'68 S Flanagan

IRISH GRASSLAND AND ANIMAL PRODUCTION ASSOCIATION JOURNAL

RESEARCH FOR FARMING

CORRIGENDA

Page 4, line 6, for "1933" read "**1938**"
Page 6, line 42, for "the constructive way" read "**a constructive way**"
Page 7, line 39, for "soil definition" read "**scientific definition**"
Page 9, line 28, for "watering" read "**weathering**"
Page 12, line 3, for "attempter" read "**attempted**"
Page 17, line 12, for "brough" read "**brought**"
Page 17, line 33, for "aspects" read "**effects**"
Page 18, line 12, for "status" read "**value**"
Page 18, line 17, for "phosphate" read "**phosphorus**"
Page 18, Table 6, caption should read "**Soil analysis of some Monksgrange fields 1947-1960**"
Page 18, Table 7, caption should read "**Changes in levels of P and K between 1954 and 1965**"
Page 19, lines 5 and 6, for "The condition of this lime deficiency" read "**This condition of lime deficiency**"
Page 20, line 15, for "on calcium" read "**or calcium**"
Page 20, line 19, for "soil types" read "**soil type**"
Page 20, line 36, delete ", we know now that"
Page 22, line 18, for "phosphatic" read "**phosphate**"
Page 24, line 17, for "have verified" read "**has verified**"
Page 27, Table 9, headings should read "**Na K P Ca**"
Page 27, line 24, for "ration" read "**ratio**"
Page 29, line 26, for "potassium" read "**potassic**"
Page 30, line 14, for "that microbiological" read "**that a microbiological**"
Page 33, line 4, for "variable" read "**viable**"
Page 39, line 38, for "sympathetic" read "**systematic**"
Page 40, line 16, for "because of intense and" read "**because of intense interest and**"
Page 42, line 11, for "Gleeson, J." read "**Gleeson, T.**"

First Edward Richards Orpen
Memorial Lecture

RESEARCH FOR FARMING

BY

DR. THOMAS WALSH
Director of An Foras Taluntais

EDWARD RICHARDS ORPEN MEMORIAL LECTURE

The family of the late Edward Richards Open has established a Trust in his memory. It is intended that the Trust Fund should be used to sponsor an annual lecture from a prominent worker in the field of agricultural research. The Trust will select the lecturer on the merit of his work and its relevance to Irish farm practice. In recognition of the lecturer's contribution to Irish farming, the Trustees will award an honorarium to the invited speaker.

The following have kindly consented to act as Trustees along with Captain Orpen's son, John Richards Orpen, and his daughter, Mrs. E. P. Hill : R. Ivan Allen, Stan Brophy, John G. Litton and Patrick O'Keeffe.

The first lecture was delivered by Dr. Tom Walsh, Director, An Foras Taluntais, on " RESEARCH IN FARMING."

This lecture took place at the Winter meeting of the Irish Grassland and Animal Production Association on Friday, 29th November. 1968, in the South County Hotel, Dublin.

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EDWARD RICHARDS ORPEN

1884—1967

Born 20th Oct., 1884, Edward Richards Orpen was educated at St. Paul's School, London, and at Trinity College, Cambridge, where he studied mathematics.

After leaving Cambridge he farmed at Monksgrange which had been in the possession of his mother's family (Richards) for five generations. He took an active interest in the Co-operative Movement as a member of the Committee of the Enniscorthy Co-operative Society, and was also active in the Farmers' Union. He took part with Loftus Bryan and Mrs. Harold Lett in the discussions which led to the foundation in Bree of the United Irishwomen, now the Irish Countrywomen's Association.

He served in the British army in the 1914-18 war in which he variously ran a school for the care and maintenance of motor vehicles and a mobile workshop for the repair of lorries in the field. After the war, he took his family to England in 1921. There he worked for a while for the Rural Industries Bureau on the revival of rural crafts in the West of England and Wales.

He returned to Ireland in 1926 and shortly afterwards started a small furniture industry at Monksgrange with 2 carpenters and 2 assistants. The worldwide trade depression closed this venture in 1931. Later he turned to tourist development and ran Monksgrange as a guest house in conjunction with a New York travel agency until the outbreak of war in 1939.

His participation in politics started in 1932 with the formation of the Centre Party. He became an active member of the agricultural committee of that party and subsequently of Fine Gael. In 1947 the then Taoiseach, Mr. Costello, appointed him a member of the Senate. His political work led him to read widely on technical and economic developments in agriculture in other countries and he set down his views in agricultural articles for the Irish Independent. These aroused considerable interest at a time when agricultural journalism in this country was at a low ebb.

He was a founder member of the Irish Grassland Association and its President in 1951/52. He died on the 14th November, 1967.

Thomas Walsh, M.Agr.Sc., D.Sc., Ph.D., M.R.I.A., is Director of An Foras Taluntais. Born at Piercetown, Co. Wexford, he was educated at the Christian Brothers Schools, Wexford, and graduated from University College, Dublin, in 1937 with an honours B.Agr.Sc. degree. He received the M.Agr.Sc. degree from University College, Dublin, in 1933, Ph.D. in 1941 and D.Sc. in 1947. He was elected a Member of the Royal Irish Academy in 1955 and to Fellowship of the American Association for the Advancement of Sciences in 1962.

Dr. Walsh was lecturer in soil science, University College, Dublin, from 1938 to 1945, soils advisory officer, Department of Agriculture, from 1945 to 1952, and senior inspector, Department of Agriculture, from 1952 to 1958. He was appointed first Director of An Foras Taluntais by the Government in 1958 and permanent Director in 1965.

Dr. Walsh has published some 80 scientific papers in national and international journals as well as many articles of a general nature on scientific developments. He has lectured by invitation to a number of international scientific societies and academies of science. He was awarded the Francis New Memorial Medal by the Fertilizer Society, London, in 1967, and the Boyle Medal by the Royal Dublin Society in 1969.

When I was invited to give this first Orpen Memorial Lecture I was pleased and honoured to acquiesce. Many of you in this audience knew Edward Richards Orpen of Monksgrange as a progressive, innovative farmer with his roots deep in the land, concerned not only with farming but also with a wide range of interests, cultural, economic and social, which compelled him to become involved in national affairs. My colleagues and I knew him more especially perhaps for other reasons—his deep interest in research, his questioning way of thinking, his need to know not only that things happened but why they happened, his meticulous record keeping, his understanding that if a scientific tool failed to produce a given result, there was a reason. Because of these and other attributes we regarded him in every sense as a research colleague.

He provided us with facilities for our work, joined in it, made observations and recordings, discussed the results and made them known. He supported us in every way he could at a time when support was so badly needed, when research was regarded as something for the back-room and when, indeed, the word was scarcely ever heard. He shared our concept that research, as a basis for the scientific development of our resources, had much to give to Irish farming—mission-oriented research, planned to advance our knowledge so as to contribute to the needs of the community. He saw, as we did, in such research a rigorous and satisfying discipline in its own right giving stimulation to those who participated in it and capable of giving many benefits to those who used its products. Captain Orpen became deeply concerned with providing an adequate agricultural research service responsible for a national programme of agricultural research through the creation of the Agricultural Institute in which he continued to have a deep abiding interest as long as he lived.

It is difficult to pay adequate tribute to such a man and from the platform of this Association which he so often graced, I can only attempt to do so by speaking to this audience, as if he were still among you with his ear attuned to take in what is said, especially anything which might be in any way new. This was one of the attributes which made him so stimulating. I have particular reason to know this, as in looking over his farming records, so kindly made available to me by his family, I have seen myself described as the dispenser of information, when I little thought I was going on record as such. Indeed, I have seen many things in black and white in these records which neither my colleagues nor I ever thought would be written down as our words of wisdom.

I might say that I have felt for some time a deep obligation to pay tribute to a man who gave so much stimulation. Coming as we did from different parts of the spectrum of the national community, I was deeply conscious of one thing and that was his deep interest in Ireland, in the things that are of this country and in what it could and should be.

For the purposes of my contribution here I hope I will be excused for selecting from a wide range of interests and activities a few matters through which my own work brought me into especially close contact with him, subjects relating to soils and grassland and to research and its use.

In approaching this subject perhaps I might bring you back to the setting at the time I first came to know him well, just about two decades ago. It was the time when our soil fertility work in the Department of Agriculture began to take shape, when the facilities which had been sought for so long and, indeed, which some years previously had been the cause of such considerable controversy, began to materialise. The effects of the war were beginning to disappear, more fertiliser was becoming available, we were already aware that the nutrient levels in our soils had, after half a century of depletion, reached as near rock bottom as they could go.[1] Lime deficiency was a major problem with a backlog of many millions of tons to be made good. We knew that a major programme of soil fertility building was urgently necessary to secure increased production of crops and pastures. In fact, for a considerable time we had been dissipating our national heritage. We knew the general road which should be followed. We were very short on certain facts. However, we were certain the position could be remedied by a deliberate, scientific fact-finding approach. This is the basis for progress today and will continue so tomorrow. The old traditional way had let us down. I might remind you that at that time (1949) our average yield of cereals, for instance, was less than 20 cwt. per statute acre, sugar beet yields about 9 tons per acre; there were some 46,000 more farmers in the country than today; we had only 10,000 tractors. The overall output from agriculture was £91 million compared with £194 in 1966. We were using then on average less than one-tenth the amount of fertilisers and lime we now use.

Some two years or so previously, experimental work at Johnstown Castle and other centres had started, and in this service, while "outside the walls", Monksgrange began to play a special part as a farm where results could be subjected to assessment under practical conditions, in the certainty that if they did not match up we would hear about it in the constructive way and where, moreover, we could attempt to quantify our findings. It was a farm which presented some unique soil fertility problems. In the early years of this approach it was not all sunshine. There were many seeming failures, many things we could not understand then, many reverses in applyng advice which would have daunted a lesser man than Captain Orpen. It is because of this that I have specially chosen some of these problems which were particularly frustrating at the time, particularly intriguing to him and on which, as time went by, he periodically brought me to book.

Consequently I am going to discuss the soil as a basic resource; its drainage, its physical condition, its acidity, its nutrient relationships. I want to talk about grassland management and I want to talk about the use of research. I wlll trace these subjects from where we started at Monksgrange, through to the present day developments and I will say something of the future.

The soil—a basic resource

It was realised from an early stage in our soil fertility work that if the results of experiments were to be interpreted and used efficiently, the information would have to be related to soil type difference as defined scientifically. That such a scientific definition was possible had already been determined by the work of Gallagher and Walsh,[2] and subsequently extended by Brickley[3] to the predominantly tillage soils of Co. Kildare and by Spain[4] in Co. Limerick.

In attempting to resolve the complex problems on the Monksgrange farm, the first step was to make a thorough inventory of the soils resources and to identify the limiting factors. This meant a detailed survey of the farm, characterising, defining and delineating the different soils occuring.

As can be seen from the soil map made at this stage (Diagram 1) very striking soil type differences emerged, paralleling practical farm experiences in a rather striking fashion. In this connection Captain Orpen had been an accurate and detailed observer and recorder of such differences. There were wide variations in different parts of the farm in relation to suitability for general cropping, and for grazing in relation to such aspects as earliness and poachability. For instance, the free draining soils of the farm exhibited a striking difference towards loss of lime compared to the more impeded soils.

Captain Orpen was especially intrigued that these production differences could be so clearly shown on what the soil augur brought up. Thereafter he became a firm convert to the concept of soil definition and classification of our soils as a basis for development. He clearly realised that the particular type of farming system or systems were inextricably linked to the soil or soils found on the farm. For us this capacity of observation as a basis for developing interpretive parameters for different soils was a most important matter at this stage.

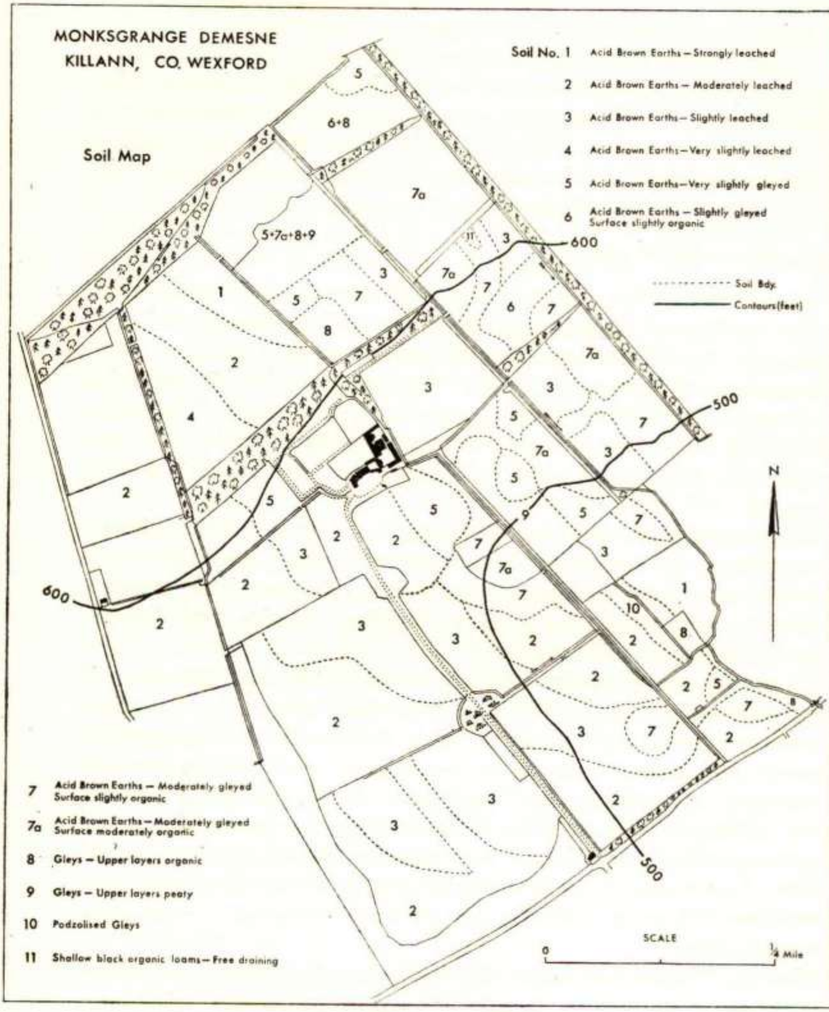

MONKSGRANGE DEMESNE
KILLANN, CO. WEXFORD
Soil Map
Soil No. 1 Acid Brown Earths — Strongly leached
2 Acid Brown Earths — Moderately leached
3 Acid Brown Earths — Slightly leached
4 Acid Brown Earths — Very slightly leached
5 Acid Brown Earths — Very slightly gleyed
6 Acid Brown Earths — Slightly gleyed Surface slightly organic
7 Acid Brown Earths — Moderately gleyed Surface slightly organic
7a Acid Brown Earths — Moderately gleyed Surface moderately organic
8 Gleys — Upper layers organic
9 Gleys — Upper layers peaty
10 Podzolised Gleys
11 Shallow black organic loams — Free draining
Soil Bdy.
Contours (feet)
600
500
N
SCALE
0
¼ Mile

Diagram 1

Our techniques of soil classification were in course of evolution. We realised that unless soil classification could be applied to the solution of practical problems, unless good interpretive maps could be made for practical use, soil survey would not achieve its potential. This was obvious to us from developments in some countries where soil survey had been approached as a more or less academic exercise.

Against the background of experience gained at Monksgrange and similar places, through the pilot survey of the soils of Bansha[5] and through the determination of the production characteristics of some of the major soils throughout the country, we set about establishing a soil survey and classification system. This, while in line with international systems and fully scientific, was to emerge as interpretive with a distinct practical function, geared to meet the requirements of this country.

Our approach can be be seen by the manner in which the problem of defining cobalt deficiency conditions in the country was undertaken. As this matter has been dealt with fully in a number of publications (5, 6, 7) I will simply summarise here, against the background of the data in tables 1, 2 and 3.

It was established that the cobalt status of our soils was related to such pedogenetic factors as parent material, weathering, leaching, podsolisation and drainage, all of which are reflected in the morphology of the soil profile. It was thus possible to classify the problem in the following categories:

(a) inherent deficiency due to low levels of cobalt in the parent material of the soil;
(b) developed deficiency due to watering, leaching and podzolisation;
(c) developed deficiency related to the moisture status of the soil;
(d) induced deficiency resulting from liming and other cultural practices.

TABLE 1: Content of trace elements[1] in relation to parent material in 3 County Wexford soils.

Soil	Horizon	Li	Rb	Be	Zr	Cr	V	Mn	Co	Ni	Pb	Sn	Mo	Cu	Ba	Sr
Kiltealy (Granite)	A_{11}	55	230	10	100	20	10	600	1	5	45	10	<1	10	300	100
	A_{12}	555	190	25	100	20	5	750	1	5	35	10	<1	10	300	100
	B	95	240	25	250	20	10	750	5	10	50	10	<1	10	300	100
	C	150	290	80	100	15	10	750	5	10	50	10	<1	10	300	100
Old Ross (Granite-Shale)	A_{11}	90	180	10	100	30	7	1,000	7	10	70	10	<1	10	350	50
	A_{12}	90	160	5	100	30	5	750	5	10	50	10	<1	10	300	30
	A_{13}	90	190	10	80	30	5	750	6	5	20	4	<1	15	300	40
	C	70	290	20	200	30	5	750	9	20	50	8	<1	10	300	30
Clonroche (Shale)	A_{11}	80	130	<5	200	60	90	4,000	17	25	35	5	1	10	350	25
	A_{12}	90	170	<5	300	75	90	4,000	15	25	25	5	1	10	450	25
	B/C	95	190	<5	250	95	95	7,500	15	70	20	5	1	10	500	30

[1]=All results expressed in ppm.

TABLE 2: Cobalt status in relation to weathering and leaching.

	Soil	
	Curragh	Moor
Horizon	Cobalt ppm	Cobalt ppm
A_1	5·0	0·0
A_2	5·7	2·2
B_{21}	7·2	9·9
B_{22}	8·7	7·2
C_1	2·2	2·6

TABLE 3: Cobalt status in relation to soil drainage class

Drainage	Free Draining Profile			Strongly Impeded Profile (very poorly drained)		
	Cobalt (ppm)					
Depth (cm)	Total	Acetic soluble	% of total acetic soluble	Total	Acetic soluble	% of total acetic soluble
0-15	7·25	0·19	2·6	1·60	0·16	10·0
16-30	7·90	0·16	2·1	1·66	0·17	10·2
30-45	8·50	0·08	0·9	3·83	0·23	6·0
45-60	7·25	0·07	0·9	8·52	0·26	3·05
60-75	7·00	0·10	1·4	—	—	—

In Table 1 we see three soils in fairly close proximity with different contents of trace elements, e.g. the low levels of cobalt and manganese in Kiltealy soils as compared with Clonroche soils.

In Table 2, the Moor soil is much more highly weathered than the Curragh soil. This is reflected in the lower cobalt levels in the surface horizon. It can be seen from Table 3 that while the total cobalt content of the free draining soil is much higher than that of the associated very poorly drained soil, the solubility of this element in the latter soil is much higher.

Proceeding in this way it was possible to delineate broad areas of cobalt deficiency and, indeed, to foretell where such deficiencies were likely to occur. This approach was highly rewarding and has been used since in the investigation of other trace element anomalies, e.g. Manganese, Boron, Molybdenum, Copper and Selenium. It has been extended since by some of my colleagues in a study of the trace element problems in European soils. [8]

In this way soil problems in general have been approached, such as for instance, the stock carrying capacity of grassland for which a prelminary interpretive map has now been attempter (diagram 2).

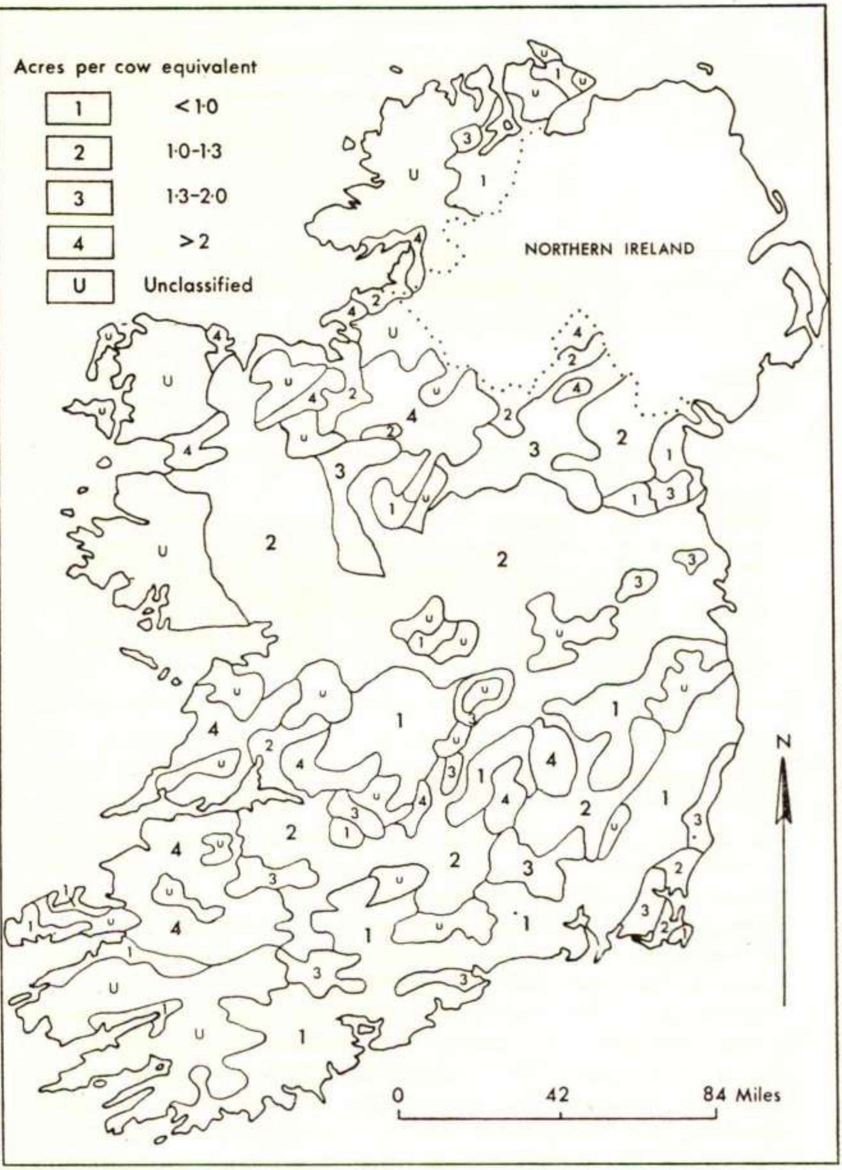


Diagram 2

Stock carrying capacity of grassland—preliminary interpretive map

I think many in the audience will know of the differences existing between the stock carrying capacity at Moorepark at one cow per acre, and Ballinamore at one cow per two acres. These differences are, of course, due primarily to basic soil characteristics which can be scientifically defined.

As agricuture intensifies, this approach will increase in importance. In the development of agricultural systems covering the chain from the soil to the table, as they must inevitably in a market-oriented environment, the first link — that of the soil — is of primary importance. There are, of course, a great many first links as the soils of our country are so variable. It is true that under extensive systems of husbandry, basic soil characteristics particularly those of a physical and physico-chemical nature, may not seems so important. However, as farming intensifies and becomes more competitive, and as we have gained mastery over the input of lime, major nutrients and, indeed, trace elements, these basic soil characteristics largely determine soil use.

Today the knowledge of our soils is advancing on a county, regional and national basis. We are defining clearly the use characteristics of our soils for various national land use purposes, whether it be the competitiveness of our soils in terms of market situations or their use for forestry, recreational or related purposes. There is a considerable variation between counties in the extent of land of different potential and as can be seen from Table 4, counties have their share of good as well as poor quality soils. Four broad land

TABLE 4. A land classification for some Irish counties.

County	Land Class (%)			
	I	II	III	IV
Carlow	67	4	23	6
Wexford	60	13	22	5
Monaghan	48	21	18	13
Limerick	38	8	43	11
Roscommon	35	38	18	9
Mayo	23	20	12	45
Cavan	23	53	13	11
Sligo	21	41	16	22
Clare	14	14	46	26
Donegal	13	25	2	60
Kerry	10	14	23	53
Leitrim	1	2	64	33

classes are shown: Class I comprises those soils with a wide use-range capable of competitive production for a variety of agricultural enterprises; Class II soils are capable of improvement to the competitive status, but for a somewhat more limited range of uses; Class III soils can also be improved considerably but would still be limited in use-range and would not compete favourably with Class I and II; Class IV soils are very restricted in use-range and even with improvement could not compete economically in agricultural production. However, soils of restricted capacity in economic agricultural production may have to continue in agriculture for social reasons and they may also have very rewarding uses for non-agricultural purposes.

The physical condition of soil

As can be seen from the soil map of Monksgrange, impeded drainage was a problem on a sizeable acreage of the land. It was natural to expect then that Orpen should have been deeply concerned with drainage problems. Indeed one of my earliest memories of Monksgrange was being brought to the Tubbernagay Lower field where the old tile drainage system had been identified at a depth of four to five feet. It was a matter of considerable fascination for him that the seemingly rather clear drainage water on coming into contact with the air should show a brown deposit, which, of course resulted from the oxidation of iron from the ferrous to the ferric state, causing a blockage in this old tile drainage system.

In his approach to drainage, Orpen the engineer, looked on it basically as an engineering problem. Early on in his exploration of the cause of drainage impedence the main problem at Monksgrange was identified as being associated with springs as a result of seepage from the adjacent hill-land area. At an early stage in the development of the Land Project a scheme was prepared for Monksgrange which took this origin of the problem into account. This development must be seen against the fact that drainage techniques, evolved traditionally for the most part, had not changed for a century or so and were the only methods available to the Project when it commenced activity. These methods allowed little scope for variation according to the nature of the drainage problem. It must be said to the credit of the Land Project staff that, faced with this position, they were prepared to innovate as the circumstances demanded. I may say in tribute to them that I have always found them open to advice and guidance in this respect. Research, however, had not at that time provided the facts. Nor indeed, in this particular respect, is it adequate yet.

It is also of considerable interest that the drainage problem identified at Monksgrange over twently years ago occupied a premier place in the recently completed survey carried out by our research staff in co-operation with the Land Project as shown by Table 5.(9) The survey was designed to collect and analyse information on the problems which made drainage necessary and on the techniques used in solving these problems.

Detailed information was collected from 16,336 schemes (120,952 acres).

TABLE 5: Drainage Survey

Major problems encountered	Acreage percentage
Seepage and springs	37·8
Impervious subsoil	31·0
High water table	23·8
Impervious topsoil	2·0
Hollows	1·8
Impervious layers	1·7
Cemented layers	0·9
Flooding	0·8
Iron pans	0·2

It is of interest to note that broken old drains were found on 43.2 per cent of the total area. This means that an existing system of broken or choked drains was found on over 52,000 acres—many of these were, of course, very old drains.

The records at Monksgrange note with interest that on a visit to Johnstown Castle the staff there " were now developing methods for the determination of soil structure ". As pointed out previously methods of drainage were traditional and had not changed for a long time. It was appreciated, however, that more research was necessary. In the early 1940's scientists in Great Britain, the United States and Russia had subjected water movement in soils to a systematic analysis, developing a theory of waterflow. This was the basis for a new scientific approach to drainage problems. Since those days our work in this sphere has proceeded systematically if somewhat more slowly. The situation has been conditioned just as much by the lack of appropriate techniques as by the resources available. However, progress has been made. At Glenamoy, for instance, research[10, 11, 12] has set a basis for the understanding of the behaviour of water, when and how it falls, what happens when it reaches the ground in terms of permeability, evaporation and the whole balance of the moisture regime.

Despite the fact that our climatic conditions create wetness in soils and that in this country it constitutes a major barrier in land use, one might well ask why so little attention had been devoted to this aspect of investigation until the work at Glenamoy commenced.

An understanding of the water-balance is essential to the development of a rational drainage system. It varies from region to region and from soil type to soil type. The work at Glenamoy has not only provided information for the Glenamoy situation of deep blanket peat *per se* but has resulted in the establishment of a methodology whereby soil moisture problems for the country as a whole can be studied.

I have dealt elsewhere with the inter-relationships between fertiliser use and soil moisture conditions[13] showing that fertiliser application can blanket drainage effects to a considerable extent as far as yield is concerned. This has emerged in a striking way from a recent report by Burke[14] which, as can be seen from the following summary of results, shows that from a total yield aspect, nitrogen eliminated the yield-depressing effect of a high water table.

Four crops, viz. two grasses, potatoes and oats were grown on blanket peat under different intensities of drainage: no drainage, 1-ft., 2-ft. and 3-ft. Drains were spaced at 10-ft. centres. All crops responded to drainage. Yields from drained plots were higher than those from undrained plots. However, with grass, an increase in nitrogen application eliminated the yield reduction caused by high water tables.

This finding has an application not only to peat soils but also to many poorly drained mineral soils. It does not, of course, eliminate the management restrictions of high water table due to wetness as such.

As shown by the results of the drainage survey referred to previously low permeability is a problem on major areas of Irish agricultural land. It may be as high as 15 to 20 per cent. It is the condition responsible for infertility of the poor lands of the northern Drumlin belt, of West Limerick and Clare and sizeable areas in Kilkenny and Wexford. This can be seen from the results of the National Soil Survey.[15]

The research station at Ballinamore, Co. Leitrim, was established in order to develop information on these soils. Results to date there have shown clearly the inefficiency of conventional drainage methods. Again, studies on water balance, drain spacing, mole drainage and the impact of different stocking rates under varying experimental conditions, have provided valuable new information. There is no short-term solution to this problem. Only systematic studies can bring the answer; even then, farming under these conditions will have severe limitations.

Poaching is another important problem which has engaged the attention of our soil physicists. It emerges as a specific problem associated with the intensification of pasture management which, for many of our old pasture soils, results in the removal of the surface mat. With more animals per acre the problem may become acute in certain soils. Indeed, for a wide variety of our soils, such as those at Ballinamore because of their weak structure, poaching is one of the major problems limiting stock-carrying capacity, and thereby restricting economic farming. Studies to date on this matter—and I must confess that because of lack of resources and techniques they have been very limited—have brough forward interesting facts. These have been discussed by Gleeson.[16]

In brief, it may be said that today for the first time we are able to measure poaching. From the techniques available, information can be obtained on the poaching potential of soils, its significance from the production aspect and how its worst effects can be overcome. These vary, of course, for different soil types and, indeed, in this respect, I might again emphasise the significance and necessity of identifying and mapping the relevant soil differences. Referring to the map of Monksgrange we can see that there is a wide difference, for instance, between poaching potential on freely-drained as compared with the impeded soils. This was well appreciated by Captain Orpen in his management approach.

There are many other problems relating to the structure and conditions of our soils which remain to be explored. As new husbandry methods for tillage crops develop, resulting from modern methods of cultivation, sowing, weed control and indeed harvesting, the limitations in our knowledge relating to soil structural conditions will become increasingly obvious. In this connection, for instance, reference might be made to the use of selective weedicides for more or less permanent crops such as fruit trees and soft fruits where weed control can be effective with favourable aspects on surface rooting and crop response. The question arose as to whether the constant use of weedicides might have a deleterious effect on soil structure. Bulfin[17] using a micromorphological technique showed that while there was a skin effect, this was, if anything, beneficial to soil structure. This was a very valuable result.

Finally, it would be very difficult to over-emphasise the importance of the structure of our soils as related to our climate, especially as we gain more control over the factors of production. After all, every day a farmer goes out to work in this country one of the main problems he has to face is that of the weather.

Soil fertility conditions

From an early stage, Orpen became interested in the possibility of soil testing, i.e., the determination of the nutrient status of soils by appropriate chemical or other methods. He had read widely of the success being achieved elsewhere by the application of such methods and was a foremost advocate of their use in this country in the early 1940's. With the establishment of the soil testing service at Johnstown Castle one of the first farms subjected to a planned system of soil testing, through the medium of advisory services, was Monksgrange.

Since those days almost yearly records were kept of lime requirements and nutrient status—a process which of itself was of very great status at the time as it enabled not only annual nutrient changes to be monitored but also the correlation of soil test data practical response effects. Information on this was very meagre at the time. These early tests, reflecting in many ways (apart from aluminium) the national situaton at the time (see Table 6), showed major deficiencies of lime, phosphate and potassium, and abnormally high levels of aluminium (Table 7). Some aspects of these conditions are now discussed.

TABLE 6: Changes in levels of P and K between 1954 and 1965.

Field	pH	Ca	P	K	A1
		(expressed in ppm)			
Upper Kilpark ...	4·9	100	0·5	50	250+
Lower Kilpark ...	4·8	200	0·5	25	200
Moat Meadow ...	5·1	200	0·5	25	300
Newtown	5·3	150	0·5	50	250
Sheepwalk Upper ...	5·0	100	0	25	200
Carlow Meadow ...	5·1	400	0·5	25	200−

TABLE 7: Soil analysis of some Monksgrange fields 1947-1960.

Year	Percent of advisers' soil samples classified as very low in P and K	
	0-½ ppm P	0-25 ppm K
1954	77	66
1957	49	32
1965	0	5

Liming and the acidity complex

As can be seen from the early soil test results from Monksgrange, a condition of very severe lime deficiency existed with pH 5.0 and extremely low calcium levels. It is of interest in this respect that the more free draining soil types showed a higher degree of lime deficiency than the more impeded types. The condition of this lime deficiency was reflected in a practical way in the fact that it was almost impossible to grow a barley crop there, very low yields being the result, while in a newly laid down pasture there was a quick die-out of ryegrass and clovers and a rather spectacular reversion to *Agrostis*-dominated swards. Test plots using ground limestone showed a very striking response from barley and indeed because of previous experience in the whole area in this respect, these tests attracted the attention of many farmers. There is scarcely any doubt that the tests had a major bearing on the rapid increase in the use of ground limestone in that particular area. This lime-deficient condition of the soils at Monksgrange was no better or no worse than that which existed in a large area of the soils of the country at that time. It must be remembered that we were then using about 50,000 tons of lime, that nationally it had been shown that there was an annual depletion of over $1\frac{1}{2}$ million tons per annum and that indeed a very serious conditon had been reached, not alone for non-limeston derived soils but also for those in limestone areas.[1] It may be of interest to record here that this data set a basis for the subsequent ground limestone scheme.

Further experience at Monksgrange showed that under the conditions there, relatively heavy dressings of ground limestone were necessary to obtain the best effect while frequent liming was required. Subsequent investigation showed that the soil had very high levels of soluble aluminium and this together with other experiences elsewhere, focussed attention on what we described later[18] as the soil acidity complex. To illustrate what this means perhaps our experience at that time might be quoted. At Johnstown Castle we had identified a situation where excess manganese under acid conditions was an important factor limiting the growth of a number of crops such as swedes, sugar beet, barley, wheat and, in a rather spectacular response effect, oats. Our later experimental work at Johnstown Castle showed that this effect could be counteracted not only by high liming but also by drilling phosphate and, for swedes, by the application of molybdenum. In other words, a complex condition existed. At Monksgrange, very high levels of readily soluble aluminium, later shown to be in the region of some 750 lb per acre, were found. On the other hand at Cushinstown not very far distant, satisfactory crops of barley were grown at a pH level exactly the same as that at Monksgrange. Here then were three distinctly different response conditions at similar levels of soil acidity as such. Later work showed that these acidity factors such as aluminium and manganese determined to a very considerable extent the quantity of lime which should be applied. As an extreme one can quote ground limestone requirements of 5 to 6 tons per acre at Monksgrange at a pH of 5.0 and of 1½ tons per acre for the peat soil at Glenamoy at a pH of 4.5 in both cases necessary to achieve optimum effects. In the latter, of course, there were no toxic elements present.

From these various experiences our work and concepts developed relating lime requirements to soil conditions, taking into account the specific factor concerned—in one place manganese, in another aluminium and in other cases molybdenum/manganese balance effects on calcium, with boron relationships also coming into the picture. I have described this situation elsewhere[18] so I will not repeat the details here except to point out that these particular experiences and studies laid a basis for our whole approach to liming against the background of soil types and ecological factors.

Subsequent experimental work has continued to advance our knowledge in this sphere. For instance, the question of fineness of grinding of limestone was of importance because with coarser grinding, costs were considerably lower. It was shown that even relatively coarsely ground limestone was reactive. In view of the decrease in the solubility of a number of trace elements under high liming conditions, the question of the quantity of lime to apply became important. Again, it has emerged that this is basically a matter of soil type relationship. For instance, on some strongly leached Old Red Sandstone soils where manganese has been removed from the surface soil, relatively low dressings of ground limestone can give rise to manganese deficiency in crops. On the other hand, our experimental work has shown that on some soils, dressings of ground limestone even up to 32 tons per statute acre give a significant response effect.

While in early years our liming requirements were based on the consideration of only pH and calcium, we now know that status of the soil, the improved knowledge of soil conditions and of the factors involved in this complex has resulted in the development of more specific methods of lime requirement determination. These in turn have resulted in recommendations involving rather higher dressings giving increased efficiency.

Today for the first time it is possible to say that the inputs of lime are equal to, or exceed slightly, the annual losses incurred through crop uptake and leaching. Well limed soils are still the bedrock of soil fertility. There is much that we still require to know about soil acidity factors to ensure continued efficiency in this process. The role of aluminium, for instance, which was so spectacularly brought forward by the experience at Monksgrange, is still not clear but it is now apparent[19] that acidity in clays, for instance, is related to aluminium and not to hydrogen ions at pH ranges of normal soils as was thought at one time. We have as yet no clear measure of aluminium activity but the work of Coulter[20] in recent years has done much to elucidate some of the complexities of the position. We are now probing deeper into these problems.

Phosphorus

Apart from the very striking position with regard to lime deficiency, the next most notable feature of the soils at Monksgrange was the extremely low level of phosphorus, as shown by soil tests. This was supported by crop response effects with the appearance of symptoms of extreme phosphorus deficiency where no phosphorus was applied. In our interpretation of the soil conditions at the time, it was also considered that because of the high level of aluminium, high iron activity in the free draining soils and low calcium levels, conditions were present for rapid phosphorus loss through reversion.

These low phosphorus levels were not, of course, a special feature of the soils at Monksgrange. They were a distinct reflection of the national position at the time[21] which showed in extreme symptoms, phosphorus starvation in both plants and animals in a number of places. It must be remembered that World War II was just behind us, a period during which the national phosphorus balance had shown a substantial deficit between the years 1940-1945.[1]

Subsequent experience at Monksgrange showed that there was little, if any, residual effect from the application of phosphates except for the manuring of sugar beet where a positive increase in test results was reported. The experience over some years gave rise to a number of questions as to the best form in which to apply phosphorus, and the best method of applicaton. To examine these problems a series of experiments were undertaken (including work at Monksgrange), with different types of phosphatic fertilisers such as semsol, reverted phosphate, ground mineral phosphate, superphosphate and others in which we were then interested. It emerged from this work that the best effect was obtained by the use of readily soluble phosphate and that a " little and often " technique was the one to follow. It was clearly shown that penetration into the soil from surface applications of phosphorus was extremely slow and that indeed any phosphorus applied could be located in the surface quarter inch of the solum. Incidentally, ths finding in turn gave rise to the need to sample pasture soils on the immediate surface in order to facilitate a recommendation with regard to fertiliser application. It had emerged that at Monksgrange where deeper sampling had taken place there was a reaction during the testing procedure between the phosphorus containing surface soil and the remainder which very much diluted the phosphorus test result.

The placement of phosphorus for cereals through drilling with the grain from which spectacular effects had been obtained had just previously been investigated at Johnstown Castle.[22] The efficacy of this procedure was clearly illustrated at Monksgrange and reinforced our thinking that with the extra low level of phosphorus in our soils, the best way was to feed the plant and not the soil. To a considerable extent this approach has persisted. It may be of interest that the more recent soil tests from Monksgrange have shown a substantial change in the position, with generally higher test results all round, and this is the national position also.

Out of the experiences at Monksgrange and elsewhere a number of important questions with regard to the phosphatic status of our soils arose. To meet this situation an experimental programme was commenced which, with appropriate variations as knowledge developed, is still in operation. I will deal with a few aspects of these results.

From observations of many old pastures throughout the country, it was a matter of considerable interest to understand why some soils appeared to have a higher capacity than others to sustain the phosphorus levels of pasture plants. This was especially so in connection with some old pastures in Meath, Tipperary, Limerick and elsewhere. In order to explore this matter McDonnell and Walsh[23] studied the position with regard to phosphorus in different particle size fractions from a range of soils. For instance, in the clay fraction there was a very distinct difference between the various soils, especially in the organic phosphorus level. An old pasture soil from Co. Meath which had received no phosphatic fertiliser for years was found to have a satisfactory phosphorus status and it was postulated that its capacity to provide this element for plant growth was due to the mineralisation of organic phosphorus during the normal biological cycle in the soils. There was, in fact, an accumulation in the organic surface 3 in. indicating a stabilisation of phosphorus in that zone. There was a very striking difference between Wexford tillage soils and Meath pasture soils in this respect.

Other studies showed that phosphorus-supplying power was related not only to the amount of phosphorus in the soil but to the release capacity. This position is well shown in Diagram 3.

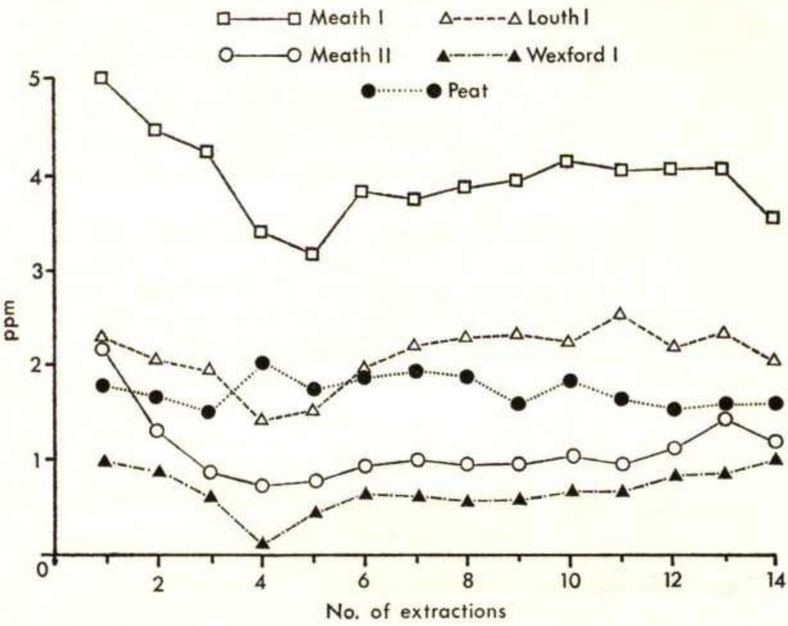


Diagram 3

Phosphorus release on successive extraction with Morgan's solution

This led to a definite advance in soil testing interpretative procedures with an understanding that the method used should be evaluated as an intensity measurement rather than a capacity index.

Another important advance arose from a study on the phosphorus status of some organic soils by comparison with mineral soils.[24] It was shown that the phosphorus in organic or peat soils was much more available and more easily extractable and that there was a striking drop in the amount extracted on continuous extraction from such peat soils by comparison with mineral soils. This can be seen from Diagram 4.

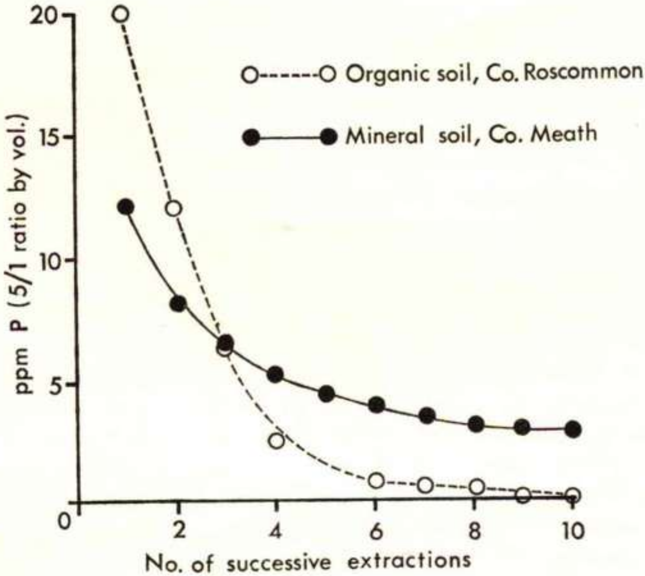


Diagram 4

Successive extraction showing the P status of an organic and a mineral soil

Later this was clearly shown again by the results of the work at Lullymore and Glenamoy [25, 26] where there has been a much higher recovery rate—some 80 percent—from the phosphorus applied to the peat soils than in the case of inorganic soils where the recovery rate is somewhere about 30 percent. In interpreting these results for our soils in general, it must be realised that the surface layer of practically all our old pasture soils has a relatively high level of organic matter. From the knowledge now available this would explain the much greater recovery of applied phosphorus than we thought possible at one time. This organic matter relationship may, in fact, also supply a clue as to why there has been such a relatively rapid build up of readily available phosphorus in our soils, particularly in some old pastures, the phosphorus recycling through the organic matter in the immediate surface of the solum.

Subsequent work by Hanley[27] and by Hanley, McDonnell and Murphy[28] have verified these earlier findings and in addition has brought forward much new information with regard to the different forms of phosphorus in our main soils. A survey[29] has shown that on average our soils contain some 751 ppm total phosphorus and that some 57 percent of this may be in the organic form. The finding that aluminium phosphates in our soils may constitute an important source of phosphorus for crops is quite different from earlier knowledge in this respect. Yet this finding has clearly emerged from a depletion study on six important soils involving 15 harvests of ryegrass, *Agrostis* and white clover.[27] It is also of significance that the form in which phosphorus is found is related to soil type.[28] An understanding of the constituents in which phosphorus is found in the organic form in soils is very important in view of the relatvely high proportion of phosphorus present in many of our soils in this form. This, as indicated previously, is of special importance in relation to the use of phosphorus on grasslands.

All this information is now playing a highly important part in the rational use of phosphatic fertilisers as a key element in soil fertility—building. There has been a striking change in the test values for samples submitted to the soil laboratory. Just about a decade ago some 90 percent of our soils showed extremely low values. Today, the position is reversed with only about 10 percent in this category, (table 6). In a major series of field experments now under way, phosphorus and other nutrient relationships are being investigated in depth as a basis for developing the best possible information to meet future needs.

Potassium

One aspect of soil fertility on which the work at Monksgrange focused special attention was that of soil-potassium-sward relationships. To put this succintly, I can do no better than quote from Captain Orpen's own observations concerning this matter.[30]

" On the foothills lying below the granite mountains of Wicklow and Wexford the farmer, in days gone by, was told that an insufficiency of lime and phosphate was the probable reason for low productivity on these lands. Furthermore it was thought that the likelihood of any potash deficiency was remote because the type of feldspar in this granite contains sufficient potassium to meet normal needs. Although some improvement followed the application of lime and phosphates, the results on the whole were disappointing and scarcely warranted the expenditure involved. This was most apparent on grassland where the more productive species soon succumbed to competition from *Agrostis* which re-established itself with astonishing rapidity.

In 1948, following the development of a soils advisory service, it was suggested that most of these soils suffered from an acute shortage of available potash and that the broken down potassic feldspars contributed very little to the amount of potash required by plant life. At Monksgrange, in 1948, a direct sowing down to grass was laid out in replicated potash strips of $\frac{1}{2}$ cwt, 1 cwt and 2 cwt of 40 per cent Potash Salts. For the first time clovers began to grow, if not vigorously, at least in sufficient strength to indicate acute potash deficiency even at the highest level of the dosage.

The following autumn a further application of 2 cwt of potash was superimposed across the strips over half the field. Now at last something began to happen; clovers became vigorous and in places even luxuriant. Observation, subsequently confirmed by tissue analysis, seems to indicate that at sowing some 3 cwt of Potash Salts should be sufficient to start growth, and provided adequate replacements of P and K are given annually, high production can be maintained even on poor hill land. To what extent productivity can be raised has not yet been determined, nor what the level of maximum profitability may prove to be on this type of land. At last, however, it does seem technically possible to double the output from grass, and at the same time improve the feeding quality of the herbage.

One field at Monksgrange sown direct in 1950 is still in a state of high production, yet so far it has not received any bag nitrogen, and we presume that what N it requires is derived from the clovers. This field has given two cuts each year for either ensilage or hay and has been grazed as well, and although it shows no build up of N in the soil at present, it seems to be able to stand up to this treatment ".

The questions raised at Monksgrange on the basis of the above experience were of particular interest. While we were aware[31] of the extent of potassium deficiency on limestone derived soils and the "fixation" reaction between illitic type clays and potassium, the occurrence of this very severe potassium deficiency on granite-derived soils was something new. However, from a national balance sheet[32] we were of course aware of the overall position. The potassium status of our soils had been severely depleted over many years and indeed at no time from the beginning of the century had sufficient potassium been applied. The first significant fact to emerge at Monksgrange was the rapid dying out of clover in sown swards. Soil tests showed a clear difference between some areas where the clover persisted and those where dying out had taken place, as shown by Table 8.

TABLE 8 :

	pH	Ca	P (Pounds per acre)	K
Good grass	6·0	2,000	1	50
Poor grass	6·0	2,000	0·5	0

These and other similar tests for Middle Kilpark showed extremely low levels of potassium as a common factor in all cases. This position was checked by tissue tests which were then developed and here again a condition of deficiency was clearly shown. Indeed there was one instance at Monksgrange where there had been an ingression of red fescue—an indicator of potassium deficiency in pasture swards—and here one of the lowest potassium levels ever in grass herbage, i.e. 0.2 per cent, was found.

Differences in the potasium level in the herbage is again shown by table 9.

TABLE 9

	Na	K	Ca	P
		(results expressed in ppm)		
Good grass	·42	1·84	0·12	0·66
Poor grass	·46	1·13	0·16	0·56

These tissue tests clearly showed that under the extreme conditions of potassium deficiency clovers always contained a lower level of potassium than the grass components of the sward—a reflection of the fact that grasses have a higher extractive capacity.

In order to explore this matter more thoroughly the plots referred to in the foregoing quotation were laid down with varying application rates of potassic fertiliser. The response was quite spectacular. Diagram 5 shows the position regarding tissue potassium.

It is of considerable interest that Orpen in his own conclusions on this matter, proposed that the potassium-sodium ratio might be of significance with the occurrence of a very wide ratio at potassium deficiency levels, and noted that in grasses the potassium-sodium ration increased to the 2.5 to 3.0 range as potassium applications increased, while in clovers the ratio remained constant. It was noticed also that as the potassium levels in the herbage increased, sodium decreased somewhat—an important fact because of the nutritional sgnificance of sodium.

The results of this work can only be summarised here. It can be clearly stated that the experience did much to set a basis for the use of tissue testing in our approach to assessing the potassium requirements of pastures, in giving information on the competition between grass and clovers for this nutrient, and, in general, forming a policy in relation to the use of potassic fertilisers.

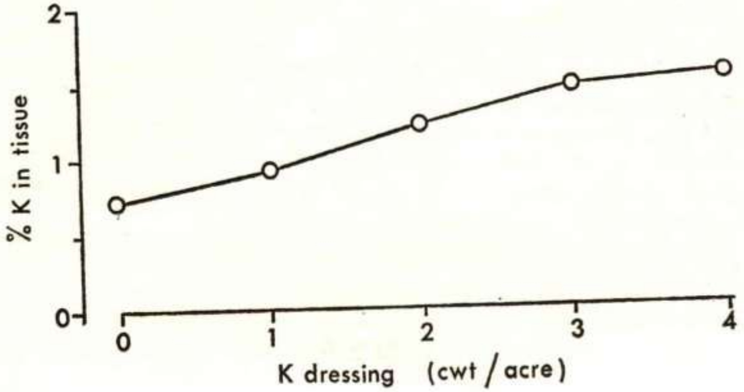


Diagram 5

K response in relation to herbage content in mixed grass-clover

It is of considerable interest that Orpen in his notes on this phase of the work included two very important observations: (1) that considerable care must be taken in interpreting tissue tests for potassium as there was a seasonal variation, and (2) that there was a stage-of-growth variation also as shown by the data obtained from monitoring the position. These were highly important deductions from the Monksgrange experiments and are still valid.

Later experiments[33] and experience showed the highly extractive nature of silage, hay and dried grass on soil potassium with a quick depletion of the readily available level in some soils. It was found that there was a very substantial difference in the capacity of soils to meet potassium requirements and also[31] that the process of potassium release was intimately bound up with the presence of certain clay minerals, such as degrading illites, in our soils, the content of which varied quite widely from one soil to the other.

On the basis of experience at Monksgrange and elsewhere, it was possible to propose principles[34] on which the potassium nutrition of plants could, from a practical point of view, be determined as follows:

(a) that level which can be regarded as the threshold point below which a lowering in potassium is accompanied by a series of physiological disturbances affecting crop growth;

(b) that level above which no further increase in crop response either in terms of yield or quality takes place, i.e. the threshold luxury level.

For this purpose clovers and grasses have different values and it may be added that while the threshold luxury value for grasses is in the region of 2 per cent, dried grass and hay samples have often been found to contain up to twice this level resulting in an extractive procedure from luxury consumption and with consequent nutrient loss.

In some recent work at Johnstown Castle, in which some 24 pasture soils representative of major areas of the country have been exhaustively cropped by a succession of ryegrass crops, there has come to light much new information in relation to the potassium-supplying power of our soils. This work has shown[35] that only five of the soils examined could readily supply the potassium necessary for a good crop of silage while a number of soils could supply only a small quantity. Some could supply a considerable proportion of the required amount from the more slowly available mineral source in the soil while others could not do this to any extent. This capacity to release potassium is related to fundamental soil characteristics in terms of clay and other minerals present and is being studied further. As with phosphorus this work has clearly emphasised that not only is the quantity of exchangeable potassium important, but so also is the intensity or relative potassium concentration in the soil solution. The relationship between these two parameters—the potassium buffering capacity—is very important in considering the uptake of potassium by crops.

The result of this work is that today we are well on the road to establishing better diagnostic methods for potassium fertiliser requirements. The practical outcome of the work from a national point of view is, of course, that today potassium is being supplied at much greater levels than in those early days of our work at Monksgrange, and these applications are taking place on a scientific basis. I think the results are obvious to anybody associated with grassland development. We have, however, in this respect reached a critical stage, especially where the intensive manuring of grassland is concerned. Now more than ever, scientific methods of diagnosis as a basis for advice are necessary if efficiency in the use of potassic fertiliser is to be ensured.

Nitrogen

The work at Monksgrange, and indeed our work in general at that time, was so dominated by the extent of phosphorus and potassium deficiencies that the role of nitrogen was not given equal attention. This arose from the fact that the economics of grassland production were bound up with making the maximum use of the nitrogen-fixing capacity of clover in swards—clover growth being dependent on adequate levels of lime and nutrients. We did not, in fact, have very much information on the amount of nitrogen which could be fixed by clovers under our conditions. The nitrogen requirements of crops other than grassland were thought to be satisfied by the release of nitrogen from soil organic matter on tillage, supplemented by farmyard manure, and relatively small amounts of nitrogeneous fertilisers were applied. Nitrogen balance studies at the time had, moreover, shown a more satisfactory overall position than for phosphorus and potassium.[1]

It is clear, however, that all was not well as judged by yields obtainable and looking back I am now conscious of the fact that nitrogen deficiency symptoms were evident in many places. Very often these symptoms were attributed to poor biological conditions. Indeed, Orpen suggested in the early 1950's that microbiological study might be carried out to explain some of these effects. At Monksgrange a particular feature was the very slow decomposition of old pasture sod in tillage—a reflection of inhibited biological activity. Some such tests were indeed undertaken. It was shown that the soil at Monksgrange had a very low nitrification rate of 35 mg per cent compared to a normal 100. It is of interest also that the total nitrogen status of the soils there was relatively low at 0.20—0.30 per cent.

Since those days considerable advances have been made in our knowledge of the nitrogenous manuring of crops generally and of pastures in particular. I am not going to dwell on the latter here as I have discussed it recently elsewhere,[13, 36] while my colleagues have presented a number of papers on the subject before this Association in recent times.

Today we realise fully that a dressing of 1 cwt. nitrogen is too low for practically any crop and that while for normal production of pastures under our economic conditions, main reliance must still be on clover nitrogen, fertiliser nitrogen has much to offer through the flexibility it provides in tailoring pasture to meet specific needs such as early and late grass for silage, hay or dried grass and to give us more control over seasonal production peaks and troughs. We now have a number of the facts which enable us to make use of this potential, and further exploit nitrogen systematically in order to achieve specific production and market targets. There are, however, one or two matters of interest which our research work has thrown up and in which I am sure Orpen would have been especially interested. For instance, it has been clearly established from experiments in the Castle field at Johnstown Castle and subsequent work there and at Monksgrange, that under good conditions of fertility the clovers in normal pastures can fix about 120 lb nitrogen per acre per annum.

A rather interesting aspect of this work in relation to nodule bacteria in peat is that when clovers are introduced without inoculation, very effective populations of these bacteria become established and this situation continues as long as fertilising is maintained. If nutrient supply is stopped the effectiveness of the bacteria declines rapidly and ineffective bacteria dominate.[37, 38]

Another line of work which is being pursued and is proving of interest is that concerned with defining enzyme pathways in the process of nitrogen fixation. Enzymes involved with some of the main processes have been identified. An important application of this work is that strains of *Rhizobium* can sometimes be typed providing a useful tool in the investigation. If the process of nitrogen fixation can be identified a rich prize awaits as even a relatively small increase in nitrogen fixing capacity could achieve valuable economic advantages. Furthermore if the process of fixing nitrogen artificially with low energy input could be mastered following these studies, there could be a major step forward in food production.

It is especially interesting that the nodule organisms, which were a constant source of wonder to Orpen and about which he had read so much, are themselves responsive to some of the same fertility and environmental conditions as the plant, i.e. as levels of lime, nitrogen, phosphorus and potassium are raised so is there a direct beneficial effect on the activity of the nodule bacteria. This can be seen from Diagram 6 which also emphasises the inhibiting effect of wetness on *Rhizobium* activity.

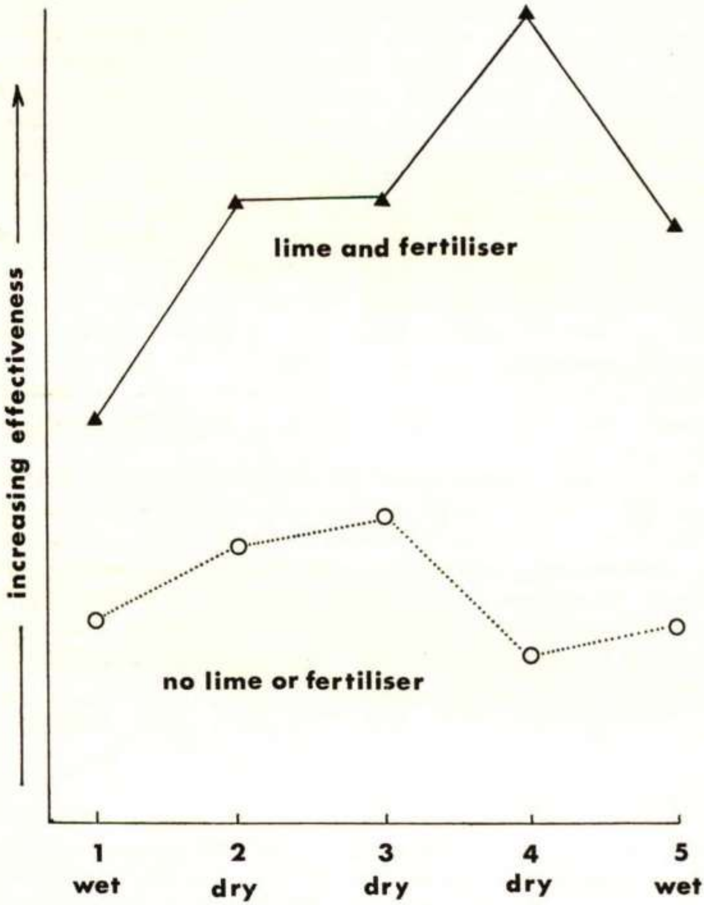


Diagram 6

Soil conditions affect root nodule bacteria of legumes

Another aspect of importance emerging from our work is that the effect of high dressings of nitrogen on pasture which, of course, either reduces or eliminates clover growth, is only transitory and that quick recovery is possible. This has been clearly shown from experimental work in the Castle field at Johnstown. See Table 10.

TABLE 10: Effect of nitrogen fertiliser on percentage clover in sward

Year	No nitrogen	16 cwt fertiliser/st. ac. s[1]	c[1]
1964			
8th year of fertiliser application	11·5[2]	0	0
1965			
Nitrogen fertiliser witheld	16·6	13·2	19·2

[1]s=sulphate of ammonia. c=calcium ammonium nitrate.
[2]percentage clover in sward in August.

I cannot leave this subject without mentioning another aspect which I feel would have especially intrigued Orpen. One of his particular interests was the inoculation of clover seeds with variable strains of *Rhizobium*. Indeed, some experiments were carried out on this subject at Monksgrange with, however, I fear, little positive result. Following similar experiences elsewhere, Masterson[39] noted that when active *Rhizobia* are brought into contact with the seeds of clovers these *Rhizobia* were, in fact, killed. similar observations had been made with other strains of legumes elsewhere. When this matter was pursued[40, 41] it was found that the seed coats of many legume species contained a material which was toxic to *Rhizobium* and that while there were a number of such toxins the main one was myricetin, a naturally occurring phenolic compound. It was further discovered that the toxic effect of seed extracts could be reduced by the addition of metal salts, salts of vanadium being especially effective. Molybdenum and cobalt were also effective and iron less so. These results are of considerable interest in view of the effects reported from time to time of some of these elements in stimulating clover growth.

Finally, this work has led us closer to the goal, i.e the elaboration of suitable soil tests to diagnose the nitrogen status of soils—at present a major deficiency. We are now getting much closer to the achievement of that objective.

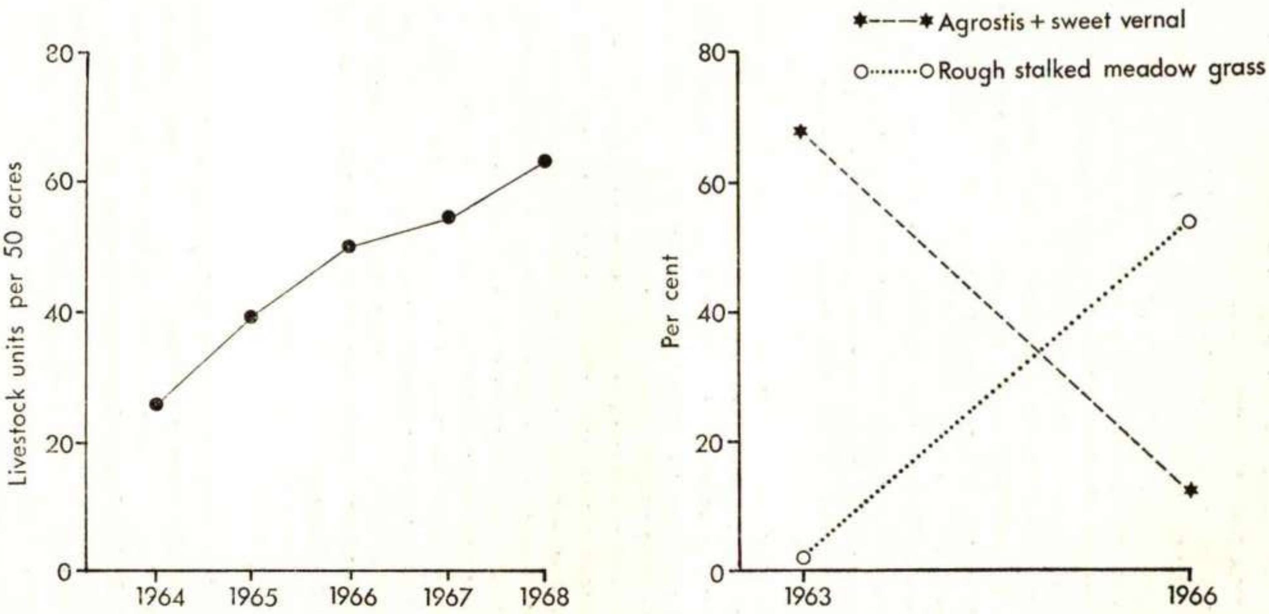
Grassland

In this lecture so far I have been concentrating to a considerable extent on problems concerned with grassland, referring to some of the individual components concerned in the grassland management complex. It can be gathered from what has been said that there must be an understanding of the weakness and strength of our soils, of how to manage nutrients, how nutrients can act as substituting factors and how flexibility can be ensured through nitrogen. In our work at Monksgrange we were, in fact, looking at these different components in an individual way in relation to systems of farming at that time which was more or less attuned to subsistence needs—systems of relatively low purchased inputs and high labour content. Indeed this approach has been expressed very well by Orpen himself when he notes that " . . . it is only when a farm is studied as a complete unit of production, rather than as a patchwork of separate items, that we can discover whether the programme adopted is achieving the most satisfactory results from the financial point of view". We were not thinking so much in terms of business farming systems. We were merely looking at the different parts of the jigsaw.

Later in looking at factors concerned with the optimum economic use of fertilisers(42) and the nature of the problem against the background of the many factors involved, the need emerged to quantify the factors not only as they operate singly but in interaction with one another. It is inevitable, of course, that farming systems should be complex because of the variety of physical, environmental, economic, marketing and social factors involved.

The approach to grassland management at the time our work commenced at Monksgrange was dominated by the plough-up policy for old pasture swards. At Monksgrange this process was undertaken with none too satisfactory results, despite the use of some of the best seeds available. Indeed, Orpen entered into quite a controversy with some of the grassland management pundits in a neighbouring country on this matter.

I have already mentioned the very rapid reversion of pasture under conditions existing at Monksgrange. Since then the position has changed materially. Our research work, based on an ecological approach and against the background that each particular nutrient has its own specific ecological effect, and that there is an interaction between the soil, its manuring, liming and the composition and management of the sward, has shown that old pastures such as the *Agrostis*-dominated pastures at Monksgrange can be improved in a relatively short time to the point where they are almost as good as newly laid down, well fertilised leys. This is particularly well shown by the work at Ballintubber where, from a base of very poor *Agrostis*-Fescue pastures of low stock-carrying capacity, high producing pastures have been developed. This can be seen from the improvement profile (Diagram 7).



BALLINTUBBER

Diagram 7

Another aspect of our investigations which has not as yet been worked out to any great extent is that of the cycling of nutrients in pastures. The fact that different systems of management can have a striking effect on the nutrients extracted is clearly shown by the work of Murphy.[43] Orpen's notes in this respect have a special relevance under the demands of the intensive systems now being developed. He wrote: "Fuller trials are required to show whether our present allowance of nutrient replacement is sufficient to maintain output at a satisfactory level. In the meantime there is a lot to be learned about grassland management, which becomes progressively more difficult as the intensity of growth increases".

A research project to take care of this aspect of soil fertility is now under way.

Many of my colleagues have presented their findings on the management and development of grassland in modern farming systems before this Association and consequently I do not propose to deal further with this matter which I have covered elsewhere.[13] I do, however, wish to stress again that our present approach is to synthesise our findings on different components—the "separate items"—taking into account the whole spectrum of factors from the soil to the market so that market-oriented, methodically developed systems can be offered for a variety of environments and needs. I would like to present a picture of these systems as consisting of a number of links about each of which we must have specific quantified information. The initial link in this chain is the soil, with each soil type determining its own specific requirements, and the terminal and motivating link is the market. Our research work, covering a wide field in the production, processing, economic, marketing and social areas, is now quantifying the individual components or links. I believe that this systematic approach to developing market-oriented systems can bring us with confidence into a future of grassland management, which will enable the potential of our soils and grasslands to be fully realised to the national advantage.

The Future

In the foregoing I have attemted to deal with some of the topics which were of special interest to Orpen, as far as I could personally judge. This does not cover his sphere of interest by any means. I know that he had an intense interest, for example. in co-operation and what co-operation, if it were operated effectively and applied to all appropriate areas of agricultural activity, could do to make the farmers' way of life a better one. I know he had no illusions about rural fundamentalism as such but he understood fully that a better way of life on the land should come basically from a better return from the land. His interest in these affairs could very well make the subject of another lecture.

I thought, however, I might conclude by attempting to take a short look into the future, a hazardous venture at any time. In the early days of our work at Monksgrange, main concentration was on production, on activities which ended at the farm gate. The whole position has now changed in line with the requirements of the nation's Economic Expansion Programme. There is now a need for information to meet new market objectives, to have facts as a basis for adjustment and to permit innovation, not only in production economics, but also in management, merchandising, processing and marketing. In the context of these changes the farm gate barrier has disappeared. It is apparent that these developments would involve consequential social adjustments, requiring research guidance. It has been a feature of agricultural development since those early days at Monksgrange that the increasing efficiency in agriculture was releasing manpower, which could have been taken up if the industrial sector had been in tune with developments in agriculture. in the context of balanced economic expansion. This, of course, was not so.

Orpen, as is apparent from his contributions, placed considerable hope in a future where the work of the Agricultural Institute would play a significant part. He was a main protagonist in the discussions leading up to its formation. This Institute has developed a national research programme in which the goals have been clearly defined. The programme is flexible to meet new needs. It has been developed in a logical way, by reaching a consensus at many levels through discussion and argument conducted in an atmosphere of mutual intellectual confrontation among research workers, advisers, the users of research in general and farmers in particular. It is hoped that to date Orpen's aspirations have been fulfilled.

As we look forward there are, of course, a number of factors of which you are all well aware and which condition the way research must move. These can be summarised as follows:

1. At home there is little, if any, dietary inadequacy, consequently any extra food which we produce must be sold outside the country.

2. Markets outside the country have quite specific requirements to be met, quality and price-wise. They are hard markets where competition is intense. Some of them we have lost in the past or have not been capable of meeting. There is little point in looking at newly emerging nations as a source of markets since in these countries, government policies indicate that the expansion

of their own agriculture is a basic element in their economic advancement.

3. Increased production in Ireland, must, therefore, be closely and systematically geared to meet the requirements of specific markets abroad; the chain from soil to saleable product must be closely integrated.

4. To face the future competitively, the Irish farmer must be concerned with this whole chain and must be equipped technologically and managerially to meet the position. This calls for an increase in the operation of business management techniques in the agricultural industry as a whole. We live in an age of rapid advances in technology with our competitors injecting major resources into research as a basis for further development. As farmers increase their business capacity. they will wish to use more and more the fruits of this technology for their economic advancement. and will expect research to provide the answers.

5. The various factors of production, transport and marketing must be harmonised, the resources for production must be clearly understood, the balance between the forces of production as they change under the impact of development must be clearly monitored and guided. This could involve major changes in the structure of the agricultural industry at farm level, e.g. in terms of farm size, if demands are to be met.

6. The expertise to engage in agriculture must be developed through the appropriate educational and training programmes.

7. The need for adjustment to meet change—economic, social and structural—not only within agriculture itself but also between agriculture and the rest of the economy, must be met. This will entail changes which will penetrate right into the structure of farms and local communities, into the social and behavioural life of people both in the rural and urban areas. Agriculture cannot be separated or looked upon as a sector apart from the remainder of the economy. Because of the required increases in the strictly industrial side of our economy, expanding at a 5 or 6 per cent level in comparison with agriculture's 2 per cent, major tensions may be created unless appropriate steps are taken to meet the situation.

Orpen, in his time, understood these conditions very well. Indeed, he was a man much before his time. He said that the farmer wants a blue-print "drawn up jointly by the economic forecasting expert together with the agricultural adviser acquainted with the capabilities of both farm and farmer with perhaps the bank manager as an observer.

" After all, the farmer's job is to grow the crop or animal, and in a world market fluctuating rapidly from year to year and month to month no farmer is in a position to judge of the future even on the home market, let alone overseas, as he cannot possibly assess in time just what his competitor proposes to grow that year.

"Therefore, if agriculture is to expand, it must have access to the necessary information both scientific and economic and this information must come in time to make the required adjustments.

"While it is true that in the post-war years very substantial technical progress has been made on quite a large number of farms in Ireland, the financial reward is still deplorably low. It is customary to regard this state of affairs as due in the main to the stupidity and lack of initiative of our farmers. This, of course, is nonsense."

Consequently, a research programme, if it is to meet farming needs must provide the necessary facts as a basis for appropriate technological developments—facts on the production of crops and animals, on storage, on processing and marketing, on the use of resources, on the economics of the agricultural industry in the total context and on social and other changes. Such research must avoid rigidity in thinking or structure. It must be conducted within the framework of a national programme of agricultural research to meet the needs of the agricultural industry, and it must proceed far beyond the farm gate.

The organisation and implementation of a research programme are only part of the problem. The question of the dissemination and use of research results is equally important. It should go without saying that results of research should be disseminated and integrated into agriculture as rapidly as possible. Orpen was fully aware of the problems involved and has noted[30] that "one of the most difficult problems which faces the farmer of today is how best can the findings of the scientists and research workers ultimately reach the farmer. Quite obviously this process is long and complicated and must at every stage be subjected to test checks and qualifications. It is all too easy to bypass some difficulty and jump to some conclusion not altogether justified by the evidence.

"Presumably when we have the Institute of Agriculture in operation some watertight scheme of flow from research worker to farmer will be set up which works quickly and without faults."

We have tried to approach this question in the most sympathetic way possible. We have tried, through the medium of developmental research, through our farmlet experimental technique, through field stations, economic test farms and a research-extension approach, to present our work in such a way that it can be used by advisory officers. The latter have the difficult task of ensuring that the work is integrated into practice at farm level. They should have the results of research made available to them in a form which they can readily put into practice. No longer can the "bits and pieces" method in the application of research be used as a basis for raising the productivity of commercial farming.

I would like to stress again particularly our present work aimed at synthesising quantified components into viable farming systems so that alternative programmes, designed to meet environmental and market variations, are available to the adviser. Through this approach the speculative element in dissemination is being removed. In addition, it should be possible to adjust such systems rapidly as new information becomes available. In all this work the computer can play a major part.

Looking back on the days of our work at Monksgrange, carried out in close association with the local instructor in agriculture, I feel we were asking too much of farmers in expecting them to integrate new information into their farming programmes in a piece-meal fashion. While men like Orpen, because of intense and innovative capacity, accepted the risks involved, I wonder how many of the young business farmers of the future would accept the possibility of failure inherent in this approach. For these young people we must put the pieces together into economically viable, worthwhile systems.

While I have stressed the need to integrate research results into the agricultural industry as quickly as possible, there are other aspects of research and its results which I would like to emphasise. Research itself is creative of new ideas and of a progressive outlook. In this process contact between research workers, advisers and farmers is most important. Orpen was well aware of this. Research workers must have the capacity and opportunity to penetrate deeply into the subject matter of their work and not always with the immediate application of their research results in mind. There must be a constant stream of new facts available for practical adoption. This involves a process from basic scientific work, through applied and developmental research, to the industry. If new techniques are to be developed, people engaged in applied research must have the opportunity of proceeding beyond immediate needs. To do this they must have the necessary motivation and intellectual equipment.

Orpen was undoubtedly a man before his time. He was a prototype of the farmer of the future—the farmer with a high level of technical, managerial and economic skills, who will require great expertise and top class performance from those to whom he will look for help in the operation of his enterprise. It is to meet the requirements of such a farmer that we must gear our developments in the educational, agricultural research and advisory services of the future.

Edward Richards Orpen was a man eager for new information. challenging the best in the research worker and adviser. Because of his own special intellectual and technological capacity, he was prepared to to apply new findings, to take risks, to understand that research workers and advisers were only human in their knowledge and capacity. He was prepared to be optimistic and to look forward to an agriculture in continual progress providing a better way of life for people on the land. He did everything he could to see that this better way was secured. To us he was a research oriented farmer, a model for the future.

I am certain that as farmers increasingly follow his way in the future, the more prosperous will be the people in rural Ireland and in the community as a whole.

It was a privilege to have known him and worked with him, and to have benefited from his advice and help.

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If you or your organisation would like to join the Irish Grassland and Animal Production Association, the Secretary, 24 Earlsfort Terrace, Dublin 2, would be pleased to hear from you.