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Throughout a varied career as schoolteacher, professor, scientist, farmer and now banker on the International Development front, I have been in many strange and difficult places. None has been more strange or difficult than this, my present role amongst economists of world statue. I am not an economist, so that on this program I feel very much alone. No longer am I engaged in agricultural research so that on this count too, I could be disqualified as unsuited to handle the topic now before this conference.

Yet I am proud to be here and deeply conscious of the honor accorded me by your invitation. I might add that none has been more surprised than my colleagues at the World Bank to see my name on your program. The Bank rather prides itself on its collection of high powered economists. It certainly does not count me amongst their numbers. In all these circumstances, I can but try to justify the confidence your program committee has placed in me in respect to the important assignment with which I am entrusted.

My only qualification for attempting the task, is that I am supposed to have achieved some practical success in co-ordinating economic and technical research in agriculture. Apparently, I am credited with actually doing this job over the last twenty-five years when I led fairly large groups of research workers in my native land. With this background, perhaps the best way of leading into the subject is to outline my personal philosophy on the

issues involved and thereafter describe the methodology and results which have been the inevitable outcome. From such an outline, the pre-requisites and conditions for a more widespread application of co-ordination may emerge.

Throughout my research life I have always believed firmly that the prime responsibility of the agricultural scientist is to serve the industry of which he is a part. In any developing country, this defines very clearly the work to be done. In practice it means applied rather than basic research. It leaves basic research to the more wealthy developed countries which can afford the luxury of the pursuit of knowledge for the sake of knowledge. It means that the agricultural technologist takes established principles and promising theories and develops from these, techniques that can be fitted into a pattern and program of production. Acceptance of this view does not imply disinterest or non-participation in basic research that turns up new knowledge, evolves new theories or modifies old ones. Soundly designed and executed applied research often does these three things as by-products of the main objective. It is fortunate that this is so, because it is this that recruits and retains within the field of applied agriculture, those bright creative minds that are essential to it. The key point is, that in contrast to the attitude of the purist who avoids as a plague any taint of economic justification for his existence, the agricultural research worker is proudly dedicated to the underlying motive of usefulness.

Acceptance of this attitude points directly to methodology. I do not need to remind this audience that farming is a business and as such is controlled by economic forces; that these forces are basic and can have effects upon agricultural performance of individuals and countries even more

potent than the forces of technical efficiency. The agricultural technologist cannot afford to ignore this at any time. He needs the active co-operation of the economist at many stages of his work. He needs this in defining, highlighting and pinpointing the problems requiring research attack for their solution for his program to be soundly based on foundations of usefulness. He needs the economist in interpreting application potentials of his results. He needs him in evaluating the consequence of his contributions upon the economic health of the industry. Clearly, this co-operation must be on a continuing basis. Not only should economic attitudes lie behind any applied technical research program but changes in programs which time must bring should be similarly based.

Acceptance of these views is not without its impacts upon the work of the agricultural economist. To the degree needed in any given circumstances, his research priorities must lie in the direction of appreciating his direct responsibility to assist the technologist. He must provide appropriate analyses of economic forces capable of modification by technical attack. He must provide adequate measurement of the impact upon efficiency of definable technological weaknesses. He must be able to delineate the areas of economic weakness as guidelines to the technologist who has to decide just where his scientific effort may best be concentrated. The economist must do all these things with a keen sense of priorities, and in fact, perhaps his greatest function is to pinpoint needs. In other words, co-ordination of effort of the type envisaged in the title of this paper implies that the agricultural economist also should be motivated by the concept of usefulness. In this he must appreciate his dependence on technology for his attitude to

be creative and forward-looking, rather than merely descriptive or historical. Without mutual appreciation of the need for and the potentials of conscious partnership along common lines, each group runs the risk of working in a vacuum. It is a tragedy that this risk is a reality in so many countries.

When I began research some 25 years' ago, my thinking was strongly influenced by a monograph on the New Zealand dairy industry published in 1926 by the late E.J. Fawcett, a Cambridge trained agricultural economist. Fawcett had spent several years in the extension field and later became Director General of Agriculture. He was the first to make a critical appraisal of the dairy industry in terms of inputs and outputs and of the relative significance of factors affecting efficiency. Based on the survey approach, the study which has largely dominated research thinking ever since highlighted five main points :

(1) It focussed attention on the overwhelming importance of pasture rather than forage crops and concentrates to the efficiency of the New Zealand dairy industry.

(2) It highlighted the key importance of output per labor unit within the New Zealand economic scene.

(3) It raised doubts as to the importance of high yield per cow - elsewhere a major criterion of efficiency - under the peculiar economic and production conditions operating in a grassland environment.

(4) It stressed the major contribution of animals per unit area rather than output per animal, to output per acre and hinted at possible important interactions between them.

(5) It advanced the concept of output per acre as the most significant single criterion of efficiency within the then and likely future economic structure of the industry and advanced production targets in such terms.

Since Fawcett's original contribution, others have carried on the work and covered the whole range of farm production in New Zealand. The New Zealand Dairy Board set up a special group to make continuing studies of a similar type, supplemented by efforts to isolate technical causes of inefficiency. The Meat and Wool Producers Boards, encouraged by this example and the many dividends that quickly accrued to dairying through technical research, stimulated by and aligned with economic findings or suggestions, followed suit and established an economic group with comparable objectives. Other farming bodies along with the Agricultural Universities likewise contributed. By and large, the coverage has been such that for many years, no technical researcher has been under any illusion as to the precise economic niche into which his or her particular contributions might fall. Equally, the economic researcher has benefitted by the two lane bridge thereby created.

It was in this general climate that I began to develop the Ruakura Animal Research Station 21 years' ago. The Station's role was to study the whole field of animal production - New Zealand's greatest industry - by welding into patterns of production, all the manifold contributions of specialist science. In this general climate I was never in doubt as to what the research program of the station should be. With such a strong personal economic bias, I had likewise no doubts as to how the program

should be implemented. Lastly, I soon became aware of the organizational implications.

Taking implementation first, the 2,000 acres of Ruakura quickly became divided into forty or fifty farmlets each carrying sufficient stock to permit not only sound scientific interpretation, but reasonable economic appraisal of the effect on production efficiency of the particular factor or factors under study. This experimental farm approach as opposed to the normal field plot technique, involved the annual use of some 750 head of beef cattle, 750 head of dairy cattle, 6,000 sheep and 1,000 pigs. This farm scale operation accelerated application of results to the industry as a whole.

On the program side, the objectives called for studies on feeding, breeding and management in a grassland environment. Nutritional teams were charged with the responsibility of studying pasture as to food for ruminants. They were specially interested in efficiency of pasture utilization, the problems of pasture production having already been mainly solved. Their main yardstick was output per acre. The interactions of this with output per animal and stocking rate became a question of great fundamental and practical economic importance. These teams were also intrigued with problems of pasture quality in relation to animal performance as providing the key to better production on problem lands and pastures. The contributions of these groups concerned have become internationally recognized. They have affected the thinking and the approach of grassland workers throughout the world, resulting also in much rewrite of standard texts on animal nutrition - a science developed mainly from studies of the stall fed, concentrate fed animal rather than the free grazing ruminant which characterises most of the sheep and cattle world.

Animal breeding teams faced the very real challenge that high output per animal might not necessarily be the most desirable goal. They concentrated on inheritance/environment studies designed to elucidate the key interaction problems. They brought animal size into their calculations as a determinant to efficiency in the special conditions of a grazing environment. They were able to demonstrate the superior contribution of animals of small size and high genetic merit to output per acre even in poor environments where stock is subjected to considerable stress. They developed breeding methods to provide such stock. In other words, they too adopted essentially an economic attitude to their work.

On the Management side, a whole host of studies were aimed at plugging demonstrated leaks in the efficiency picture. Output per labor unit as well as per acre were the underlying targets. Thus, the daily task of cow milking, the greatest single labor demand of the dairy farmer, was tackled by a milking machine team. Its contributions of non-stripping, machine stripping, the herring-bone milking shed, circulation machine cleaning, and improved milking routines based on time motion studies and physiological experimentation soon led to major improvements in milking management, and stepped up the practical level of cows milked per man from 50 to 90 head. These contributions alone, today permit the national herd of 2 million to be milked by 8,000 fewer milkers than were needed 15 years' ago - a wage saving equivalent to over £ 6 million per annum. On the animal health side, effort was concentrated on management procedures designed to reduce the impact of the most serious causes of heard and flock wastage. Industry surveys pinpointed these with accuracy, so that one by one, major scourges have been

eliminated from flocks and herds and the average length of productive life of livestock raised to a level higher than in any other major livestock country. On the organizational side, it cannot be too greatly stressed that this attitude and approach virtually forced the adoption of a special type of research organization. It insisted on a project basis to research in which the requisite specialists including economists were drawn together as a team with the common objective of attacking the problem decided upon. This is in marked contrast to the more usual type of organization where scientists are grouped in relatively independent specialist departments and where, in consequence, co-ordination, and in particular, economic co-ordination is most difficult to obtain. The project method tends to keep the feet of the scientists firmly on the ground. Specialist departmentalism so easily leads to him occupying a zone so high in the air that he is rarely conscious that the farmer exists as an economic being.

This approach described has had marked effects upon industry output and efficiency in New Zealand as even a casual examination of my country's export data indicates and economic studies support. More important to economic development, technical research of this type has extended greatly the horizons in respect to production potentials. Fawcett's target of 200 lbs of butterfat per acre of 1926 had to be lifted first to 300 lbs in the '40s and 400 by the '50s. Before I left the station in the early '60s, the 500 lb* barrier, like the four minute mile, had been broken. Similar expanding targets for meat per acre have also been set on the basis of proven performance. To justify my earlier contention that even ad-hoc work of this type is capable of turning up new knowledge of basic importance, it is not without significance

* For European workers accustomed to thinking in terms of milk, this is equivalent to 1,200 gallons of 4 per cent FOM per acre from pasture alone.

that the relatively small Ruakura professional staff earned, over the period, five Doctorates in Science and nine Doctorates in Philosophy - all from Universities of high international standing.

Lest it be thought that the units under my control alone have been responsible for progress made or alone have embraced co-ordination with economic thinking, let me stress that this is not so. Most New Zealand technical research in agriculture has been and is economically oriented. All the major advances have so originated. The scope for further progress along the same lines is great.

Thus, the continued concentration on phosphates in association with clovers as the key to high level production of animal food from permanent grassland has been due to continued demonstration and appraisal of the economic soundness of this approach. The unique and pioneering development of aerial application of phosphates in association with legume seed to over 10 million acres of hill and mountain lands with almost incredible benefits to productivity arose not merely from the economic necessity to use such areas as a matter of top priority but from a full appreciation of the continuing need for low labor costs and high per labor unit outputs. The spectacular transformation of millions of acres of New Zealand lands by application of the trace elements, cobalt, copper, molybdenum or selinium did not arise from the inquisitiveness of backroom scientists on the role of individual chemicals upon plant and animal health. It sprang from the determined and sustained effort of scientists dedicated to conversion of useless lands into usable ones.

So much for the philosophy, the methodology and the consequences. Of greater significance to this meeting should be ways and means of bringing

about greater co-ordination between economic and technical research than exists at present. There is a special need for this in the under developed areas of the world.

Deliberate organization toward co-ordination is not easy to envisage or to accomplish. So much depends upon attitude to research - the attitude of scientists, of farmers, of politicians and of the general population. This attitude springs from the complex of forces that mould and develop the kind of people of a country. It is derived from the kind and quality of their education at all levels. It is geared to their standards of social and economic development. It stems from the people's needs and the extent to which these are consciously recognised by the majority.

Obviously, strong association between economics and farming technology in New Zealand cannot be attributed solely to Fawcett's simple monograph. This merely focussed attention on problems and indicated ways and means and in particular indicated priorities. The reasons why I and my associates have gone about the business of technical research in the way we have is because our environment forced this approach upon us. We were conscious of the tremendous and pressing problems of a raw and undeveloped land. We belonged to a young nation in a hurry to grow up. We were interested in a high standard of living for our people and ourselves. There was no time to adopt the leisurely approach of the academician. Our immediate needs were pressing and clear cut. In this general climate, we had no alternative.

One is tempted to draw an analogy with Denmark, where the economic crisis at the turn of the century through the opening up of lands of the new world, forced a new way of life on the people - and perhaps was responsible

for the economic bias of technical research for which Denmark has been renowned ever since. One is equally tempted to look at the converse in the United Kingdom which so long relied upon the farm lands of her Dominions and Colonies to the detriment of her own agriculture - a situation perhaps largely responsible for the pre-occupation of British agricultural research workers with the pure rather than the applied and the lack of conscious planned attack on production problems of economic importance. When I reviewed the organization and programs of the major production research stations of Britain in 1958 on behalf of the Agricultural Research Council, it was noteworthy that none employed an Agricultural Economist, and that so few programs and projects were based or justified on economic grounds. It was staggering to find scientists so rarely exposed to the thinking of farmers and with such little knowledge of or interest in the practical problems of the industry they were selected to serve. In making such comments I am not unconscious or unappreciative of the substantial contributions to knowledge that have come from the British system. It is not without significance however, that countries other than Britain herself have capitalized on this knowledge more rapidly and efficiently.

During my last 2½ years of service with the World Bank in a wide range of undeveloped countries, one outstanding impression has been forced upon me. This is, that while organized research in the field of agriculture is largely noticeable by its absence, what does exist, rarely involves a partnership between economics and technology of the type under discussion. Most research in practice in these countries is based on the thinking and approach of the sophisticated highly developed western world. It is seldom oriented in the direction of the countries' development needs. Research trainees have tended to go back home from overseas training without any

conscious appreciation of the dignity of useful work. Their training has often been too specialized and their subsequent research designed far more to provide the prestige of publication in a scientific journal than to bear upon pressing local problems. A wide range of examples of this could be quoted if time permitted. In practice, this widespread situation constitutes one of the great barriers to investment lending in agriculture. Far too frequently, our attempts in the World Bank, to finance agricultural development projects capable of contributing to the economy of the individual and the country are handicapped or frustrated by quite inadequate local data of methods, possibilities and potentials which an economically oriented research program could have provided so easily. Far too often the Bank is thrown back on educated guesses in order to participate at all. The danger of such guesses needs little emphasis. There is a tremendous need for pre-investment studies which are soundly based in terms of both economics and technology. This international gathering, at this present stage in history, could perhaps do no better job than to use every effort to draw the attention of emerging nations to these deficiencies and to encourage and assist any movement toward remedying them. In this connection it is worth stressing that the chances of effecting economically oriented agricultural research should be far greater in countries where research organization is virtually absent or only in the process of evolution than in countries where the vested interest of long established organizations tend to work against any change in outlook or approach.

In summarizing, I would suggest six pre-requisites for co-ordination of economic and technical research in agriculture. These are :

(1) Both economic and technical research workers in agriculture should be motivated mainly by the ideal of 'usefulness'.

(2) Both groups should be trained to appreciate their interdependence and that the full benefits of their respective contributions depends upon a continuing conscious partnership.

(3) Research administrators should be selected who appreciate the desirability and need for this co-ordination, so that their policy in leadership, in the search for funds, in the formation of priority programs, in organization and in the selection of staff is determined accordingly.

(4) Research organization should be on a project, rather than departmentalized Basis so that the targets and responsibilities of each worker are unmistakably delineated.

(5) Politicians and Governments, particularly in undeveloped countries should be urged to concentrate much less on the prestige of academic research and much more on research geared to the pressing developmental needs. They should be helped and encouraged to this end.

(6) Western world training of scientists for service in undeveloped lands should be re-examined and re-organized in the light of the high priority of economically oriented research.

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