a permanent headquarters of the Council and the home of the National Academy of Sciences.

The divisions of the Council embrace many committees. One of these on nutrition is to consider problems in the field of animal as well as human nutrition, and another relating to fertilizers and soils has recently undertaken to catalogue, with the aid of the Office of Experiment Stations, all the projects bearing on this field which are now under way at the experiment stations, in the Department of Agriculture, and at other institutions in this country. Such a classified list of live undertakings may serve as a basis for coöperative or coördinated attack, and it may later furnish the means for a thorough digestion of the investigation in particular lines, in order to determine what may be accepted as established and what next steps are indicated. The work of the National Research Council bears, therefore, on that of this Association, and it seems not improbable that to an extent the two may join hands.

The Association of Land-Grant Colleges has, as you know, taken a definite stand in favor of coöperation and proposed the formation of a joint committee with the Department of Agriculture, to be known as an agricultural research council. As yet but little progress has been made in consummating the idea, but the step is a most interesting one as evidencing the present attitude of experiment station workers. Various other organizations, such as the botanists, pathologists, agronomists and the chemists, are committed to the idea of encouraging organized research.

That coöperation in research of various types and grades is feasible and practical there is increasing evidence, drawn from experience in lines where it has been going on. Dr. Hale, of

the National Research Council, has called attention to a number of notable examples in astronomy, physics, engineering, geology, and chemistry. In the study of sediments and sedimentary deposits, for example, the geologist must have the help of the chemist; and, as Dr. Hale points out, "it is easy to see how an investigator choosing to deal with some aspect of this large, general problem would be assisted by information regarding related work planned or in progress, and how readily as a member of the group he could render his own researches more widely useful and significant." In connection with one of the undertakings referred to, Dr. Hale mentions that certain specifications were formulated but those who took part were not bound by any rigid rules. On the contrary, as he says, "they were encouraged to make every possible innovation in the manner of attack in order that obscure sources of error might be discovered and the highest possible accuracy in the final results obtained. The outcome demonstrates most conclusively that organized effort and freedom of initiative are by no means incompatible."

The organization of investigation logically begins with the individual station. To a considerable extent the present policy and program are largely an accumulation of the past. Hence changes may be brought about only slowly. The war led to a review of station projects and the stressing of certain ones of special importance. In a number of cases this has had a permanent effect and resulted in a revision of the entire station program. I have been much impressed with the systematic attempts at several stations to develop a program of work which would be not only more live but more definitely adapted to the special problems and needs of their localities. For example, one station appointed a committee on projects to review the whole list, ascertain the status of each project, the time it had been going, the progress it was making, its prospects and importance, and the work necessary for its completion. This committee under the supervision of the director made a catalog showing for each project the publications issued upon it, its relation to other work of the station, its adequacy, and the future plans of the leader. The latter appeared before the committee and discussed his

projects, explained their importance, and in the end recommended what ones should be continued and what should be brought to a close as soon as feasible.

The advantage of such a review must be apparent. Each project stood on its own merits. Some which had been drifting but had been using up money were detected, and their future decided. In this way a conservative and safe means was provided of sifting out the less active or important as soon as practicable, and a basis furnished for a live, active project list. You will recognize that it furnished the best possible means for establishing coöperation and coördination within and without the station.

At another station a research committee was appointed to revise the project list in much the manner referred to above, but in addition to construct a program of station work designed to better cover matters of prime importance and less dependent on chance or special preference. To this end the heads of departments, extension specialists, and county agents of the state will canvass the needs for investigation, and the suggestions presented will be weighed and incorporated in an adequate constructive program of investigation. Other stations have taken similar steps, but there are indications that the practice might well be more general.

Most stations have too many projects. They are to some extent accumulations, and represent a desire of individual workers to have a considerable list of undertakings. To this extent they embody a false idea, an ambition not in accord with the present views of investigation. It is desirable to encourage narrowing the scope in many cases, and organizing the work so that it will be more definitely centered on specific questions of limited range. The very fact that stations have forty, fifty, and even a hundred projects shows how widely their efforts are being scattered, how far they fail of concentration.

How many projects did Hellriegel have when he set about settling once for all the long contested question of whether legumes take nitrogen from the air? The famous Rothamsted station has always limited its efforts quite definitely. It has

concentrated on special questions, and has broadened its field of investigation almost entirely as a result of questions which the progress of these studies developed. Hilgard concentrated the work of his station on soils and their utilization, expanding his program only gradually as new funds came. One of the chief reasons why Hopkins met with such success in his studies was that, although they covered a quite wide range, they were definitely and consciously centered in his purpose to develop principles of soil fertility and permanent agriculture.

The specialist with only two or three projects may accomplish more for his own reputation and for the permanent benefit of practical agriculture than one who is attempting to carry a dozen or twenty, as some unfortunately are. It is an aid to the man with a long list of projects to have this list reviewed by others in a sympathetic but critical manner, and account of stock taken. It helps him to discard or terminate those he may have been doubtful about, and to direct his efforts along more constructive channels.

Such a scrutiny provides not only against a scattering of effort but against superficial, intermittent work. It may even affect the composition of the staff itself. Station staffs have been made up in the past largely on the basis of departments instead of problems. The reason for this is clear and need not be elaborated; stations have often had to make the best of the material at hand. But with a larger number of persons now assigned primarily to research, the special needs of the station and the lines it plans to study may well figure in the search for a worker and the assignment of duties. In other words, men may be sought to do definite things.

Too often a botanist or a chemist or an animal husbandman has been brought into the staff because there was a vacancy, and then asked to outline some projects, and perhaps told that as he was to be paid partly from the Adams fund he must get one or two lines that would fit that fund. More rarely perhaps is he advised of the station's program and invited to take hold of some phases of problems included in this program, to occupy at least a part of his time. How different is the case with an

industrial concern which opens research laboratories! The latter has certain problems to be worked out and is on the lookout for others in its field which are likely to prove profitable.

Such a selection of men to carry forward predetermined lines is entirely feasible in the case of station forces. When the director of the Maine Station went in search of a biologist he had a very definite purpose in view, and although the man he selected had never worked in that particular line and was not familiar with poultry raising, he was thoroughly trained, and he adapted himself to the situation, developing a department of research of national reputation. There are, of course, many similar illustrations which go to reinforce the feasibility of the station itself making and shaping the general plan of operations, and giving it direction, instead of leaving it to the various departments working independently, or making it contingent on the individual ability of the teaching staff.

It is becoming clearer with the development of station work that in large measure it should be organized around problems. In this the relations of the various departments need to be considered. Broad questions will often involve coöperation, or a division of the inquiry between departments. This may mean either a close working together, or an approach from different standpoints, or the taking up of separate but essential phases of the question. It may even involve one department working for another or under its direction for the time being.

In the drift toward specialization, scientific men have more and more segregated themselves into groups each of which confines itself to the study of a special and often narrow field. Specialization represents a great advance. It recognizes the deeper insight, the necessity of intensive study, and a differentiation of field and of skill. But specialization is opposed to generalization and may unfit men for it.

While specialization has served greatly to advance scientific knowledge, there is a danger in its isolation of retarding the solution of complex problems like those in agriculture. These problems have often been worked upon from the standpoint of the individual specialist, without particular reference to what

investigators in another branch are doing. From the standpoint of the individual a special phase and not the broad problem may become the unit. It does not necessarily require a specialist to see a problem, and he may not see it in its entirety. The analysis of a question is an important step toward its study, and such analysis often needs the combined insight of specialists in different fields. Hence the advantage of organization of research around problems in such a way as to unite this viewpoint and means of attack.

Some men are more resourceful in planning and conducting investigation than others. There are some who are natural leaders, and others who do their best work in association. It is the business of the director to determine this and to use his force and facilities to the best possible advantage. It is one of his functions to study the workers and their work, to determine whether the latter is progressing as it should, to ascertain its needs if there are weak points, and to provide help from another department where it is required. He should form a judgment of the members of his staff, and until he has that there is little warrant for authorizing large undertakings. We ought to avoid experimenting with men as far as possible.

Economy of the supply of workers, and especially those of outstanding ability in research, suggests utilization of their talents to the utmost. Research is not alone for the few if proper guidance can be supplied. Leadership is of great importance to make most highly effective the work of the rank and file. The history of science shows to how large an extent discoveries and important deductions have rested upon long series of accurate observations requiring care and patience, but not necessarily great genius. "The method of science is not a mysterious gift of genius but a practical tool in the discovery of facts and their application to the problems of everyday life." Much credit, therefore, belongs to the patient workers whose efforts help to make discovery possible provided their work is so done that it can be knit together.

A man's inherent right to work independently depends first on his ability and his particular problems, and second on the

requirements of the station program. Such right may never mean freedom from supervision or direction. It should not be forgotten that the workers in an experiment station are members of an organization, bound together by a common interest and purpose, and subject in the final analysis to the general plan of a public service institution. This does not imply any narrow view, the sacrificing of ambition, or the subordination of individuality, but it implies loyalty to a cause and to an organization. It means, what has long been clear and freely admitted, that many of the intricate problems in agriculture are larger than any individual, and that their solution as rapidly and completely as is humanly possible is something the public has a right to expect from these institutions. It is natural therefore that stations should frequently find it desirable to combine their labors and their forces. The fact that the director and his staff constitute the experiment station, and that they themselves in very large measure determine its working program, makes it a singularly democratic institution in which loss of individuality need rarely be feared. Merit will tend to attain its proper level.

Dean Thatcher, of Minnesota, has recently made a strong appeal for the adoption of "such a real spirit of coöperation as will bring to the solution of our problems the combined results of training and experience of all the workers who can contribute anything to either the immediate progress of an investigation or its final practical application." To develop such a spirit, he describes the conference groups of scientific workers which have been established at the Minnesota Station. The purpose is to provide an opportunity for frequent discussion and friendly criticism of the methods and results of research in progress, and to insure that when any new project is being considered all phases or scientific aspects of the problem may be given due consideration and properly provided for. The result has been a very pronounced growth of the general spirit of coöperation at that station. The plan is worthy of wider introduction.

A natural effect of thoroughly organizing the work may ultimately be felt in the type of problems attacked. There will, of course, be many projects which aim at the settlement of some

single fact or local question, but more and more the type of problems to be studied will be such as relate to broad fundamental questions of permanent character and wide application, bearing ultimately on the formulation of good agricultural policy and practice. These from their nature will inevitably call for relating the work of different departments, and suggest coöperation both in attack and in interpretation. General principles, broad underlying facts, and the understanding of their limitations and controlling factors, have a far more enduring value than results which pertain to minor questions or deal primarily with local aspects or conditions.

When the work of a station has been well organized, when each house has been set in order, the way is more clear for arranging for effective coöperation or coördination between stations. This should not be on too extensive a scale, especially at the outset, and should be as free as possible from complications and cumbersome machinery. A small number of undertakings are more likely to succeed than if the attempt is made to bring a large part of the work into coöperation. A few things well and satisfactorily done are more important than many less effective ventures. It is by success in coöperative effort that the plan will win friends and conviction, and will grow by its own force if the means are provided.

For most of the experiment stations the organization of their work with reference to what others are doing is no longer a matter of preference alone, but in a greater measure is impressed upon them by present conditions. Insufficient funds make such action necessary if the stations are to cover the field and render the service expected of them. Individual workers and separate stations have their quite distinct limitations, and their efforts may be materially supplemented and strengthened by those of other institutions. It should be realized that joint effort is a means of making the work of each station and each individual worker more effective.

The American stations comprise a system having a common purpose, as well as local responsibilities, and confronted with many problems common to regions extending far beyond state

boundaries. The stations do not exist merely to themselves or for their states. They have a unity of purpose, and a range of interest which is not confined to the local aspects of problems. They are interdependent. They can economize their time and funds, and make their efforts more productive of sound conclusions by so relating their work as to cover certain problems completely, make the attack more concentrated, and the results more readily comparable or intelligently harmonized.

Coöperation may lead to a more intensive study of the nature of the problem—what it really involves, what features or branches of science are included in its manifestations, and hence the means of approaching it, instead of viewing it from a one-sided, individualistic standpoint, or in the practical form in which it comes up to the station. One great need is a more careful definition of problems. In agriculture they are unusually complex, and the factors they embrace are often quite obscure. We are apt to see these problems in their composite character, as involved, practical questions, rather than in their fundamental aspects. Attempts to solve them in such form really aim at providing empirical rules for farming and usually lead to results which are themselves largely empirical.

Coöperation and correlation may result in minimizing duplication. Repetition is all right if warranted, but we all know there has been a vast amount of going over similar ground in a similar way without adding anything new that is material or contributing to the final solution. There is, of course, little reason for duplication which is not constructive and fails to take account of what has gone before.

Then again the lack of coöperation and better understanding has had an unmistakable effect on the public. Fragmentary, inconclusive and discordant results have led to criticism and lack of confidence. There is still need to inspire the confidence of the public, to create the feeling of dependence on the teachings of experimentation, and above all to avoid confusing the farmer and his teachers.

If the extension workers are to bank on experiment station results and conclusions, the latter must be well fortified and

beyond the controversial stage when they are given out for popular consumption; we should agree fairly well among ourselves, or understand why we do not agree without reservations. I think the station bulletin is an improper place for criticism and controversy. These are appropriate in their place, but their proper place is the scientific journals and the meetings of specialists. In the station bulletin they are likely to be misinterpreted and to weaken the position of investigators.

One essential to joint effort is the provision of conference of those involved or disposed to join hands. Nothing can take the place of this in organizing work, and in analyzing and determining what should be covered in the solution of a problem. Coöperation must be a democratic effort. A centralized, made-to-order plan, to be followed rigidly by those who participate, starts off wrong. Coöperation should begin with the outlining of the problem and the making of the plan. It is in this that the different views and breadth of knowledge of facts and conditions are of great advantage. Out of the exchange of ideas and the discussion of the real nature of the question at issue there should come more carefully digested and effective plans for attack.

Finally the plan should preferably be as simple and elastic as the subject will permit, leaving as much latitude as possible to individual initiative, preference, and ingenuity. The whole effort should be informal, but at the same time it should not be without coherence and follow-up, or it will disintegrate into unrelated, independent effort.

The most important thing at this time, therefore, is to recognize the advantage and develop the spirit of coöperation. The next is to provide the opportunity and means for it. There needs to be a wider knowledge of what is being done and where, such as you have attempted to provide, and there should be free intercourse among those engaged in common undertakings. I think it is becoming apparent that we have less and less to fear from unworthy competition as a result of exchange of ideas, and more and more to gain from combined and coördinated effort.