LINCOLN COLLEGE

(Canterbury Agricultural College)

UNIVERSITY OF NEW ZEALAND

SCIENTIA ET INDUSTRIA CUM PROBITATE

The Proceedings of the 8th Lincoln College Farmers' Conference

1958

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A Canterbury Agricultural College Publication

"If I have an apple and you have an apple and we exchange apples, then we each have one apple, but if I have an idea and you have an idea and we exchange ideas, then we each have two ideas."

—Chinese Proverb.

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LINCOLN COLLEGE FARMERS' CONFERENCE

1958

Committee:

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Mr S. M. Wallace, Nelson Creek, Westland.

PROGRAMME

MAY 1958

OPENING

The Chairman, Mr S. C. Bowmar:

I wish to welcome you on behalf of the Committee and hope you will find something of interest and benefit to you all. We are sorry the Minister of Agriculture, the Hon. Mr Skinner, is not with us but you all know the reason why and I ask Mr Boord to extend to the Minister our congratulations on his patience and perseverance in his mission. We are pleased to have the acting Minister with us.

It is gratifying to see the Conference becoming more and more popular with farmers. This is how it should be as it is conducted for your benefit.

We are here to learn how to increase production and do it economically, to discuss and find, if possible, solutions to general farming problems, and to learn in what way the latest developments in science can help us in everyday work. New ideas should benefit us on our own farms.

We hope you will enjoy this Conference. I have much pleasure in asking Mr W. H. Gillespie, M.P., to welcome our guests on behalf of the Board of Governors.

Mr W. H. Gillespie, M.P., Chairman of the Board of Governors:

It is indeed my very great pleasure and privilege to extend to you on behalf of the Board of Governors, staff and members of the College generally, a very cordial welcome and to express the hope that your annual Conference will once again be an outstanding success. I look upon this farmers' conference as a sounding board for farmers' affairs and their difficulties. Indeed I might express the thought that it has grown into being the parliament of farmers, especially of the South Island.

I hope that what you see going on here will give you all great satisfaction because we are trying to lift Canterbury Agricultural College out of the rut it was once in and make it a place of which you will all be proud. At this moment we are laying plans to provide for you people a worthwhile Conference Hall here. I can tell you at this moment that we have considerable funds in hand but not quite enough. Those funds I hope will be subject to a £1 for £1 subsidy when the application is made. We want a little more finance and perhaps you as farmers might help us out of our difficulty so that we can provide the type of hall which will be suitable for a conference such as this.

At the present moment, because of certain happenings, farmers are receiving much advice from many people. My view is that there is too much pessimistic talk about and if farmers exercise for the next year or two a little prudence in their business and apply a little optimism then all will be well for them. . . . It is true that as far as the national economy is concerned things are not so rosy, but that is someone else's worry. I would say to farmers that they should not try and change the system of farming too rapidly. There is room for change I know but you have to grow to the farming business and your own particular farm and should give much thought if you are going to bring about any particular change in your system. It is like changing an economy; you must be careful not to move too quickly.

I once again extend to you a very warm welcome on behalf of the Board of Governors and staff of the College generally. I want also to extend a special welcome to the Hon. Mr Boord, acting Minister of Agriculture, who is going to open this Conference for you. He, like all other Ministers, is a very busy man and I express pleasure that he is able to come here this morning and open this Conference.

The Hon. R. Boord, Acting Minister of Agriculture:

First of all I would like to thank those people who have been responsible for asking me to come along and deputise for Mr Skinner on this occasion. I feel it quite a privilege to be invited here to such a gathering as this and being asked to open this particular conference. I want to pass on to all of you from Mr Skinner, the Minister of Agriculture, his regrets that he could not be here on this particular occasion. As you all know well, he is busy on an important job overseas which is causing some concern to this country. In the six o'clock news this morning you will have heard more about the situation.

I might sav a word about research and land development, particularly that which has taken place in this country during the post war years. I think it is true to say that the end of the possibility of large-scale land development as we know it now is in sight. Only one and a half million acres of undeveloped land in the country remain to be brought in. At the present time, through the combined efforts of Government and private enterprise, land is being brought in at the rate of 100,000 acres a year. If only one and a half million acres are left to be brought into production, then 15 years will see the end of the job. I would suggest that future increase of production must come from the better development of the land we already have in production. There have been great increases through aerial top-dressing, modern means of controlling weeds and new methods advocated through such places as agricultural colleges. Years ago thousands of thousands of acres of land in the Rotorua area could not support stock. If it had not been for the work of scientists in this country and the discovery that cobalt could remedy this situation, those acres would still be as unproductive as they were in pre-war years. As long as we have scientists continually working on this sort of problem then we can increase production.

I cannot come to Lincoln College here without making some reference to the work of the College itself. For many years now this particular College has been assisting farming development all over New Zealand. Most of you will recall Ivey's early work on fertilisers and nobody could forget Hilgendorf's work on wheat and Calder's on crops. This Conference is one of the new developments by which Lincoln College has attempted to pass on to farmers information of the latest developments. The College, too, in recent years, through work on the Ashley Dene property, has shown what can be done with dry land. . . . Research is a tremendous asset to our country and I only wish the Director and his staff well, and thank the Chairman of the Board of Governors for the work that they have done and wish them everything well for the future.

I heard Mr Gillespie say something about subsidy. If there was any promise made by the previous Government in that regard it will be carried out; and when Mr Gillespie has the money and has a proposition, if he comes and talks to this Government we will do everything we can within the lines of our policy; we will try to let people get the things they feel they need. . . .

I must say something regarding the present situation as regards our overseas earnings. For the first time since the 'thirties we have faced the situation whereby we have had major price falls in three or four of the main exports we rely on for our overseas funds, and the exchange-earning capacity of this country has dropped considerably. It is a serious situation but not one we should face without confidence. We must use our heads and brains and work out to the best of our ability what to do to maintain the standards we have in this country. I have the problem of having to make that exchange £1 do what 25/- did before. The exchange problem is one we cannot do much about.

If the Government runs short of money within a country it has means by which it can augment that which it has. We cannot do that with exchange; we can only earn it or borrow it. It is a difficult situation. Most people realise it in this country but we are having some difficulty in stressing this fact on exporters in England that every time wool drops 1d it is a £2 million loss for us, with 1d drop in butter we lose more than £1½ million in overseas exchange; and with lamb a drop of 1d is equivalent to £2 million. This is one of the problems we are up against overseas. Mr Skinner has tried to persuade the British Government to prevent dumping because it has ruined the prices we received in the United Kingdom. The British Government has admitted that with the extra supply coming from other countries it has depressed the market to our disadvantage and is requesting the countries concerned to stop subsidising so that the supplies they have been producing for the British market will be reduced. The British Government will also consider the imposition of anti-dumping duties. If we request England to reduce imports of foreign butter in order to keep prices up, we must be very careful that we do not produce extra butter in this country and put it on the market to replace or more than replace the butter which has been taken off and thus push the price down. We must not increase supplies or we will further depress our own market.

Not so long ago we had a Young Farmers' Radio Leadership Contest and as acting Minister I had to say a few words of introduction. Professor McCaskill was the question-master, and the last question he asked was, "In view of the fact that prices are falling overseas what would you do to supplement your income?" One New Zealander said, "I would increase my production of butter." The Australian, who was the winner of the contest, said, "I would diversify my production and grow other things." I agree with the Australian. In the slump in 1930, farmers increased production of butterfat something like 50 per cent. and sold the whole lot for less than the original price. We must take steps to prevent this happening again. It is not so applicable to the South Island as it is in the North Island. I do not think personally that a fall in the price of wool was caused by any over-supply factor; a simple and basic reason for the fall in price of wool was credit conditions which pertained in other countries such as the special bank rate in England. There is a chance that we can over supply both meat and butter markets. Just at present the Meat Board is pressing the Government to take some action in regard to meat supply on the British market. There are only two things we can do to get rid of our surplus. One is to find new markets and the Government will do everything it can in that direction. . . . The other is to diversify our own production in this country.

The other day, as Minister of Customs, I was approached for the issue of an import licence of nearly £400,000 for the import of sausage casings into this country. If the dairy farmers in the north would grow more pigs instead of increasing their supply of butter then a large sum of money could be saved in overseas funds in importing sausage casings. The problem is to secure items with which we can diversify. Pigs mean the growing of more meal and there has been suggested the possibility of growing some beef on dairy farms. I had a request to import maize into this country. Years ago we could grow all our own maize. I also had a request for the importation of oats. It seems to me quite wrong that we should be importing these things into the country when we can grow them here. The diversification of production will help to keep our own prices up and save overseas funds. There is not much dairying in the South Island, but diversification of production could yield us more wheat. We increased the wheat price by 2/- a bushel for the express purpose of encouraging local production. We import over £5 million worth of wheat per annum. Recently we have established a linseed oil industry. We could increase potatoes most years. We have been importing egg pulp again and all that has to be paid for in overseas exchange. I suggest that we must make plans now for a diversity of production. Diversification away from dairy produce and meat would not only help the country as a whole but I believe in all sincerity would save yourselves from a fall in prices in future.

I am delighted to be here and wish you the best in your deliberations and declare this Conference officially open.

THE ORGANISATION OF AGRICULTURAL RESEARCH IN NEW ZEALAND

W. M. Hamilton, Secretary, Department of Scientific and Industrial Research.

Five years after Cook's first visit to New Zealand James Watt invented the first practical steam engine (1774). No other single discovery, till the present atomic age, has meant so much to mankind as the steam engine. It ushered in the Industrial Revolution and what has been aptly termed the "scientific age."

We already take for granted radio, television, modern transport and the astonishing advances in plastics, synthetic fibres, medicine, atomic power and now sputniks. Imagine if you can, what farming in New Zealand would be like without refrigeration, without modern transport, electricity, fertilisers, trace elements, modern insecticides or improved strains of crop and pasture plants, to mention just a few things which come easily to mind. It requires a few moments' reflection to realise the extent to which the pattern of our living, and even of our thinking, has been moulded by the scientific advances of the last century.

I have mentioned these aspects of scientific work for two reasons. Our effort in the field of science is of prime importance because I believe it will, in large measure, set the limit to our rate of advance in new and improved farming techniques. Because of this, we should organise our research so as to achieve maximum efficiency or, to put it another way, to maximise the dividend from our investment in research.

"Research" is a word which has become fashionable in recent years and it probably conveys a slightly different meaning to each one of you. I have used the word **research** to mean the search for new scientific knowledge as distinct from **scientific service** work which is the application of known scientific methods to answer specific questions such as "How much calcium carbonate is there in this sample of limestone?"

The use of the word research is further confused by talking about "pure," "fundamental," "basic" and "applied" research. Even scientists are not always careful about how they use these terms. The difference between "pure" and "applied" research is one of objective, not of method. "Pure" research aims to gain knowledge for its own sake without thought as to whether the results will be of practical value, while "applied" research is directed to the solution of problems of practical importance. Naturally enough most of the scientific work undertaken by Government departments is applied research or scientific service work.

A considerable number of agencies undertake research or scientific service in New Zealand and it is not easy to obtain accurate figures of their expenditure. Thirteen Government departments provide funds in their budgets for scientific purposes but only eight of these employ scientific staff, the other five making grants for research to other organisations. Only four departments—Agriculture, Meteorological Services of Civil Aviation, Navy and D.S.I.R.—spent over £100,000 on scientific work last year, when Government departments provided approximately £3.1m. in their budgets for scientific work.

Various other organisations such as the Cawthron Institute, the museums and industry provide funds for scientific work and a number of these are in receipt of grants-in-aid from Government departments. Taking into account these grants, the expenditure on scientific work in New Zealand in 1957-58 is shown in the table as follows:

Expenditure on scientific work by expending agencies

	1957-58 £'000
D.S.I.R.	1,419
Department of Agriculture	873
Marine Department	10
Internal Affairs	15
Forest Service	85
Meteorological Service	403
Ministry of Works	10
Navy Department	130
Medical Research Council	86
Universities	115
Cawthron Institute	24
Museums	12
Carter Observatory	5
Royal Society of New Zealand	5
Research Associations	161
Industry	310
	£3,663

On the basis of this estimate New Zealand as a whole spent approximately £3.66m. on scientific work last year. Expressed in terms of the national income (gross national product) this means that we spent approximately 0.36 per cent. of the national product on research and scientific servicing. This figure may be compared with 1.6 per cent. in Britain in 1955 and 1.5 per cent. in U.S.A. in 1953.*

Nearly half the total shown above is expended on agricultural research. Sources of expenditure on agricultural research are summarised briefly below:

	Expenditure 1956-57 £'000	Estimates 1957-58 £'000
D.S.I.R.	620	671
Department of Agriculture	773	873
Cawthron Institute	13†	13†
N.Z. Dairy Board:		
Grant to Dairy Res. Inst.	31†	35†
Herd Recording Dept.	20	20
N.Z. Wool Board:		
Grant to W.I.R.I., etc.	10†	10†
N.Z. Meat and Wool Board—Economic Service	21	22
Fertiliser Research Assn. Industry Contribution	4†	4†
N.Z. Meat Board:		
Grant to D.S.I.R.		9
Meat Research Institute Industry Contribution	20†	20†
	£1,512	£1,677

†Grants on approximately a £ for £ basis are made to these organisations by D.S.I.R., which also makes grants of about £8,000 p.a. to both Lincoln and Massey Colleges.

*Annual Report of the Advisory Council on Scientific Policy 1956-1957. H.M. Stationery Office, London.

Gross farming income in 1956-57 was £305m. so that the expenditure on research in that year represented 0.5 per cent. of the gross value of production, or approximately £10 per head of persons actively employed in farming.

It will be obvious from the table above that over 90 per cent. of the funds available for agricultural research in New Zealand are channelled through either the Department of Agriculture or D.S.I.R. Broadly speaking, D.S.I.R. is responsible for soil and plant research while the Department of Agriculture undertakes animal research and, in recent years, has extended its scope into soil and irrigation research.

The present organisation has grown over the years with only informal attempts at co-ordination. No single body has had the responsibility of advising Government on scientific matters and any department has been free to make representations through its Minister to Government for research facilities, without reference to any co-ordinating authority. In some respects the organisation which has grown over the last 30 years is illogical, e.g., in the separation of soil and plant research in D.S.I.R. and animal research in the Department of Agriculture, but on the whole it functions reasonably efficiently by comparison with overseas. This is primarily due to the fact that New Zealand is a small country and that most research workers working in similar or related fields know one another personally.

The D.S.I.R. is unique among Government departments in New Zealand in having an Advisory Council of Scientific and Industrial Research to assist it in formulating research policy and allotting research priorities. The Council comprises eight members and a chairman, of whom not more than two may be civil servants. The Council reports directly to the Minister in Charge of Scientific and Industrial Research but its responsibilities are effectively limited to advising on the activities of the D.S.I.R. It has no power to co-ordinate the activities of other Government departments or organisations unless these matters are referred to it by Government. Since, however, Council makes annual grants to the two Agricultural Colleges, to Cawthron Institute and to the incorporated research associations, it does mean that the research activities of these bodies are substantially co-ordinated with that of D.S.I.R.

The chief shortcomings of the present organisation of research are:

(i) There is no body with the responsibility for allotting broad research priorities and seeing that funds are channelled to give effect to these.

(ii) The solution of many problems demands team work, sometimes involving a number of scientific disciplines. This type of approach is less easy to achieve if workers are employed in different organisations.

(iii) The public is confused as to what body is responsible for different phases of research. Such confusion hinders efforts to obtain adequate finance and facilities for research.

(iv) The staffing of all existing departmental research comes under the Public Service Commission, whose control is not well suited to scientific staff.

(v) There is no body with responsibility for advising Government on questions of scientific and technological methods affecting the expansion of New Zealand industries or the utilisation of our natural resources.

How is research organised in other Commonwealth countries?

Each country's research organisation has grown to meet local conditions and most have been revised to meet changing needs. With the exception of D.S.I.R. in the United Kingdom, all the research organisations take the form of corporate bodies with executive or advisory councils. The position is briefly summarised in the table below:

Country	Name of Organisation	Form of Organisation	Council	Notes
Australia	C.S.I.R.O.	Body corporate	Advisory	Prior to 1949 Council was Executive.
United Kingdom	D.S.I.R.	Department	Executive—Prior to 1957 was advisory	All come under control of Lord President who co-ordinates with assistance of an Advisory Council on Scientific Policy.
	A.R.C.	Royal Charter	Executive	
	M.R.C.	Royal Charter	Executive	
Canada	N.R.C.	Body corporate	Executive	
South Africa	C.S.I.R.	Body corporate	Executive	
India	C.S.I.R.	Body corporate	Executive	

The organisation of research in Britain has gradually evolved into what is probably the best co-ordinated system in the Commonwealth. The three civilian research organisations (D.S.I.R., A.R.C. and M.R.C.) all come under the Lord President of the Council, as also does the Atomic Energy Authority and the Nature Conservancy. He has to assist him an Advisory Council on Scientific Policy consisting of twelve appointed members and the secretaries of the three civil research organisations.

Principles underlying research organisation

The British Commonwealth Scientific Conference, consisting of senior scientists from all the research organisations in the Commonwealth, met in Australia in 1952 and was asked by some Commonwealth countries, then contemplating setting up research organisations, whether they could lay down any general principles to guide them in deciding on the form of organisations to adopt. The Conference adopted a statement on the national organisation of research which is too long to quote here in full. This statement says: "A good deal of experience has now accumulated, and certain general principles have emerged which this Conference considers it of value to enunciate.

"(i) The successful conduct of the affairs of a national research organisation demands the fullest appreciation of the objectives to be achieved and of the scientific work which must be undertaken to that end. For this reason the full responsibility for the government of a national research organisation covering one or more of the three fields of industry, agriculture or medicine, should be placed in the hands of a Council, Executive Committee or Board of senior scientists, with whom may be associated senior representatives of industry, agriculture or other interests as appropriate.

"(ii) Such a body should be directly responsible to a Minister appointed for the purpose by the Government, and should be freed from all other political control and influence. It should have a strategic function and recommend broad lines of policy, including the distribution of scientific effort within the organisation and therefore the main financial allocations within the total sum of money made available by the Government.

"(iii) Once broad lines of policy have been determined, the executive officers of the organisation appointed for their scientific knowledge and administrative capacity should have complete responsibility for their general implementation, as should directors of laboratories for the conduct of the actual research programmes.

"(iv) The organisation should have direct responsibility for administration, including the appointment and promotion of staff, both scientific and other. It should have the power to appoint to its staff the most suitable men of high scientific ability and promote them as individuals, judged in terms of their scientific merit and achievement."

The statement goes on to stress that "The strength of scientific effort in any country depends primarily on the universities," and the Conference emphasised the "importance of ensuring that adequate facilities are provided at the universities for training scientists, especially at the post-graduate level, and of enabling university staff and students to contribute to the advancement of science." The statement also goes on to say: "Since a national organisation should have the primary function of investigating problems, the solution of which would contribute most effectively to the welfare, prosperity or health of people, the first responsibility of its governing body should be to survey the national problems requiring scientific investigation, and thereafter to determine research priorities."

What form of organisation would suit New Zealand conditions?

Most scientific services to industry and most of the permanent scientific services of Government, e.g., geological survey, magnetic survey, seismology, etc., are already in D.S.I.R., the only major exception being meterological services, which are in Air Department. Because of the major role of metereological services to aviation they should remain where they are.

It is in agricultural and biological research that lack of co-ordination is more apparent. The Producer Boards, Federated Farmers, and other bodies have suggested that co-ordination in this field should be achieved by the formation of an Agricultural Research Council. It has not always been clear from reports whether the sponsors of these proposals have regarded an Agricultural Research Council as a new organisation incorporating all existing agricultural work, or whether they have regarded it merely as a co-ordinating body superimposed on the existing organisations. Obviously these two possibilities might have very different results.

Before discussing this, however, I think it would be helpful to look a little more closely at the general principles laid down by the British Commonwealth Scientific Conference in relation to New Zealand conditions.

Appointment and control of staff

The staffing of all existing research in Government Departments in New Zealand comes under Public Service Commission control. Public Service Commission control of major research organisations does not operate in any other Commonwealth country with the notable exception of D.S.I.R. in U.K. Even in this case the situation is somewhat different since the Civil Service Commissioners in England certify that a person is suitable for appointment to the Civil Service; thereafter his promotion, within specified scales, is in the hands of the department concerned.

I think it is significant that all Commonwealth research bodies established since the mid-twenties have been excluded from Public Service Commission control. A recent editorial in the scientific journal "Nature" (18/1/58) says: "It seems to be generally admitted that the orthodox type of Government department is not suited where research is concerned."

In New Zealand, our personal relations with the Public Service Commission are excellent but the system was designed to control a predominantly clerical service and is not well adapted nor flexible enough for its 1-2 per cent. of scientific employees. In fairness to the Public Service Commission it should be said that they have done their utmost to modify the system within the existing statutory limits to meet the needs of scientists. Notwithstanding this, the system still has certain disadvantages, the chief of these being:

(i) It is difficult to appoint a senior officer from outside the Public Service to a department. Any public servant who has applied for an advertised post has the right of "appeal" against his non-appointment. In the case of an appointee from outside the Service, it is necessary to prove that the outside appointee is "in great degree" more suitable for the post than any applicant from within the Service.

(ii) The principle of relativity in salary rates between different sections of the Public Service has held scientific salary scales in New Zealand well below world parity. Salaries of directors of major research units in D.S.I.R. are £1,200-£1,600 behind salaries for comparable posts in the United Kingdom. In consequence, we have lost many outstanding scientists to overseas posts and there is no possibility of attracting replacements of equal calibre from overseas or, because of the appeal system, of appointing them if we could attract them.

As set out in the general recommendations of the British Commonwealth Scientific Congress quoted previously, it is essential that a research organisation "should have the power to appoint to its staff the most suitable men of high scientific ability and promote them as individuals, judged in terms of their scientific merit and achievement." High calibre in research personnel is essential to efficient use of research funds, and whatever form of organisation is envisaged must achieve this or its efforts will be largely in vain. I believe the chance of achieving this would be better if research were outside Public Service Commission control.

Should we separate agricultural research from other research?

It is probable that the grouping of most Government sponsored research into one body, which might be called a National Research Council, or the division of these functions between two smaller bodies such as an Agricultural Research Council and a Council of Scientific and Industrial Research would both work fairly smoothly. If there were two bodies it would obviously be necessary to take steps to ensure close co-ordination between them. This should present no great difficulties and could be achieved by overlapping membership between the two Councils, possibly the chairman and secretary of each being members of the other.

The answer to this question must hinge on three main factors:

(i) Size of organisation. It is clear than in a country undertaking research on the scale of the United Kingdom, the separation of civil research into an Agricultural Research Council and a Department of Scientific and Industrial Research is desirable to avoid the organisations becoming too unwieldy. On the other hand, the Commonwealth Scientific and Industrial Research Organisation in Australia undertakes both functions and believes this has great advantages.

(ii) One of the disadvantages of two organisations would be in team work on difficult problems. One would in effect be merely shifting the current departmental barrier between plant and animal research to a new division in the field of research. Unless careful control were exercised, there would also probably be duplication of expensive equipment and skills between the two organisations.

(iii) The difficulty of deciding what is agricultural research. We find in D.S.I.R. that the non-agricultural branches such as Dominion Laboratory and Dominion Physical Laboratory, can be of considerable assistance to our agricultural research work. Any attempt to divide the present units of D.S.I.R. into agricultural and non-agricultural would present some problems.

It could be argued that the formation of an Agricultural Research Council as a separate research organisation would obtain more support from the farming industries than if this were grouped with other research. On balance, however, I believe this objective could be met while still retaining the advantages of having all research in one organisation.

Should the research organisation embody a council?

As stated by the British Commonwealth Scientific Conference, I believe that a council fairly widely representative is desirable to ensure that all points of view are considered in allotting priorities, to ensure liaison with outside interests and to act as a sounding board for new ideas and proposals. On considering the composition of such a council, I believe it is important that a preponderance of members should have a good scientific background and that members appointed to it should not be appointed as "representatives" of any outside bodies but should act in a personal capacity and be appointed for their broad knowledge of the subjects involved. I also favour a system of rotation of membership whereby a member is appointed for a specific period of say four or five years and is not eligible for immediate re-appointment except in the capacity of chairman.

There is room for debate about whether such a council should be executive or advisory, though in practice there may not be much difference in working between the two. There is some difference in overseas practice in this matter. The D.S.I.R. in the United Kingdom had an advisory council for 40 years and in 1956 made the council executive; the C.S.I.R.O. in Australia worked for 20 years under an executive council and in reorganising in 1949 made it advisory. However, the great majority of research organisations in the Commonwealth have councils exercising executive control over the organisation.

Should industry contribute to the cost of research?

There have been suggestions from time to time that the farming industries should contribute toward the cost of agricultural research. As mentioned earlier, the present cost of agricultural research in New Zealand is approximately £1,677,000. If this were to be financed on a fifty-fifty basis with Government, farming industries would need to find approximately £800,000 a year.

At present some of the smaller, more highly specialised agricultural industries such as tobacco, hops and wheat, make a contribution toward the cost of research, while the larger and wealthier industries such as sheep and wool, meat and dairy, contribute only minor amounts. This seems a somewhat unfair situation but is accounted for in part by the difficulty of assessing how much research is actually directed towards each of these activities.

The sheep industry in Australia is at present contributing approximately one million pounds a year to a central research fund, which is largely expended by C.S.I.R.O. with smaller amounts to other bodies. Should we be aiming to do likewise in New Zealand?

Without at this point attempting to answer the question, any reorganisation of research should envisage the ability to retain gifts or donations for the purpose of research. Such contributions are probably more likely to be forthcoming for an organisation which is not a Government department.

What should be the functions of a research organisation?

I think at this point I can usefully summarise the functions of a research organisation to serve the farming industries. As I see them the chief functions are to:

(i) Select projects and determine research priorities. As a basis for this there must be a continuing survey and assessment of farming problems by the organisation's own officers and by liaison with other departments and organisations and the farming community.

(ii) Organise facilities and provide conditions which will enable it to recruit and retain high calibre staff who have a reasonable prospect of being able to solve the problems selected.

(iii) See that problems are carried to a conclusion and to permit this, see that research units are not over-burdened with projects or expected to drop everything to chase each new will-o'-the wisp. A nice balance is needed here; one of the hardest jobs of the research administrator is to decide when to stop a project which does not seem to be getting anywhere.

(iv) Provide proper liaison with extension services and the regulatory services of Government so that research results are translated into practise with the least possible delay.

(v) Be competent to tender sound scientific advice to Government on matters coming within its terms of reference.

(vi) Be competent to co-ordinate expenditure of funds entrusted to it for scientific work and to administer efficiently the research units under its control.

EXPENDITURE ON AGRICULTURAL RESEARCH IN NEW ZEALAND

Branch	Expenditure 1956-57 £'000	Estimates 1957-58 £'000
D.S.I.R.		
Animal Ecology Section	8.8	10.0
Applied Mathematics Laboratory	16.9	18.5
Botany Division	25.0	26.3
Crop Research Division	52.3	59.3
Entomological Division	24.3	28.6
Fats Research Laboratory	19.9	20.6
Fruit Research Division	34.8	41.9
Grasslands Division	90.7	93.4
Plant Chemistry Division	25.9	34.1
Hop Research Station	7.2	7.3
Plant Diseases Division	72.1	78.7
Soil Bureau	89.5	90.8
Tobacco Research Station	8.9	11.5
Wheat Research Institute	10.3	11.7
Grants to:		
Commonwealth Agricultural Bureaux	14.1	18.7
Lincoln College	8.0	6.0
Massey College	8.0	8.0
Cawthron Institute	11.0	11.0
Dairy Research Institute	28.1	30.1
Fertilisers Mfrs. Research Assoc.	4.3	4.3
Meat Industry Research Institute	20.0	20.0
Publications, Journal of Science and Technology and Bulletins	10.0	10.0
Share Head Office Administration	30.0	30.0
Gross Total D.S.I.R.	620.1	670.8

DEPARTMENT OF AGRICULTURE		
Animal Research Division	388.4	406.7
Extension Division:		
Soil Fertility Station	42.4	43.2
Winchmore	30.8	38.5
Field Experiments	16.0	20.5
Invermay Experimental Farm	28.0	29.6
Horticultural Division	12.0	16.3
Soil Conservation (Exp. areas)	62.9	84.8
Salaries (estimated)	192.0	233.0
Gross Total Department of Agriculture	772.5	872.6
Cawthron Institute	13.5	13.5
N.Z. Dairy Board		
Grant to D.R.I.	31.2	35.2
Herd Recording Dept	20.0	20.0
N.Z. Wool Board—Grants to W.I.R.I., etc.	10.0	10.0
Fertiliser Mfrs. Research Assoc.	4.5	4.5
Meat Research—Industry Contribution	20.0	20.0
N.Z. Meat & Wool Bd. Economic Service	21.0	22.0
N.Z. Meat Board — Glasshouses Grasslands Division		8.5
	120.2	133.7
Total £'000	1,512.8	1,677.1
Gross Farming Income £M	305	*
Research Expenditure as percentage of Gross Farm Income	0.49	*

* Not available.

CONCLUSION

I have said earlier that the present organisation of research in New Zealand is working fairly efficiently with reasonably good co-ordination and no unwarranted duplication of effort. At the same time, I believe the over-all efficiency of the research effort could be improved by some reorganisation. I believe some such reorganisation could provide for better allocation of research priorities. It could offer better opportunities for team work in the solution of difficult and complex problems and, I believe, it would have a better chance of retaining some of our brilliant young graduates in employment in New Zealand and, over-all, increase the efficiency of the research effort.

Question: I would like to raise the point as to how funds are allocated for different branches of research. A large number of veterinary clubs in New Zealand are carrying out research work on their own. We are all agreed the work is of vital importance to primary production and cannot be done without money. The system at the moment is that clubs are endeavouring to find money by scrounging from the Meat and Wool Board and Veterinary Services Council. Should the collection of funds be done by some central organisation in the form of a research council?

Dr Hamilton: It is a matter of faith. Monopolies are not a good thing and while I think there is need for better co-ordination in the broad field of agricultural science and research in New Zealand I would not like to see a complete monopoly created through which everybody had to go for funds and if they could not get them through it they then would have no funds.

Dr I. D. Blair: Dr Hamilton referring to the report of the British Commonwealth Scientific Conference 1952 quoted words to the effect that the strength of scientific effort in any country depends primarily upon the universities and emphasis was given in that report to the importance of ensuring that adequate facilities are provided at the universities for training scientists.

In New Zealand because the University in earlier years did not fulfil its educational obligations to encourage learning (research) equally with teaching, the situation has developed wherein research at its best has become established entirely dissociated from the teaching body—the University.

We are perturbed by this situation as it now affects this College of Agriculture. The research departments need agricultural scientists. It is one of our functions to assist in their basic training. We understand that we are required to guide an infusion of trained men into practical agriculture, others into extension services and a fair proportion of suitable men into research positions.

Can we do the latter? In point of fact there are in some disciplines of plant and animal science better men and women in the research units outside the Colleges and they have all the tools for the job. That is all right for the research stations but as an example on the other side I am one of the teachers who knows that my honours students will get their research foundation only to the extent that I am able to persuade my friends in the Crop Research Division to give of their research time to assist with the training of these men. We have a happy liaison with the Department of Scientific and Industrial Research men at Lincoln but the part they play is unofficial based upon our personal friendships among staff.

I remind you that of the one and a half odd million pounds expended annually on agricultural research in New Zealand this College receives about £10,000. How grateful we are that the Department of Scientific and Industrial Research has enabled research to be done here within that limit and our thanks are due to Dr Hamilton and his predecessor, Mr Callaghan, for their support and interest.

But we must conduct research in order to have on hand facilities to illustrate the principles to students. Thus we must, as a College, be fitted into a plan of research organisation in no small or token manner. Dr Hamilton did not mention when referring to other countries and their organisation how the Americans have done it. I wish he had, for in that country, which may be temporarily lagging with sputniks, the training of agricultural scientists is second to none. The University there is the focal centre of agricultural research and the governmental agencies are closely integrated—not administered mark you by the University. If something of the kind is not achieved here, and we seem to have a more promising situation developing here at Lincoln, then the situation of the University and this College in particular in regard to the capacity to train graduate students is approaching disaster.

BLOAT

A. T. Johns, Plant Chemistry Division, Department of Scientific and Industrial Research, Palmerston North.

Sheep and cattle have a very capacious digestive system which allows them to make use of the fibrous material of plants which is poorly digested by non-ruminants. Such utilisation of plant material is brought about by microbial fermentation in the first two of the animal's four stomachs. This fermentation "vat" is reported to have a capacity of up to 40 gallons in a large animal.

The fermentation which takes place in the absence of air produces enormous quantities of gases of high calorific value. In fact, a cow may produce something like 120 gallons of gas a day about half of which is methane. If methane could be made use of, two to three cows could supply enough gas for cooking in a normal household. It will be realised that when the cow cannot get rid of all this gas by belching, it rapidly blows up and produces the state known as bloat.

Why do sheep, and cattle in particular, bloat? It is obvious that anything that causes a blockage of the throat and prevents the elimination of gas will give rise to the trouble. It can arise from a number of different diseases which cause some obstruction, such as tuberculosis of the mediastinal glands. However, here we are concerned with the uncomplicated condition that arises from the grazing of pastures which contain a high proportion of clover.

Bloat is most commonly associated with the grazing of lush green legumes. Lucerne, white and red clover, ladino clover and peas have all been incriminated at various times. Bloat is also frequently experienced in New Zealand on chou moellier and has been occasionally reported on green cereals, lush young grass, turnips and cabbage. Bloat on young spring grass appears to be not uncommon in England and has been produced experimentally on rapidly growing young ryegrass in New Zealand.

Cattle appear to be more susceptible to bloat than sheep. However, in some areas, as in South Africa and Australia, where pure stands of lucerne are grazed by sheep, losses from bloat can be a serious problem. Dairy cows are usually considered to be more prone to bloat than beef types but it may well be that dairy animals are in general pastured on the better swards.

It is often claimed that trouble from bloat has increased in recent years and that modern grassland farming based on more vigorous strains of clovers is partly to blame. While vigorous clover growth is essential in countries such as New Zealand as a means of providing sufficient nitrogen economically for the grass species in the pasture, there is no doubt that it is also the chief cause of bloating in animals grazing such pastures. The farmer has to learn to manage the newer strains of clovers so that fertility is built up rapidly and the pasture soon becomes grass dominant.

Bloat is, however, by no means a new ailment. Richard Peters, writing in the Agricultural Magazine for October, 1807, on hoven in cattle, pleads that farmers should not be prejudiced against clover, "this great and extensive improvement." He gives a warning, however, against the danger of feeding cattle with "young and soft clover loaded with dew or rain." He adds that "any succulent or juicy food if moist with rain or dew, has a capacity to generate air, which by its expansion in the animal produces hoving. Lucerne, pea vines, green Indian corn and buck-wheat have under my own observation occasioned this destructive calamity."

After describing the bloat symptoms, Peters goes on to its treatment and gives four remedies:

(1) Immediately stab the animal on the **left side,** behind the hind rib and the hip bone, not too near the latter, with a small knife.
(2) A beast has been relieved by violent eructations, on the tongue being suddenly and forcibly drawn out.
(3) Another instant and very efficacious remedy is raking the beast and drawing out the superabundant faeces.
(4) Another in the first stage, frequently successful, and always useful as an auxiliary, after the more prompt methods before recommended, is **drenching.** For this purpose he mentions sweet oil, raw linseed or even train oil, or melted hog's lard.

Loudon (1825), in his Encyclopedia of Agriculture, lists the following internal remedies:—a pint of gin to each animal, oil (which condenses the air), a strong saline solution, new milk to which tar is added, or a strong solution of ammonia in water.

A number of these remedies are in use today, though I have not heard of gin in this connection in recent years. We have confirmed that oils are effective in preventing and alleviating bloat but for other reasons than that given above.

You may well ask the reason for the lack of progress over the last 100 years in finding the cause of bloat and in providing better control measures. The chief reason is the sporadic nature of the disease, and the difficulty of producing it experimentally so that controlled experiments could be carried out. Unless you can run properly controlled experiments, you do not know, when you get no bloat after a treatment, whether the animals would have bloated or not if they had been left alone, whereas if you can get bloat you have something positive. These difficulties have been partially overcome by the use of bloat-prone identical-twin cows, stall-fed on cut clover.

Bloat has been produced regularly enough under these conditions to enable us to determine the factors in the production of the condition. Many hypotheses have been put forward in the past to explain the ailment, e.g., lack of fibre in the diet, over-eating of succulent feed, general poisons such as the cyanide-containing substances in white clover, specific muscle poisons and too rapid a production of gas. Any one of the explanations would be inadequate on their own to explain why some animals in a herd bloat while others on the same pasture do not.

Our findings from research work designed to find the fundamental causes of the ailment may be summarised as follows:

(1) Weather Conditions

It is frequently stated by farmers that weather conditions such as heavy dew, rain, wind or humid cloudy conditions, are responsible for the development of bloating pastures. We have found that, although bloat may occur under any of these weather conditions, any one has not been better than another, for producing bloat on cut red clover. There seems to be no particular time of day when the incidence of bloat is consistently greatest as it appears to vary from season to season. We have found some difference between animals as to the time of day when they tend to bloat.

Some years ago we watched the Massey herd for several weeks and recorded bloat cases. At this particular period, 11 a.m. was the peak for the incidence of bloat. This year, at Flock House, near Bulls, there have been several weeks when there has been no bloat at all during the day and the whole herd has been bloating between 5 and 6 p.m. There were very heavy dews during this period but bloat did occur on one night where there was little dew. This outbreak at Flock House is the most clear cut difference between periods during the day with regard to incidence of bloat we have experienced, but we have not determined what change in the plant or animal is responsible for this.

(2) Stage of Growth of Clover

Bloat is usually associated with young rapid growth of clover and there seems to be no doubt that the majority of cases do occur on this material. However, we have had severe bloat on red clover in flower and with some seed set. We have cut red clover and produced bloat on the wilted material. On two occasions the wilting has been taken to the hay stage and bloat was produced on red clover hay. Bloat on lucerne hay is not unknown in the U.S.A. and we have had a report of it from North Auckland. Hence succulence is not a factor necessary for the production of bloat.

(3) Influence of Rate of Feeding

It is frequently stated that the rapid ingestion of succulent pasture is a predisposing factor in bloat production and that greedy eaters are the most prone to bloat. We have not found this to be so. We have had animals that will bloat on perhaps 20 lb of clover, whereas others eating similar fodder will show no signs of discomfort after rapidly eating 80 lb.

Hancock, at Ruakura, also showed that it is by no means always the high producers that bloat and that some of his poorest producers were the best bloaters.

(4) Rumen Movements and Belching During Bloat

It has been postulated that bloat is due to an inhibition of the belching mechanism either by a spasm of the throat muscles, a lack of stimulus for the belching reflex or by an inhibition of the rumen movements. We have found that neither belching nor muscular activity of the fore-stomachs appears to be inhibited during the early stages of bloat.

A number of workers have postulated that the central feature of bloat in ruminants is a paralysis of the rumen muscles by histamine. The agent is considered to be present in the fore-stomachs or produced by an allergic reaction. The use of adrenalin or anti-histamines in the treatment of clover bloat was found by us to be dangerous and increased its severity.

(5) The Tendency to Bloat Appears to be an Inherited Animal Characteristic

We have found similarities between identical-twin cows and differences between sets of twins in their bloating behaviour. This confirms the observations of many farmers that the tendency to bloat runs in families. However, this difference between animals in bloating behaviour is not an absolute difference. When the pasture is potent enough, all animals in a herd may bloat. Moreover, it has been found that some animals may be susceptible to bloat for a particular period and others not, while at another period the susceptibility pattern may be reversed. This, and other evidence, indicates that the difference between animals in their bloating behaviour is not due to any constant factor such as anatomical abnormalities.

(6) The Administration of Anti-foaming Agents

This proved to be the only completely reliable method of prevention and treatment of the condition. When a dose of 2-3 oz of vegetable oil was given to an animal before feeding on bloat-producing clover, it was 100 per cent. effective in preventing bloat for the subsequent feed.

Many other methods of reducing the risk of bloat in the grazing animal have been advocated but none, except perhaps the use of penicillin, has proved reliable when susceptible animals are grazing bloat-potent herbage. The most-commonly used treatment for bloat is drenching with turpentine and vegetable oil. It was thought in the past that the action of the turpentine was that of an irritant but its true action has been shown to be that of a foam breaker.

Bloat has been classified into two distinct types described as "frothy" and as the "free gas" type. However, our observations on many hundreds of cases of bloat on clover in animals with a rumen fistula have shown that bloating is correlated with the degree of foaming in the fore-stomachs. We now consider it doubtful whether there are two distinct forms of pasture bloat and believe that the supposed differences are only different degrees of frothy bloat. We have observed with pasture bloat that there is always some free gas present and it seems likely that the amount is a function of the stability of the foam.

The situation regarding the two types of bloat was well illustrated recently by some American workers who described the condition of a cow which died from bloat after feeding on fresh lucerne tops. After death, the animal was tapped with a trocar cannula and only free gas escaped. When the rumen was slashed open with a knife, however, the stomach contents were found to be extremely frothy. The authors stated: "Had the rumen been opened with a knife at the start, one would have undoubtedly obtained the impression that no free gas was present as it would have escaped with the frothy ingesta."

In searching for the substances that cause bloat, we have to remember that both animal and plant factors contribute to the condition resulting from foam formation in the fore-stomachs. Inspection of the stomach contents through a fistula has shown, in animals which subsequently bloat, that foaming is usually present before feeding. This indicates that both the state of the stomach contents and that of the feed are important in determining whether an animal is going to bloat or not.

Control of Bloat

The use of mature grass-dominant pastures is the best single measure of protection against bloat that we know of at the present time. Under our New Zealand system of pasture management we cannot do without clovers on account of their vital role as suppliers of nitrogen to the sward. Just how low the proportion of clover has to be to provide a safe pasture will depend on the potency of the clover. In the U.S.A. a figure of less than 50 per cent. clover has been considered safe but in New Zealand we have seen bloat on pastures containing 25 to 30 per cent. clover. Other control measures of this nature may be considered such as the use of safe feeds, i.e., rough pasture, autumn-saved pasture, crops and silage. The main value of these lies in their use while dangerous pasture is maturing. There are, however, obvious limitations to any extensive use of such feeds and it is not always possible to plan to have them on hand when an outbreak occurs. There are always likely to be periods when a potent clover-dominant pasture has to be coped with.

There are two general methods available for coping with outbreaks of bloat:

(a) oil spraying aimed at preventing foam formation
(b) oral administration of penicillin to slow down production of gas.

(a) Oil Spraying

The most reliable method of bloat control is total area spraying, since the cows are always on sprayed pasture and have no option in taking in the oil. In this method, the whole area to be grazed by the cows in 24 hours is sprayed prior to turning the animals on to it, the rate being not less than 3 oz of oil per cow. The rate of oil per acre will depend of course on the density of the feed, while the actual volume of spray made up will depend on the performance of the spraying equipment used.

There are four main precautions which must be taken in using this method.

(1) The area to be grazed must be judged conservatively. If too large an area is allowed, the oil will be spread too thinly and insufficient may be taken in by individual cows.
(2) There must be no access to unsprayed pasture. The animals may be confined to the sprayed area by means of an electric fence and the pasture sprayed that can be reached from under the fence.
(3) The area should be sprayed as evenly as possible.
(4) There should be no back grazing on to regrowth.

Sprayed pasture may be a little unpalatable at first but the cows quickly become used to it. When peanut oil, tallow or paraffin have been used, no taint has appeared in the milk or cream even when rates as high as 10 fluid oz of oil per cow per day have been used.

The procedure may appear costly but farmers who have used it believe that they cover the cost of spraying with the extra production they achieve compared with what they would have had if bloat had been allowed to continue.

Where it is not possible to spray the pasture, due to steepness of the land, anti-foaming agents may be added to the drinking water. Treatment of the water supply is a less reliable method of treatment because of the variation in drinking pattern from animal to animal and in the same animal from day to day. The animals must obviously not have access to any other source of water than the treated one.

(b) Penicillin

Barrentine in the U.S.A. tried the oral administration of a number of antibiotics for the prevention of bloat in steers. Penicillin was the only one which prevented bloat without undesirable side effects. He found that single doses of 500mg. of procaine penicillin protected yearling steers from bloat for from 1½ to 3 day periods. The penicillin had to be given several hours before it was effective in preventing bloat.

In our experience with dry and lactating cows, fairly effective control of bloat has been obtained by the use of 100 mg. to 200 mg. of penicillin every two to three days. Control was not 100 per cent. as there are some animals that do not respond to the treatment. Work in conjunction with the Dairy Research Institute has shown that at the level of 500 mg., procaine penicillin does not pass into the milk or affect the quantity or quality of the butterfat. No adverse effect on appetite has been noted but rather the reverse. The tendency is for penicillin-treated animals to eat more than the untreated. Cases have been experienced where milk let-down has been interfered with due to over-eating.

We have found that after a period of feeding the animals do tend to become resistant to the action of penicillin. Another drawback to its use for bloat control in a large herd is the difficulty of administration. It can be mixed with a dairy ration or given in tablet form. Many cows will not take the dairy ration and have to be dosed. Barrentine has used penicillin incorporated in a salt lick but this would not ensure an even distribution of penicillin in a herd in this country.

Penicillin appears to be of most use where a farmer wishes to treat a few cows in a herd or a whole herd for a short time.

It will be seen that we now have some methods of controlling bad outbreaks of bloat when a farmer strikes a period of clover dominance in his pasture. We have as yet no method of dealing with the odd case that occurs in a herd. Only when we gain an understanding of all the many complicated factors involved, both plant and animal, will we have the possibility that all cases can be controlled.

The research programme at the Plant Chemistry Division, D.S.I.R. is aimed at achieving this end.

Question: We do not get very much bloat in South Canterbury, but this year because we had 15 inches above normal rainfall we had one or two cases. Has Dr Johns had any success with the probang; we have never lost an animal and by using the probang take the gas out straight away?

Dr Johns: Yes, you can use a probang. It has been used in the Massey herd on severely bloated animals which cannot struggle to their feet. In the early stages drenching is safer. If the person is not used to using a probang you may harm the animal and unless you can direct it to the right layer you will not be relieving the animal. In the case of a skilled operator it is all right.

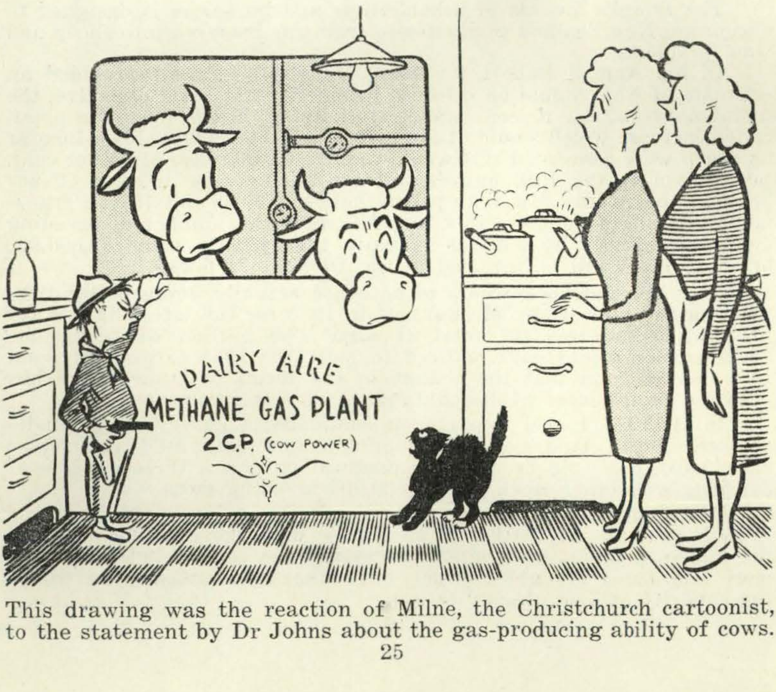
Question: What is a probang?

Mr Grant, Waimate: It is a tube with a cane inside which is passed down the animal's throat into the stomach. The cane is withdrawn and the gases escape.

Dr Johns: In the North Island our probangs are rougher. If you have a method that works go ahead and use it.

Question: There seems to be some tie-up between bloat and the sugar content of the animal. I understand there is a sugary slime which is partly the cause of foaming in the animal's stomach. We get the vet. in for milk fever and he injects calcium into the blood stream. I would like to know more about it, whether there is any connection between too much sugar in the animal and bloat?

Dr Johns: When you have trouble with milk fever the vet. injects calcium and sugar. Milk fever is usually due to a deficiency of calcium and you can get a type of bloat associated with it. It is not the normal pasture bloat. We believe you may get an inhibition of the rumen due to lack of calcium. The milk fever is also often associated with a ketosis which can be due to lack of sugar in the animal. There is no tie-up between the two troubles.



This drawing was the reaction of Milne, the Christchurch cartoonist, to the statement by Dr Johns about the gas-producing ability of cows.

THE NEW ZEALAND WOOL BOARD RESEARCH PLANS AND RESULTS TO DATE

F. R. Callaghan, Scientific Adviser, N.Z. Wool Producers' Board

Sheep and wool research in New Zealand requires to be planned to meet two main objectives. The first, a local one, is to maintain and improve our present standard of prosperity. The second, mainly an international one, is to meet the challenge of artificial fibres, in particular, the true synthetics as represented by nylon, terylene, orlon and similar materials.

The New Zealand Wool Board's research policy is designed to meet these two main objectives.

Locally it is associated:

(1) with the New Zealand Meat Producers' Board in the sheep surveys undertaken by the Gisborne Veterinary Club;

(2) with the Department of Agriculture in the Purua Footrot Control Scheme;

(3) with the Department of Scientific and Industrial Research, Lincoln and Massey Colleges in a number of investigations relating to sheep and wool;

(4) with the Department of Scientific and Industrial Research, New Zealand Woollen Mills and Woolscourers in wool problems at the Research Institute, Dunedin.

Overseas, as a member of the International Wool Secretariat, it participates in research work in progress at Leeds University, Woollen Industries Research Association at Torridon and in other institutions in the United Kingdom, U.S.A. and Europe.

The Board's awards of scholarships and bursaries is designed to encourage New Zealand graduates to train for research into sheep and wool problems.

In his Annual Report for 1953, Mr E. J. Fawcett provided an estimate of what would be involved in meeting the local objective, the maintenance of our present standard of living, in the face of a population increase which would attain a total of 3,000,000 by 1975. Insofar as sheep were concerned this would require an increase of 2½ per cent. per annum on the 1950 figures and a total increase of some 60 per cent. in the twenty-five year period between 1950 and 1975. Translated into sheep numbers this would involve the number of breeding ewes increasingly by 500,000 annually till by 1975 some 35,000,000 breeding ewes will be included in the Dominion's flocks.

New Zealand flockowners to date are actually doing better than meeting the goal set by Mr Fawcett in 1953 for the latest figures for breeding ewes gives the total at some 28.9 million whereas some 26-27 million would have sufficed to meet the 1958 target. It must be borne in mind that the change in the terms of trade which has occurred in the interval discounts some of this advantage.

In 1955 the Lands Department completed a survey of the undeveloped Crown lands of the Dominion and estimated that some 2,360,000 acres could be used for pastoral purposes, these capable of carrying with other stock some 3,800,000 breeding ewes.

The point is evident then, that in order to maintain the increased growth in sheep population to keep pace with the growing needs of the human population, it will be necessary not to rely indefinitely on more land being brought into use, but rather on increasing the carrying capacity of land already in use.

This is already being done. On the experimental farm of the Grasslands Division at Gore, some ten ewes and lambs per acre have been maintained on pastures only. At Ashley Dene, Lincoln College on light shingly soil has increased carrying capacity from three-quarters of a dry sheep to over three ewes and their lambs per acre.

At this Conference last year, Mr Scherp showed the possibility of increasing the sheep carrying capacity, wool production and lambing percentage on a hill-country farm in Marlborough. By top-dressing, improvement of pastures and new management practices, Mr Scherp doubled his wool clip in six years, doubled his flock in twelve years, increased the average clip per sheep from 8½ to 12 lb in the same period while his lambing percentage of 96 in 1950 advanced to 115 in 1956.

It seems obvious therefore that advance in the sheep industry will follow the line of grazing of more sheep per acre, a course which will bring to mind immediately the dangers of disease, the old adage being that each sheep is the next sheep's worst enemy, the problem of ensuring feed supplies adequate to meet seasonal fluctuations and changes in the breeding of sheep and their management. These comprise the groups of new problems which will have to be faced. The results stemming from advances made in grassland science in the last quarter of a century, have undoubtedly contributed more than anything else to the progressive increases which have taken place in the Dominion's sheep population, in wool, lamb and mutton production. However, these advances have not been achieved without certain drawbacks being encountered especially in the realm of nutritional diseases such as facial eczema and ill thrift, and changes having to be made in breeds of sheep.

Lambing Percentage

A fairly safe assumption is that disease imposes one of the greatest, if not the greatest, handicaps upon increase in sheep population and in the costs of producing wool, lamb and mutton. This is emphasised when the lambing percentages published by the Department of Agriculture in the Annual Sheep Returns are examined. The latest figures for 1957-58 year are as follows:

	%		%
North Auckland	86.2	Marlborough	91.5
South Auckland	91.6	Nelson	92.3
Gisborne	81.2	Westland	104.7
Hawkes Bay	91.5	Canterbury	103.8
Taranaki	91.2	Otago	100.1
Wellington	93.4	Southland	111.3
North Island	89.2	South Island	100.6

Sheep Surveys and Research

The figures for these percentages have remained constant for a number of years and show a progressive decrease in lambing percentages in land districts from south to north. The low percentage of 81.2 occurring in the Gisborne district led the New Zealand Wool and Meat Producers' Boards to assist the Gisborne Veterinary Club in a survey of lamb losses occurring in that district. In the course of three years, data were accumulated which revealed that an infectious disease—epididymitis of rams—was the major cause of the lamb deaths. Concentrated research undertaken at Wallaceville led to Dr Buddle's discovery of a vaccine which will control this *Brucella ovis* infection in rams, and this vaccine, now in production, is being used extensively to control the disease.

Mr David McFarlane who is in charge of the Gisborne Survey, analysed the accumulated lambing data and noticed the low figures provided by two-tooth ewes. These varied greatly according to the class of country on which they were grazed. Lambing percentages for two-tooth ewes on stud farms were reasonably high, they were less on flat arable pastures and very low on hill country. This led to a study of the mating behaviour of two-tooth ewes and Mr Inkster at the Ruakura Hill Country Research Station found that the period of heat in two-tooths was often very short, a matter of a few hours only and he showed that by confining the ewes in small paddocks during the tupping season, lambing percentage was markedly increased. Under intensive mating conditions 26.5 per cent. of the two-tooth ewes in the experimental flock remained dry, while under extensive conditions 43.9 per cent. failed to get in lamb. The corresponding figures for mature ewes were 19.0 per cent under intensive and 15.5 per cent. for extensive mating. These studies explained the reason why two-tooth flocks grazing in hill country had low lambing percentages owing to the contour of the land making the ewes more remote from the ram. Management practices can therefore, now with understanding, be adopted whereby lambing percentages may be increased in flocks of young sheep. Studies on older ewes which have failed to produce lambs for two seasons have shown that two-thirds of these have conceived mostly after one service when intensive mating conditions have been a feature of their management in their third tupping season. The other third, when slaughtered, showed various abnormalities in their reproductive organs.

The Gisborne survey technique devised by Mr David McFarlane was given a test in Canterbury, Nelson and Hawkes Bay where it revealed that different patterns of lamb mortality from that found in Gisborne existed in these areas. While the Gisborne survey provided other interesting results, these two examples will suffice to show the value of such surveys in directing research into specific channels where the findings can be implemented to give economic results in actual flock management.

Other Approaches to the Lambing Percentage Problem

However, in order to complete the picture of research effort stemming from recognition of the Dominion's low lambing percentage, mention may be made of other work proceeding at various centres which has a bearing on this problem.

Crossbreeding is under investigation at Ruakura, Massey College and Lincoln College. At Ruakura, Border Leicester x Romney crosses have increased lambing percentages by from 10 to 15 per cent. over Romneys. Massey, testing Cheviot x Romney crosses, weaned 170 per cent. lambs from the cross compared with 84 per cent. from Romneys. At Lincoln, Border Leicester x Corriedale gave an increase of 23 per cent. in lambs weaned, over pure Corriedale.

In studies of Romneys and Corriedales at Lincoln and Massey, woolly-faced ewes have given over 20 per cent. less lambs than those with faces clear of wool.

At Ruakura and Lincoln the oestrus cycle and ovulation rate of ewes is being studied, preliminary indications showing progressive increases in the number of eggs shed after the first period of heat, so that tupping in late March and April is likely to provide more twins and a more compact lambing period.

The influence of hormones in increasing ovulation, stimulating heat at out of season periods, increasing wool growth and meat production are being investigated at Ruakura, Massey and Lincoln, all with the objective of gaining new knowledge to enable lambing percentages to be improved.

At Lincoln, studies of sheep's ova have shown that a considerable percentage appear to develop abnormalities after fertilisation by the ram and consequently fail to develop.

This gives in brief an incomplete summary of the research efforts now being made in New Zealand to deal with the important problem of lifting the present fertility of our flocks to a higher level. In this range of studies, the influence of disease, nutrition, breeding and management are all receiving attention.

Foot Diseases

The New Zealand Wool Board has been much concerned about the incidence of foot diseases in New Zealand flocks. It has been evident to the Board that fear of footrot has been a deterrent to many farmers to topdress their land, because the resulting improved pastures by retaining moisture longer, appear to favour the development of foot disease. Further, owing to the greater chances of infection occurring when sheep were more concentrated in their grazing per acre, farmers are reluctant to increase their flocks at the risk of incurring footrot.

In co-operation with the Animal Industries Division of the Department of Agriculture and with a group of 28 sheep farmers owning over 22,000 sheep in flocks ranging in size from 200 to 4,500 sheep, and varying in management, the Wool Board initiated an operational research trial to test out the application of the Beveridge control technique under practical farm conditions. This trial arranged in the Purua district near Whangarei is now in its third season and the number of sheep owned by co-operating farmers has ranged from 22,000 to 30,000 during the period of trial. Considerable success has attended the efforts made by instructors and farmers, under the guidance of Mr Chas. Ensor, and the latest figures are:

Clean	3 farms	268	sheep
Presumably clean . .	16 ,,	13,731	,,
Almost clean . . .	6 ,,	7,121	,,
Still considerable infection	2 ,,	1,500	,,
		22,620	

The degree of footrot infection at the first inspection, over all the flocks in the trial made in the three seasons was: 1956, 41 per cent.; 1957, 3.2 per cent.; 1958, 3.4 per cent. These figures indicate that a small hard core of disease persists which is difficult to eliminate and which is capable of rapidly infecting the whole flock once suitable conditions prevail. It is these few sheep upon which much effort must be expended in order to get completely rid of the footrot.

The difficulty experienced in determining whether footrot has been completely eliminated arises largely through the problem of distinguishing readily between footrot, scald and the possibility of the occurrence of other foot diseases which are not readily identified with certainty. This phase of the trial is now receiving special attention. The trial has indicated the efficiency of the Beveridge method of controlling footrot, and high-lighted the need for thoroughness in dealing with every phase of the treatment. From the work already done, much valuable material has been gained from experience which will prove useful for instructional purposes throughout the Dominion. Despite the fact that footrot has not been completely eliminated, the participating farmers have expressed themselves as well satisfied with the measure of partial control which they have achieved and are convinced of its economic value.

Fleece and Wool Studies

Fleece and wool studies are in progress at Massey College, Lincoln College and at the Wool Industries Research Institute, Dunedin.

At Massey College, fundamental studies are in progress on the development of the wool fibre in the skin follicles which produce the different groups of fibres which form a normal Romney fleece.

Fleece rot which produces yellow, orange, red and green stains in fleeces, colours which will not scour out, have been shown by Messrs Fraser and Mulcock at Lincoln College to be caused by a *Pseudomonas* bacteria which under certain moist weather conditions is capable of producing strong chemical pigments. Dr A. E. Henderson has shown that there are strains of Corriedale sheep whose fleeces are immune to this staining and studies are proceeding to ascertain the reason for this. In the course of these studies, it was observed that a noticeable thickening of the skin tissues occurred within a few hours of shearing, and that this thickening persisted for some weeks, no doubt to serve a protective purpose following removal of the fleece. This led to some further investigations as to the length of wool which should be left on a sheep to provide it with some reasonable protection against bad weather following shearing. While not much attention has been devoted anywhere to this problem, data from some Scottish experiments interpreted for New Zealand conditions, indicated that slightly more than half an inch of wool was the desirable minimum "safe" coverage for most New Zealand breeds. This result provides some guidance for the design of the snow comb used as an alternative to blades, which are considered to be safer in districts exposed to sudden weather changes at shearing time.

With the assistance of a grant from the Nuffield Foundation, Mr D. S. Hart at Lincoln College, after studying the seasonal rhythm which occurs in wool growth, a rhythm which he showed experimentally was associated with varying hours of light and darkness exercising an influence on the pituitary and thyroid glands of sheep, has followed this up by implantation of the hormone, thyroxine, which, done at the proper season, stimulates wool during the autumn and winter months mainly by increasing the length of the fibre. Though this work is still in the experimental stage, the indications are that thyroxine implantations are capable of giving average greasy-fleece-weight increases of from one-third to over one pound without any loss in grade or count, with a reduction in breaks and cotts, and with no increase in ewe mortality or reduction in lambing percentage. Much work remains to be done before thyroxine can be recommended for general use to stimulate wool growth.

The Wool Industries Research Institute in Dunedin is an Industrial Research Association established by the Department of Scientific and Industrial Research in which woollen mill owners, woolscourers and the Wool Board collaborate with the Department in studies of wool from the time it leaves the sheep's back till it becomes fabric. The Institute provides an invaluable link between growers on the one hand and manufacturers on the other. It enables the results of overseas research findings to be interpreted into use in New Zealand woollen mills and woolscouring plants.

One of the Institute's recent valuable achievements was the work done on pre-lamb shorn Romney and Corriedale fleeces in which these were put through every stage of manufacture from the greasy fleece to the finished fabric, as would be done in a woollen mill. The result at every stage showed that the pre-lamb shorn wool was superior to comparable wool from sheep shorn after lambing, and that buyers had no reason for discounting the value of pre-lamb shorn wool on account of its characteristic looseness in the fleece, and for other features in which it differed from wool shorn at the normal time. As the practice of shearing prior to lambing is progressively increasing, the result of the exhaustive tests carried out by Dr L. F. Story and his staff at the Wool Industries Research Institute, gives a valuable indication that this practice can be pursued by farmers with every confidence that it leads to improvement and not to detriment in wool quality.

New Zealand, as the largest exporter of crossbred wool, has an obligation to understand fully the qualities and variations occurring in this class of wool. In this sphere we are far behind the Australians in their knowledge of Merino wools and so at Lincoln College, Massey College and the Wool Industries Research Institute a systematic study of New Zealand Romney wool characters has been inaugurated. Some of the early results from this effort may be quoted as being of interest. Random samplings from pre-lamb shorn Romney and Corriedale fleeces showed that the pre-lamb wool was from two to two and a half times as strong as that from post-lamb shorn wool. Samples taken from one side of a ewe shorn prior to lambing were over twice as strong as those from the other side, which was not shorn till after lambing. The progressive decline in wool strength which occurs as the season advances was indicated by breaking strength tests made on random samples selected from 50/52, 48/50 and 46/48 wool store-bins. These were:

October . . .	135 lb breaking strength
December . .	115 „ „ „
March . . .	68 „ „ „
May . . .	53 „ „ „

These figures give with some precision information relating to weakness which is regarded as perhaps the chief defect in the quality of New Zealand crossbred wool, and which becomes more pronounced towards the end of the season. This work is as yet only in its preliminary stages, but some of these early findings which may require further verification in the future are of interest.

Overseas Research

As a member of the International Wool Secretariat, New Zealand participates in the research work promoted by that body. In 1956 the I.W.S. budgeted £123,000 for research, New Zealand's contribution being £29,000 or 23 per cent. of the total. This total has since been increased by some £42,000.

These funds are allocated in varying sums to eight research institutes in the United Kingdom, to nine in Europe and three in the United States of America to enable specified projects to be undertaken. The chief grants are made to Leeds University and to the Wool Industries Research Association at Torridon.

The scope of the research work overseas is confined to manufacturing problems and to fundamental problems affecting wool. It is designed to bring about improvements in threads and fabrics processed from wool. As New Zealand exports most of its wool to the U.K. and as only some 3 or 4 per cent. of the clip is manufactured by local mills, it is appropriate that research work on crossbreds should be done in the country where the wool is processed. Through the Wool Industries Research Institute in Dunedin the results of overseas research can be interpreted for New Zealand usage. A few examples will give an indication of the nature of some of this overseas research work.

Three machines, the Autocount, the Autoleveller and the Ambler Superdrafter have been recently designed to provide improved and readier means of ensuring uniformity of yarn thickness, a matter of considerable importance in ensuring evenness in woven fabrics. One of these machines, the Autocount, automatically reduces the range of weights from 34 per cent. previously secured by careful supervision, to 17 per cent. These three machines, designed and tested at Torridon, are being installed in a number of woollen mills.

At Torridon also, it has been shown that through improved attention being given to a number of factors during the scouring, drying and carding processes the percentage of waste products (noils) can be markedly reduced. The adoption of these precautions is estimated as providing a saving of £1,000,000 to the wool industry.

Torridon is investigating the development of unsightly "pilling" in woollen fabrics which is alleged to have increased in recent years through increased amounts of short fibres having been left in the yarn. The twist on the yarn has not been found to have the importance that was attributed to it, and it appears that tight fabric twist is the best precaution against "pilling" in either knitted or woven fabrics.

Investigations to develop improved methods to render wool shrink proof, continue at Torridon and a recent method in which wool is treated with peracetic acid and sodium hypochlorite simultaneously has given promising results as an effective and inexpensive process.

At Leeds University a method has been devised for the permanent pleating of all-woollen fabrics and this is now being used by manufacturers in the U.K. and thus the challenge of terylene and terylene mixtures which pleat remarkably well and permanently, is being met. Incidentally, another process developed in Australia by Dr Lipson at the C.S.I.R.O.'s Wool Textile Research Laboratories, Geelong, is now in commercial use by garment manufacturers producing durable pleated all wool trousers and skirts. This is known as the Si-Ro-Set process.

The conversion of wool wax by the use of micro-organisms into desirable and saleable products is also being studied at Leeds University, a problem which is of considerable interest to woolscourers, to whom the disposal of effluents always presents real difficulty.

A whole range of problems connected with the dyeing of wool is also under investigation at Leeds University, and as improvements in the finish of wool fabrics are considered desirable by the I.W.S. the University is also engaged on studies in this sphere.

In Germany special studies are being given to chemical processes designed to increase resistance of wool to attack by insects, fungi and bacteria. Already the chemicals, dieldrin and aldrin, have shown their efficacy in the control of lice, keds and blow-flies in the fleece and also their toxicity to the carpet beetle and clothes moths in woollen fabrics.

At Princeton in U.S.A. a very comprehensive investigation is in progress, designed to show just what is the significance of the points on which greasy wool is judged (strength, crimp, lustre count, etc.) in the quality of the finished fabric. Preliminary results dealing only with crimp indicate that fine crimp provides a stiffer top, superior spinning, a slightly bulkier yarn which does not make a bulkier fabric when woven, a slightly weaker yarn with a slightly better surface appearance, better drape and better wear.

Associated with the overseas wool-research programme, only some of the practical aspects which have been dealt with above, is a considerable amount of fundamental work in the physics, chemistry and biology of the fibre whose complicated structure gives an association of very desirable qualities, which provide it with a merit which, so far, has not been met by any of the synthetics either alone or in combination.

The Challenge of Synthetics

The strong challenge of the synthetics will always require much effort to meet. In quantity alone their production increases have been impressive. Recent figures have given the increase in production of various fibres during the period since the outbreak of World War II.

Wool	28%	increase
Cotton	27%	,,
Rayon	207%	,,
Nylon Types	600%	,,

Some indication of the effort made by manufacturers of synthetics to develop their industry is provided by an eminent American scientist who, in a recent paper, reported that three cents out of every dollar's worth of synthetic material sold was taken for research and development. This applied only to manufacturers of synthetics in the U.S.A. To this must be added the efforts and expenditure made by European manufacturers. If New Zealand woolgrowers did the same with their product which last season sold for some £110,000,000, then over £3,000,000 would be available for research and development in the interests of wool. A liberal interpretation of the total amount spent locally and overseas by New Zealand on research in sheep and wool, places this figure at £230,000.

Some Recent Improvements in Woollens

The challenge facing wool producers can be met along two main approaches the first of which is concerned with the use of science in improving manufacturing processes and eliminating the recognised defects in wool fabrics. Progress in this direction is being made. In 1957 at the suggestion of the chairman of the New Zealand Wool Board, the I.W.S. arranged a conference in London attended by 20 of the world's leading wool scientists to deal with what was termed "Easy Care Problems" associated with woollen fabrics. At this conference, attention was devoted to the research efforts being made to overcome defects associated with woollen materials such as felting, shrinkage, laundering, creasing, resistance to soiling, staining, pilling, etc. Recent achievements and matters still requiring research, received scientific consideration and were dealt with and plans made to promote investigations in this particular section of problems associated with woollen fabrics.

The tendency for wool to felt and shrink has been overcome by the adoption of any one of a number of anti-shrinking chemical treatments all developed in recent years, a number of which are in use in woollen mills. Insect attack by beetles and moths can now be prevented almost permanently with treatment with dieldrin and aldrin.

Permanent and durable pleating of all wool fabrics is a recent advance made by English and Australian wool scientists.

In the U.S.A. marked progress has recently been made by the application of a fluorinated hydrocarbon to woollen fabrics giving a high repellency to oil, water and dust, hence overcoming staining. This treatment, known as the "Scotchguard" process, already proved in the upholstery of motor cars and aeroplanes, was now in use in flannel and gabardine apparel. This treatment is an answer to one of the "easy care" virtues which are claimed for synthetic fabrics.

The sterilisation of woollen blankets, especially in hospital use, has always proved difficult, costly and slow. In recent years the prevalence of H-bug staphylococcal infection in hospitals has been attributed partly to blankets being one of the principal carriers, for, unlike sheets, and overalls, they could not be boiled. Suggestions have been put forward that woollen blankets should be replaced in hospitals by blankets made of synthetics, which could be boiled, as was done with cotton and linen materials. At the Christchurch Public Hospital laundry where thousands of pairs of blankets are laundered weekly and at St. Helen's Maternity Hospital, Wellington, where the throughput is on a much smaller scale, a technique has been developed in which woollen blankets are boiled and sterilised without either shrinking or felting taking place, thus maintaining the status of wool for hospital bed usage.

World Wool Production

The second approach in maintaining the position of wool among the world's fibres, comes from the farmer making use of all the knowledge which science can provide him in producing more, better and cheaper wool. This, perhaps, is the approach which will provide the surer and speedier results.

Recent figures have shown that wool production is stationary or decreasing in many countries of the world. Australia, New Zealand, the United Kingdom and Uruguay represent the only countries where increases are evident. Last year the world total production of wool showed a slight decrease. Stock piles of wool, with perhaps the exception of France, are at an unusually low level. This state of affairs presents a distinct threat to wool, for if manufacturers run short of wool for spinning and weaving they will be obliged to turn to alternatives to keep their machines in operation. No doubt the salesmen of synthetics will be on the doorstep ready to supply the manufacturers' raw material.

The prospects for increasing wool production in many overseas countries at present do not seem very bright. In the U.S.A., despite price support for wool, the sheep population at 26,000,000 has, in recent years, shown a declining tendency, while in South Africa, sheep numbers have remained almost stationary.

It is obvious therefore, that it is sound policy for the New Zealand farmer to improve on the present six per cent. annual increase in wool production, and ensure that there is sufficient cross-bred wool available to mills, to meet the demands of a rapidly increasing world population and to avoid the woollen manufacturers having to resort to alternative fibres to meet their needs.

Question: Are the blankets you mentioned as suitable for hospitals being manufactured now? Hospitals have great trouble with the H-bug. Is it possible to have pre-shrunk blankets?

Mr Callaghan: Almost every woollen mill in New Zealand can, if it is asked, provide pre-shrunk blankets by one of the processes I have referred to. As far as the H-bug is concerned, I feel the blanket is taking an undue amount of blame. The H-bug organism is killed by something less than boiling temperatures. Consequently if you can boil the blanket the H-bug is killed but the blankets can easily be reinfected after boiling from bugs in the atmosphere.

Question: As regards footrot, after four years of treatment we still get 3-4 per cent. of cases. A great many people in the south are worried with scald. Why cannot you cure that trouble? If you slaughtered the few hundred sheep you cannot clean up would the flocks then be free, if they are free can you keep them free, if not why not?

Mr Callaghan: Foot-rot boils down to the difficulty of diagnosis. The Beveridge technique aims at the Achilles heel of the problem. The foot-rot organism is incapable of living away from the sheep in the soil or grass other than for a short period. In dry Australia the organism will die almost at once. In wet conditions it will last three weeks. If you can diagnose a sheep as not having foot-rot and put it in a pasture that has been spelled from sheep grazing on it for two to three weeks, that sheep should remain free from foot-rot. It may get scald which may be a forerunner to foot-rot. You must be quite sure that those you have are really free. Foot-rot can remain in a concealed state in the foot for 12 months or more. The organism gets into a small lesion and then when conditions arise it breaks out again.

You could kill infected sheep to get rid of the trouble. It has been done in Western Australia where there are flocks in dry areas which do not have foot-rot. Farmers in other areas whose sheep get foot-rot sell the flock for slaughter, spell the land for three weeks and buy clean sheep. The number of farms that have foot-rot infected sheep is now about 20 in the whole State. They are obliged to sell any sheep they want to sell through special saleyards for slaughter. It is a much more difficult problem in New Zealand but, if Banks Peninsula, for example, was a district which had no foot-rot in sheep, it would be a great reservoir for you to buy clean sheep from. You would sell off your infected sheep, spell the farm for a fortnight or more and restock with sheep from Banks Peninsula.

Question: In view of the economics of the situation I would ask what else is being done in this country and possibly overseas in the way of research into the whole foot-rot problem. No-one is clear between foot-rot and scald and what the tie-up is. Is anything being done to find out the tie-up and what to do?

Mr Callaghan: Yes. Foot diseases are pretty like bloat. We have been doing research for a long time. In Australia at the present time they are devoting quite a lot of attention to endeavouring to clear up the difference between scald and foot-rot. The C.S.I.R.O. has two or three men working on that and work is also going on in Victoria. In New Zealand the Wool Board has been pressing for this type of research work. We accept the Beveridge technique. What are the difficulties in putting the Beveridge techniques across? There is the lack of ability to diagnose properly. There is too much faith in formalin and bluestone. There is the difficulty of the farmer in finding and treating the last lesion. One must have hygienic methods of operation on the foot. The Department of Agriculture has advertised for men to undertake research into all diseases of the feet of sheep.

DEVELOPMENT OF THE FLEECE AND EFFICIENCY IN WOOL GROWTH

A. E. Henderson, Lincoln College.

In general terms efficiency in wool growing could be said to be the achievement of the greatest possible margin between cost and return. This is without doubt chiefly a problem for the economist for in it are many factors quite apart from those concerned directly with wool growing. But if we confine ourselves to only a section of the problem, that of making most efficient use of the resources of food supplies and breeding animals that are clearly available to all farmers, we still have a very large field in which to make our enquiries.

There is no need to emphasise that the return of money for wool depends most on how much you have to sell and perhaps a good but somewhat crude gauge of efficiency is to think in terms of amount of clean wool produced per acre. Next in importance is the kind of wool you have to sell, its fineness, colour, crimp, softness, length, its freedom from hairiness and cotts and its staple strength. Of all of these things fineness has by far the greatest influence on price and while the exact influence of the other factors mentioned is hard to define they all have some effect and are worth some attention.

We have then to examine first the factors that are responsible for determining the kind of wool a sheep may grow. Then next we must examine how we can most efficiently or economically exploit the potentialities of the sheep, by general management and utilisation of feed supplies.

The Wool-Follicle Population

The things that determine the kind of wool a sheep grows are fairly numerous and before we can very well discuss these we must first have some knowledge of the population of wool manufacturing units, the wool follicles and, how this population developes and behaves.

There are two kinds of wool follicle, primary and secondary (Fig. Ia, b, c). Primary follicles have, as will be seen, a full complement of accessory structures, namely a large fat gland, a sweat gland and a follicle muscle. They are usually but not always larger than the second kind which have only a small fat gland but are without a sweat gland or follicle muscle. Both kinds of follicle are slightly spiral in shape, are approximately 1-25th of an inch long, have a copious blood supply to the base of the bulb and around the lower third of their length and in sheep growing crimped wool the bulb is not in direct line with the follicle shaft.

A recent interesting discovery is that secondary follicles may branch just below the skin surface to give eventually a cluster of follicles—up to nine in a cluster—having a common opening in the skin (Fig. Ic). These branched follicles have been found in many breeds but they occur most extensively in the Merino and are in large part responsible for the great density found in that breed.

The follicles are not arranged haphazardly, they occur in groups having quite recognisable architectural features. Each group has three primary follicles arranged as if on the margin of an ellipse and within the ellipse are a number of secondary follicles (Fig. II). Each breed has a characteristic ratio of secondary to primary follicles and while this is of considerable importance in determining fleece type it is perhaps overshadowed in importance by the way in which follicles initiate and develop during formation of the group.

TYPES OF WOOL FOLLICLE

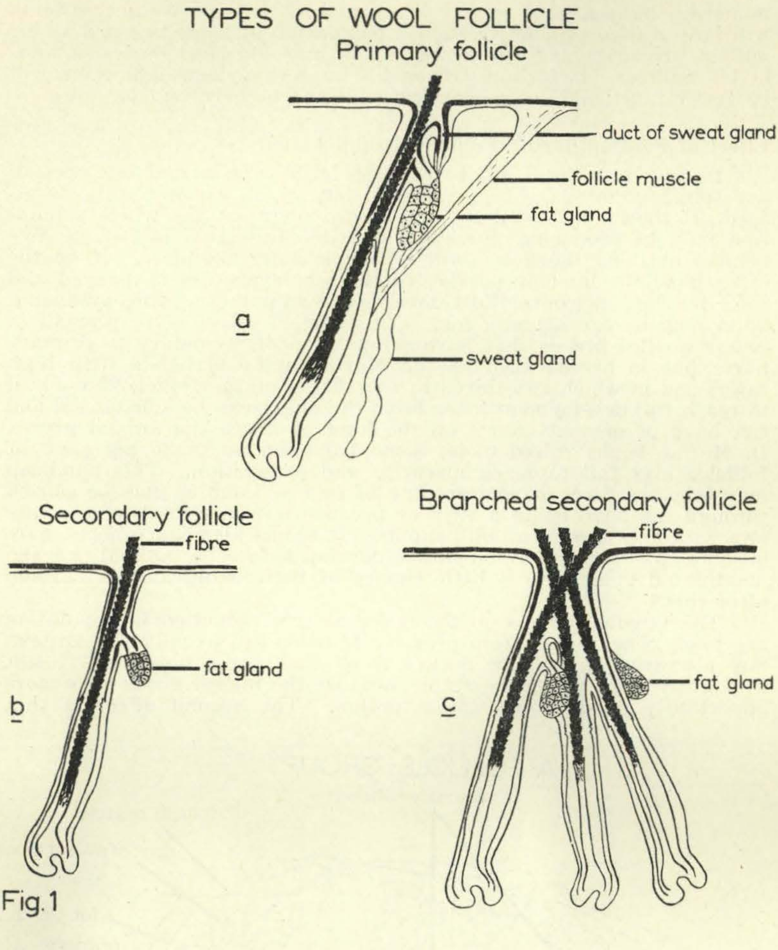


Fig. 1

As is suggested by the name, primary follicles appear first and the first of these are initiated about 60 days after the lamb begins to develop. They continue to appear over the next 25 days and probably because of their comparative isolation they tend to grow large. From 85 days on, secondary follicles are initiated and by the time the lamb is born, at about 145-148 days from conception, all follicles have been initiated. However only a portion have fully developed. Follicles require about 40 days for their development so that at birth we can expect all the primary follicles to be fully developed and producing fibres and we can expect some of the earliest secondaries also to have achieved full size and be producing fibres.

So far as we know all breeds of sheep that we are interested in have similar total numbers of primary follicles. They have something like two and a half million. At birth these same breeds also have similar numbers of fully-developed secondary follicles—approximately three productive secondaries for every primary. Thus on a numerical basis a lamb of any breed and of average weight at birth will have a total productive follicle population of some two and a half million primaries and seven and a half mission secondaries, a total of ten millions. If for any reason the lamb is underweight there will be fewer functional secondaries; if it is large there will be more.

Effect of Feeding during Follicle Establishment

In any lamb there will be at birth large numbers of late secondary follicles that have been initiated but which are not fully developed. If the lamb is well fed and is growing fast the whole population may be producing fibres by the time the lamb is four to five months old, and the fleece will be numerically complete. If on the other hand the lamb is poorly fed the whole process is delayed and some follicles may never fully develop and so potential fibre-producing units may be permanently lost. This sort of effect is very small in coarse-woolled breeds that have a low ratio of secondary to primary fibres but in breeds such as the Merino and Corriedale with high ratios and in which two-thirds to four-fifths of the follicles have still to reach full development after birth the effect can be substantial and can have permanent effects on the kind of fleece the animal grows. In Merino lambs raised under some handicap up to 25 per cent. of follicles may fail to reach maturity and production. This handicap may take the form of poor feeding of ewe or lamb or may be caused through the lamb being a twin or because it was reared by a young ewe with only moderate milk supply. It seems also that unless there is some opportunity for follicles to develop before the animal is seven months old then there is little chance of their being able to develop after this.

The tangible effects on the fleece of this reduction in population are two. Since fibres from primary follicles are usually the largest, any alteration in balance in favour of the larger fibres will result in slightly more tip on the staple, because the bigger fibres have more opportunity to dominate the situation. The second effect is that

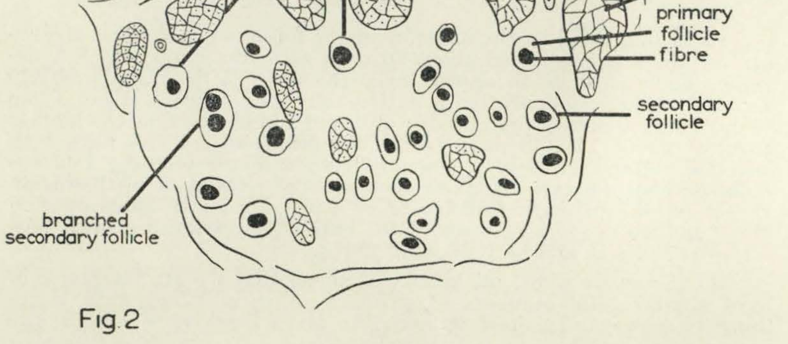


Fig 2

because of the reduced population of fibres, each fibre that is there tends to be larger. This comes about because any juvenile handicap does not apparently affect the inherent ability of the sheep to convert food materials into wool. All that happens is that materials for wool growth are transformed by fewer follicles and the resultant fibres are thicker and larger than if the same animal had had opportunity to develop the full potential numbers. A count difference equivalent to that between 60s and 64s has been recorded in adult Merinos some of which had been restricted in early growth through poor feeding of the ewe during pregnancy.

The situation therefore is that in Merino sheep particularly and to some extent in Corriedales any sheep that was caused to grow slowly in its first five to seven months will have slightly coarser and longer wool than it was intended and this may spoil some selection effort. Further, since 60s wool is worth some eight per cent. less than 64s wool, price per pound will be lower and total return less. This of course assumes that treatment after seven months is comparable.

At this point it must be emphasised that this alteration in quality, length, and to some extent nature of the tip is brought about by simple decrease in numbers of follicles following on poor feeding of the young animal.

The Hereditary Pre-natal Check

The next event to be described is not affected in any way by feeding, it is one governed almost entirely by the breeding of the animal and the effect on the fleece is brought about through an alteration in relative size of primary and secondary follicles and fibres. Total number is not affected and again there is no effect on the ability of the sheep to produce a quantity of wool.

To understand how important this effect can be we must realise that we are dealing with a biological population among which all the elements of opportunity and competition exist. Consider then the enormous opportunity that the comparatively isolated early follicles have—they start to grow nearly 90 days before the latest follicles and the earliest of them are fully developed and producing fibres some 50 days before the latest follicles initiate. By all biological principles such an advantage must result in these early arrivals being able to grow large and to become very firmly established. Those coming later must face increasingly strong competition which inevitably results in a smaller size and a correspondingly small output of fibre. If this procession of events is allowed to go unchecked then lambs are born with a rough, hairy coat and the resultant fleece is extremely tippy; also the staple formation and crimp expression is poor or non-existent and a close examination will reveal a very large range in fibre diameter and length within the staple. This kind of fleece turns up occasionally in all breeds but it is typical of the Scotch Blackface, Herdwick, Swaledale and very many European breeds.

Fortunately sheep can be bred in which there occurs, early during pre-natal fleece development, a profound check to size and activity of the earliest-starting follicles. This then gives later-appearing follicles more opportunity and as a population, the size of the fibres they produce approaches or equals the size of fibres produced by the earlier follicles. Birthcoats of these lambs are smooth and curly and the adult fleece which follows has every chance of being well crimped and having the staple well defined with a minimum of tip. The Merino and Corriedale must be specially mentioned here because an added factor operates to bring about some measure of evenness in the adult fleece. This added factor is the appearance of very large numbers of late follicles which by combined effect appear to cause some reduction in the activity of the early-starting follicles. It is possible therefore to have Merino and Corriedale lambs born with a rough, hairy birthcoat indicative of little check and to have these same sheep grow a flat-tipped blocky-stapled fleece which may even be well crimped. However very many of the lambs so born have a fleece which is more variable than it should be; it has a rather indeterminate staple formation with a fairly obvious amount of what is called "cross-fibre." These latter effects are caused by the bigger fibres in the population being held firmly at the tip at a level with other fibres by grease and dirt and subsequently because of their greater length-growth-rate these fibres become very convoluted and interfere with staple and crimp precision which depends greatly on similarity of dimension of fibres. In these breeds therefore that have high fibre-numbers the situation tends to be dominated by the very large population of late-appearing fibres. However as the sheep grows older some of the population ceases production and the sheep become less able to support growth in the smaller follicles, particularly in bad seasons. If this sort of thing happens then the fleece will be increasingly dominated by the bigger fibres, style will be lost and staple tip will become more obvious and ragged. Although we have no direct experimental proof, it is very probable that it is this kind of fleece which gives us the doggy wools which appear in considerable quantity in old sheep. This sort of thing does not happen in coarse-woolled sheep because the situation is dominated from the very beginning by the very much larger early-starting fibres. Fortunately few genetic factors are involved and selection against rough wool, whether it concerns only part or the whole of the fleece, can be very effective.

Quantitative Wool Production

The events so far described, one a numerical effect induced by feeding and the other an effect governed by breeding which alters the balance of relative sizes of follicle and fibre within the population are those affecting the kind of wool and neither of them has a noticeable effect on potential quantity of wool which has, as pointed out before, the greatest influence on wool returns. This does not mean however that the sheep that grows the most wool is the most profitable. In most forms of agricultural production the principle of diminishing returns operates and in wool production the sheep provides no exception to this principle.

Obviously no matter what machinery for producing fibre exists, if it is not supplied with materials on which to operate then it cannot function. To grow wool therefore a sheep must first find and eat the essential materials. Then its digestive system and all the body powers concerned with breakdown of complex materials and re-synthesis of these into even more complex substances must be brought into play so that eventually the materials required for fibre growth are delivered into the blood stream and transported to the vicinity of the follicles. But while all this is going on, the sheep must use some of these materials for provision of energy so that it may meet the day to day expenses of living. It must also provide some material for some or all of the other productive processes such as growth, fattening, pregnancy and lactation.

The question of efficiency in quantitative production is therefore concerned with how much and what the sheep eats, the efficiency of its digestive system and the way it apportions the nutrients so obtained between wool production and all other requirements.

The amount a sheep eats can be taken as proportional to its body weight and this appears to apply generally through the range of breeds and sizes of sheep within breeds. It seems also that there are no very great differences among sheep in their ability to digest feeding stuffs but it is perhaps wise to mention here that the breeds differ somewhat in their liking for and ability to handle large quantities of certain feedstuffs and this seems to be largely a matter of temperament. Because of the similarities that exist with respect to appetite and digestion it is not surprising to find a strong positive relationship between body weight and wool production. Over a flock it can be established that the heaviest sheep grow most wool, and differences between heavy and light sheep are at the rate of approximately 0.03 lb clean wool per pound body weight.

High wool-production and high body-weight are in general the result of greater food consumption by the bigger sheep. A striking example of this is provided by fleece-weight returns for three groups of Romney lambs that had been treated very differently from birth until they were shorn at 52 weeks of age.

TABLE I

Clean Dry Wool Production per Head and per 100 lb Body Weight of Romney Lambs

Feeding	Body Weight at 52 weeks lb	Lb Clean Dry Wool	Lb Clean Dry Wool per 100 lb Live Weight
Good . . .	119	5.8	4.9
Poor . . .	57	2.6	4.6
Poor to 5 months then Good .	91	4.3	4.7

It will be noted that despite large differences in total production the production per 100 lb of sheep is approximately the same.

As a general principle then we may say that the more a sheep eats the heavier it will be and the more wool it will produce. This

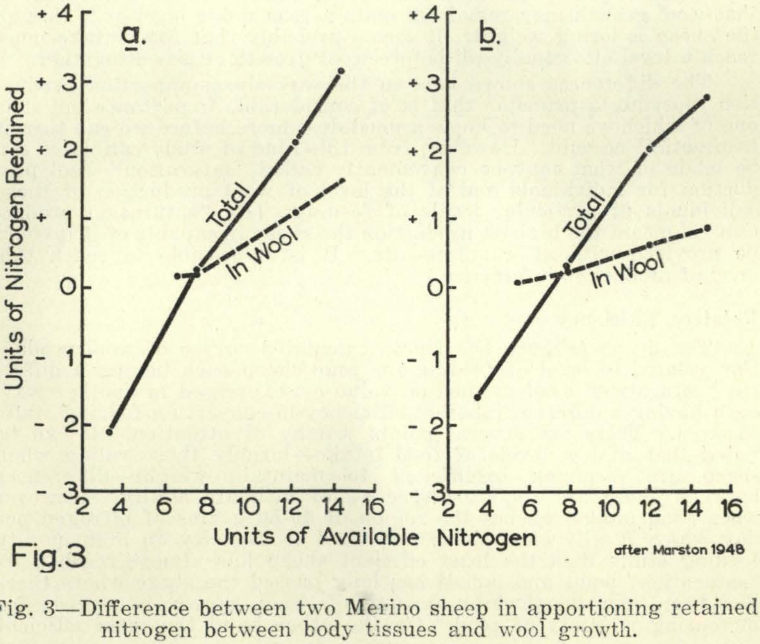


Fig.3

Fig. 3—Difference between two Merino sheep in apportioning retained nitrogen between body tissues and wool growth.

statement is obvious and well known but it clouds a lot of thinking concerning sheep efficiency. The things we should be most concerned with are these. What are the differences between sheep in the way they apportion their food materials into those for wool production and those for other purposes? And, secondly, what are the differences in utilisation of foodstuffs at different levels of feeding?

To deal with the first point we must admit that the statement that the heaviest sheep produce the most wool is a generality and this being so it is possible to find heavy sheep that produce a light fleece and small, light sheep that produce heavy fleeces. If we are dealing with a breed kept primarily for wool production, then for economy of production the choice would appear to fall on the small sheep growing a heavy fleece. However if meat production in any form must be considered, then some middle course must be chosen.

It is usual in many studies of this kind to use nitrogen as the measure of food intake and of gains on the part of the animal with respect to both wool production and general body gains. This measure has been used in Figure III (A and B) which illustrates the differences that may occur between sheep of the same breed, strain and age and feed at the same level in the way they utilise feeding stuffs for productive processes.

The sheep represented at A while it is reasonably well-fed makes better total use of its food for productive purposes as indicated by the fact that the heavy line reaches a higher level than that of sheep B. It however uses a very high proportion of this for wool growth and actually stores less as body tissue than does sheep B which has generally a lower efficiency except at very low levels of feeding. It may be argued that the second sheep might be the better where dual production is required.

Another quite important principle is illustrated here and that is that wool growth may remain at quite a reasonable level even though the sheep is losing weight. It seems probably that food intake must reach a level of virtually nil before wool growth ceases altogether.

The differences shown here in the way sheep apportion production illustrate a principle that is of considerable importance but it is one of which we need to know a good deal more before we can turn it to practical account. However, from this kind of study estimates can be made of what may be conveniently called "saturation" wool production for individuals and of the level of wool production of these individuals at particular levels of feeding. (By "saturation production" is meant the highest production the sheep is capable of if it could be provided with all requirements. It is impossible to reach this level of production in practice.)

Relative Efficiency

The graph (Figure IV) shows calculated curves of wool production related to level of feeding for four sheep each having a different "saturation" wool production value or, expressed in another way, each having a different inherent efficiency in converting feeding stuffs to wool. There are several points worthy of attention. It can be noted that at low levels of food intake—largely those ruling when sheep are receiving insufficient to maintain weight—differences between sheep are small irrespective of ultimate ability. However when food intake reaches the region of 40-50 grams of nitrogen per day which it will when sheep may feed to capacity on high quality feeding stuffs then the least efficient sheep has almost reached its "saturation" point and indeed has long passed the stage where there has been any worthwhile amount of wool grown in return for increasing amounts of food. On the other hand the most efficient

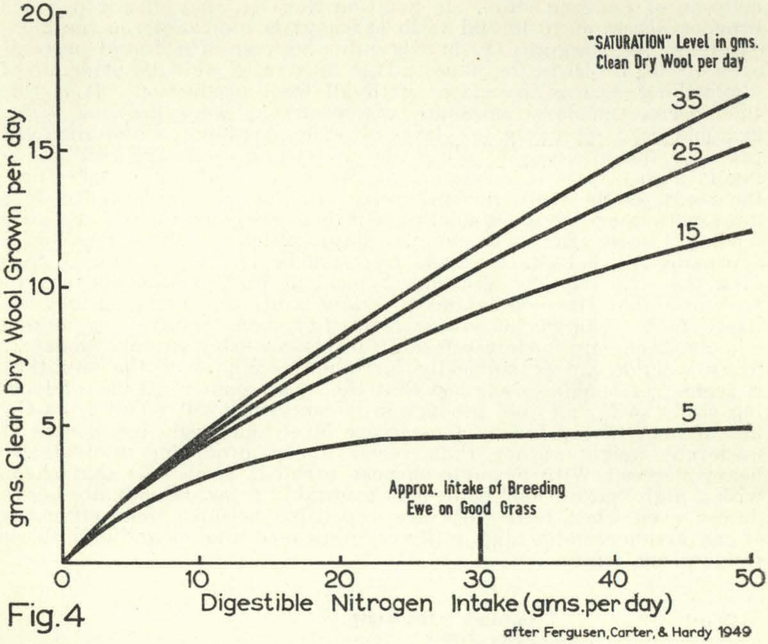


Fig. 4

Fig. 4—Efficiency of food conversion by sheep with different "saturation" levels of wool production.

sheep has reached a high wool-production level, it is still growing a worthwhile amount of wool for each additional unit of food and is obviously far from reaching "saturation" point. Obviously this sheep has a wool-producing capacity far beyond its appetite and perhaps the ability of feeding stuffs to provide nutrients essential for wool growth.

Production of the Average Sheep

It needs no argument at this point to decide that with our dual-purpose requirements we want neither the least-efficient sheep nor yet the most efficient simply because this latter sheep would be in reality a single-purpose sheep, admirable of course if that was the requirement. If we care to make certain assumptions, chiefly that our most numerous Romneys, Corriedales, Halfbreds, and Merinos behave in the same way as the Australian Lincolns, Corriedales, Polwarths and fine Merinos on which all this information has been obtained—and there is no good evidence as yet that they are different, then we can calculate that our average sheep has a "saturation" wool production value somewhere about 15 grams clean dry wool per day (= 0.033 lb per day = 18-20 lb greasy per year). Some attempt may now be made to discuss the second of the questions posed earlier: "What are the differences in utilisation of foodstuffs at different levels of feeding?"

The wool-production curve representing what is probably near to our average sheep has been redrawn and extended (Figure V) and to it has been added the wool increment likely to result for each addition of ten food units. In addition the efficiency of sheep which produce fleeces of 10 lb and 15 lb (greasy) is indicated (on the basis of greasy fleece weight the breeds differ because of different percentages of clean wool in the fleece). This illustrates well the principle of diminishing returns associated with all wool production. It is this that decides in large measure the profit in wool growing. For example at a relatively low level of feeding (10-20 grams nitrogen per day) the efficiency of utilisation of feeding stuffs for wool growing is high—but it is seemingly at the expense of other body functions and is therefore not generally acceptable. With added feed units, efficiency decreases and, at a level corresponding to very good feeding (40-50 gram nitrogen per day), efficiency of conversion is approximately halved. If sheep feed can be cheaply produced, then even the relatively-low efficiency typical at high feed-levels may be still profitable. If good balanced feeding stuffs are costly, as they are likely to be in areas of low soil fertility, poor rainfall, or unkind climate, then only moderate feeding levels resulting in only moderate fleece weights are economically justifiable. Whatever the situation, it seems reasonable to suggest that the most economical use of feeding stuffs so far as wool production is concerned will result from the use of many sheep fed at a moderate level and producing fleeces of moderate weight rather than fewer sheep producing individually heavy fleeces. With a single-purpose breed it is obvious that sheep with a high "saturation" point may profitably grow individually-heavy fleeces even when feed units are expensive because their efficiency of conversion remains high until very high feed intakes and high fleece weights are reached.

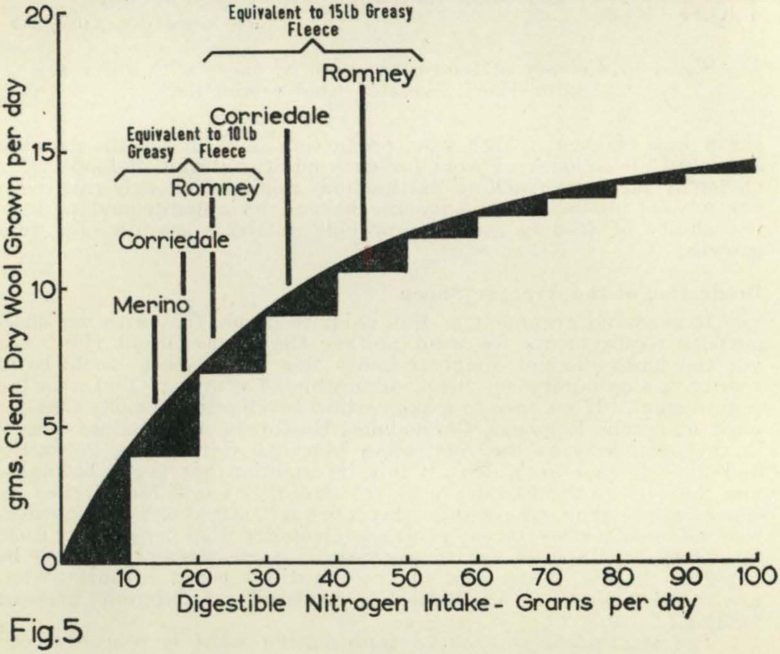


Fig. 5—Conversion of food to wool by the average sheep.

Conclusion

Although there is a tremendous need for much more comprehensive investigation of all these relationships we can from the information at our disposal formulate some guiding principles. The things that control a sheep's ability to produce a certain quantity of wool can be conveniently divided into three. First, those that are inherited. It seems likely that efficiency of conversion, "saturation" level of wool growth (which governs the rate of decline in wool growth with increasing levels of feeding), and foraging ability and appetite come into this category. The second group of directive factors are those due to the permanent effects of early environment; these are characteristic of the individual sheep but are not passed on to progeny. Size and, following this, appetite are good examples of such factors. A sheep reared as a single lamb on a ewe with a very good milk supply will have the best opportunity to grow big and this larger size tends to allow it to have a greater food through-put. Third, comes food supply both quantity and quality, and this, equated to the seasonal demands of the animal, governs the opportunity that the sheep will have to exhibit its potential ability.

As far as we are able to judge it seems that when the yearly fleece weight is approximately 10 lb greasy, conversion of food to wool is at a very high level of efficiency. If attention is paid to the kind of wool the animal grows, by breeding for a well defined staple that shows no rough or hairy tip and by good feeding of the young lamb then fleeces of this weight can be very good. If feeding is such that much higher fleece weights than 10lb are reached then the fleece may be very slightly higher in grade and of course there will be more to sell: however, the margin of profit on this extra wool per sheep at a very slightly higher price is likely to be very small and resources would be better employed in feeding additional sheep. As an alternative this very good feeding could be most efficiently employed if we could identify the sheep with a high "saturation" wool production. Let us be optimistic and hope that we may yet be able to do this easily.

Question: It would appear that it would pay to starve your sheep as much as possible as long as they are still in health. Surely this is not the best practice?

Dr Henderson: It seems from this work the process is repeatable. Providing a sheep is not diseased you can take it down the graph or up the graph by reducing or increasing the feed. If producing fat lambs, you have other requirements you must observe otherwise you cannot obtain your objective. The real question is at what point on the graph the farmer intends to produce at in order to balance his efficiency of wool production, efficiency of lamb production, stock health and so on. My interpretation is that you can do that at about a 10 lb fleece weight.

Question: If you shear twice a year would you get more wool than shearing once, i.e., every six months?

Dr Henderson: Yes. You get it in two ways. One is by removing wool every six months you avoid weathering by which you lose wool. Two is by the appetite of the sheep; the appetite rises substantially and stays high for three to four weeks. Because it eats more it grows more wool. The measurement is ½ to 1 lb more wool per year.

Question: To put another 2 lb on the fleece is going to cost more in feed, but what about quality? Would not you get a better quality fleece with better feeding?

Dr Henderson: It is quite true that the more sheep are induced to eat the more wool they will grow and the better wool it will be. If you set about equipping a sheep with a good foundation to its fleece then you can actually reduce your production to a very low level without causing significant change in type of wool. The Merino has an even fleece; the failing of a lot of Romney and Corriedale wools is the unevenness in fleece and the slight tippiness. In these breeds the better the feed the better the fleece. If the sheep are underfed you would only get an 8 lb fleece and lose most of its good points. The difference in price between one grade of wool and another is not more than 3d. You would need to increase the fleece weight from 9 to 14 lb before you change the fleece by one grade. Two to three pounds of extra wool would be needed before you get another 6d lb.

Question: Does the relationship between appetite and shearing apply under all conditions, lambs as well as ewes and different breeds?

Dr Henderson: Yes, young sheep and old sheep. One experiment was on Lincoln, Corriedales, Polwarths and Merinos, and they all behaved alike.

Question: If we did aim at a 10 lb fleece how could we allow for the varying seasons we have in Canterbury?

Dr Henderson: If you aim at 10 lb and have a good season the fleece may go to 11 lb or 12 lb; your feed is cheap and so your cost of production is low. If it is a bad season then the fleece might be down to 9 lb and every unit of food grown on the farm has been expensive. The aim of average stocking is to produce a reasonable fleece weight with regard to the levels of efficiency and requirements of production. In stud breeding it is quite usual for the fleece to go to 12 or 14 lb. The whole thing is definitely a problem for the individual.

MOISTURE IN WOOL

J. E. Duncan, Wool Supervisor, N.Z. Department of Agriculture

If I told you that for years our Department of Agriculture has been aiding and abetting the export of water from New Zealand at an average price of £3 per gallon you might suspect some underhand business. However I can assure you that everything is above board and perfectly legal, and the water is contained in scoured wool where it is perfectly natural for it to be. I shall have more to say about that presently, but in the meantime let us consider moisture in other products.

Quite a number of things with which you are all familiar, such as timber, paper, tobacco, cereals, biscuits and numerous other products of both natural and artificial origin, all contain moisture in varying quantity. This moisture is derived from the atmosphere and fluctuates in amount according to the humidity of the surrounding air. Timber is a very good example and actually behaves in a very similar way to wool, and normally contains about the same percentage of moisture—about 13 to 14 per cent. As you all know, timber can be naturally seasoned by leaving it stacked in a shady place freely exposed to the air or it may be kiln-dried by artificial heat. Kiln-drying is now much the more common way of dealing with building timber because the moisture left in is then strictly under control. The reason of course, that moisture is important in timber, is not to do with its weight but rather its dimensions, because timber which is over- or under-dried will swell or shrink in use and cause all sorts of troubles. With wool, on the other hand, it is weight that matters rather than dimensions, and moisture content assumes a very important role in wool transactions because of its effect on weight. Silk was one of the first products whose value was recognised to be considerably influenced by changes in weight due to monsture, and as long ago as 1805 a conditioning house was set up in Lyons to determine the moisture content of silk, and to make appropriate adjustments to the invoice weight according to the moisture content. In 1875 an international conference was called at Turin to consider the question of official "regains" and standard allowances for moisture in textile fibres. Not long after that, in 1887, a special act of Parliament was passed in Britain to enable the Bradford Conditioning House to be set up for the purpose of determining the condition or moisture content, of wool tops, yarns and other wool products. The Bradford Conditioning House is now, of course, very well known throughout the world and its certificates have international recognition. Besides carrying out tests for moisture in wool in its various forms, it also performs many other tests on fabrics such as fastness to light, strength tests, abrasion tests, water-proofing, moth-proofing and other things with which we are not directly concerned at the moment.

Natural Changes in the Weight of Wool

Under conditions found in various wool-producing countries, wool can change in weight due to variations in atmospheric humidity to quite a considerable extent. Several examples will serve to illustrate this. Wool grown in Colorado, where the natural humidity is very low, picks up quite a lot of weight when it is transferred to the sea-port of Boston for sale. Again, in Queensland, wool is grown under similar dry conditions and picks up weight when it is sent to the coastal selling-centres. Coming nearer home, wool from the Chatham Islands and the West Coast is sent to Christchurch for sale, and reacts in a similar way by losing moisture and weight in the dry Canterbury climate. Now if you will look at the large graph you will see depicted the changes in weight of a typical bale of greasy wool over a period of a season, while it was held in a broker's store in Wellington. The actual weight of this bale was an average of 346 lb but it fluctuated, as you can see, 6 lb over and under this figure according to the time of the year, i.e., a total variation of 12 lb. You will notice from the second line on the graph that there was a fair correlation between the weight of the wool and the average humidity for the month, but of course the wool usually lagged behind a bit. Wool in a bale is not freely exposed to the atmosphere and the speed with which it will change in weight depends not only on the humidity but the ventilation and the access of air to the individual wool fibres. Bone-dry wool which has just been removed from an oven is exceedingly hygroscopic and initially picks up water very fast from the atmosphere as you can see from the other graph. It has picked up more than half the water it is going to absorb in the first few hours.

Now I want to distinguish between water *on* the wool fibre and water contained *in* the wool fibre. If wool is exposed to a saturated atmosphere of 100 per cent relative humidity it will pick up all the moisture that it is possible for it to absorb—about one-third of its own weight in the bone-dry state. We do actually get periods when the humidity is 100 per cent., particularly in the coastal areas of New Zealand, and such conditions may persist for several days, when we generally refer to the conditions as being "sticky" and uncomfortable, particularly if the temperature is high. Under these conditions, if wool is spread out loosely in a thin layer, and there is free air circulation, it can actually pick up practically the full regain of which it is theoretically capable, but when it is baled it does not have the same opportunity. If we immerse clean wool in water for a period, then remove it and wring the water out of it, or better still spin it out in a hydro-extractor, we will get rid of most of the visible moisture, but the wool will still contain, say, 60 per cent. of its dry weight in water. About half of this will be contained *in* the fibre; the other half will be *on* the surface in the form of a very thin film. When wool is dumped in our stores prior to export it is placed under an enormous pressure and the fibres are squeezed closely together so that the amount of air between them is drastically reduced. Under these conditions the wool cannot change its moisture content at all rapidly, and will always lag behind the changes that occur in the surrounding atmosphere, so that it never reaches full equilibrium with its environment.

Mutual Agreement on Moisture Content of Wool

I mentioned a moment ago that the international conference at Turin agreed on certain internationally-recognised regains for wool and other fibres and I give here an abbreviated list of a similar set of regains which were agreed upon at subsequent conferences in various places and are now recognised throughout the world wherever there is trading in wool.

Some International Wool Textile Organisation Standards of Regain

Clean scoured wool	17%
Tops in oil	19%
Tops drycombed	18¼%
Worsted yarns—drycombed	18¼%
Lister and Noble noils	14%
Pure wool flannel, blankets and rugs	17%

I must emphasise that these regains are purely arbitrary figures. For instance the regain of scoured wool in the Commonwealth is 16 per cent. while in European countries it is 17 per cent. Both these figures do bear some relationship to the amount of moisture the wool would take up under conditions in, say, Bradford or Roubaix, but they do not tie up closely with the amount of water wool would absorb naturally in Denver or Central Otago. The point that matters however is that these figures are internationally recognised and if the various parties in a transaction all abide by them it does not really matter what the figure is so long as they are in agreement that it is acceptable. Before wool testing started in New Zealand "rafferty rules" prevailed here in regard to the actual ways in which scoured wool was sold. A number of things could happen. Most wool scourers were in the habit of over-drying their wool. Before the war many of them green-dried the wool. This meant spreading it out in a paddock and allowing it to dry under natural conditions. During the war, however, the scouring industry went ahead by leaps and bounds and most concerns put in modern drying machinery, in which the wool is dried by hot air which has passed over steam coils. Many of the wool scourers had had no previous experience of this method of drying and tended to go much too far. In one extreme case when we first started testing for moisture, we came across a line of scoured wool which contained only four per cent. of moisture and when the invoice weight was adjusted after testing, the certificate showed an allowable increase of 29 lb per bale. This of course is an extreme case, but at the time our activities commenced in 1951 it would be fair to say that the average bale was overdried to the extent of at least 2½ per cent or approximately 7lb. This meant in effect that where the wool was sold on New Zealand weights, as it usually was, 7 lb of wool was being given away as a free gift to the buyer on the other side of the world. The wool would eventually pick up this 7 lb in weight from the atmosphere. Very often it regained most of it on the journey from New Zealand to its destination. Some shrewd individuals realised this and made arbitrary additions to the New Zealand weights on the assumption that the wool would have picked up this additional weight on the voyage. If this actually happened all was well, but sometimes the wool might be stowed against the engine-room bulkhead under warm conditions and it picked up little or no weight. The result would then be a claim for short weight which the New Zealand exporter perforce had to meet. This sort of thing led to considerable ill feeling and certainly was not in the best interests of our export trade. Quite apart from this it also meant that our scourers were wasting many tons of coal in over-drying the wool to this unnecessary extent.

How Wool Testing Started in New Zealand

In 1948 the writer gave a paper at the first meeting of the Massey College Wool Association in which he stated the case for a wool testing house in New Zealand. Nothing definite happened for the next three years although considerable interest had been shown in several quarters in this suggestion. In 1951, as you will all recollect, New Zealand wool prices sky-rocketed and the whole question of the loss in weight we were experiencing due to over-drying assumed a new importance, and there was a sudden demand for something to be done about it. Briefly, it led to the Department of Agriculture undertaking to sample and test wool for moisture content and to issue wool-conditioning certificates, which stated the actual moisture content of the line of wool, and also made an appropriate adjustment up or down to give the correct invoice weight.

Methods of Sampling and Testing for Moisture Content

The equipment used for sampling consists of a heavy-duty electric drill, a steel tube about an inch in diameter and 18 inches long at the end of which is screwed on a hardened steel cutter, and plastic bags into which the samples are placed so that the moisture content will not change prior to testing. This method is generally referred to as core-boring or core-sampling, and originated in America about 1940, where the U.S. Department of Customs used it for determining the clean yield of greasy wool. It was important to know this accurately for each line of wool coming into the country, as the duty payable was based on this factor. The author obtained some American equipment and tried it here on our scoured wool but found that it

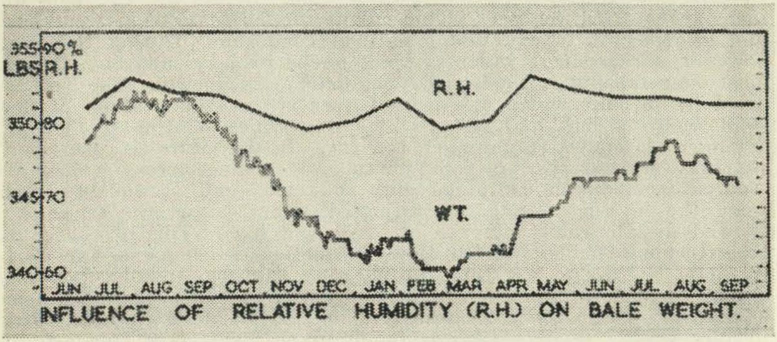


Fig. 1—Changes in weight (Wt.) of a typical bale of greasy fleece wool, while held in a broker's store in Wellington over a period of 12 months. The mean monthly Relative Humidity (R.H.) is based on 24 readings each day.

was almost impossible to push the large 2-inch tube, then in vogue, into the bales. The next step was to modify the equipment to suit our conditions and that which you see here today is the outcome of our work. Actually three things have chiefly made it possible to establish this service. First, suitable sampling gear; second, the express air-freight system run by N.A.C.; and third, availability of suitable impervious plastic bags in which the samples can be quickly and safely transported. When we commenced our sampling activities we had very little information to go on in regard to how many samples it would be necessary to take on a given line of wool, so we played safe by sampling every bale, and in small lines we took several samples from each bale. Later, about 1955, I got Mr A. R. Edmunds, who was then our physicist in Auckland, to have a look at the problem and he did a very thorough job on it and has now written up the result of his findings in a separate paper which he will be publishing shortly. In a nutshell it vindicated most of our original method, and the main alteration that we made was to shift the position in the bale from which we draw our sample to give a truer representation of the wool in the bale. We now push the core-boring tube into the bales four inches in from the seam at one end and running parallel with the long side, and bales are sampled alternately, caps and butts, and also taken in random order. This method of sampling gives a very satisfactory average, and the moisture content of the sample will agree within 0.2 per cent. or less of the true figure for the whole line 95 times out of 100. This is far and away better than any result that can be achieved by hand sampling. Now to summarise the operations in sampling and testing:

1. Every bale is core sampled at least once.
2. Every bale is weighed immediately after sampling.
3. The composite sample is sent in a triple-sealed container to the laboratory.
4. Sub-samples are usually extracted from the blended composite sample.
5. These sub-samples or the whole sample are dried and weighed separately as a check and the average result is used.
6. The wool conditioning certificate is calculated from the laboratory results, and typed, signed and airmailed to the client together with the weight sheets.

On the wall you will see displayed an enlargement of one of our certificates and briefly the significance of the different parts is as follows: On the left there are several columns in which the brand of the line of wool and its bale numbers are described. The gross, tare and net weights are given, and the place where the weighing was done is noted. On the right-hand side you will notice the result

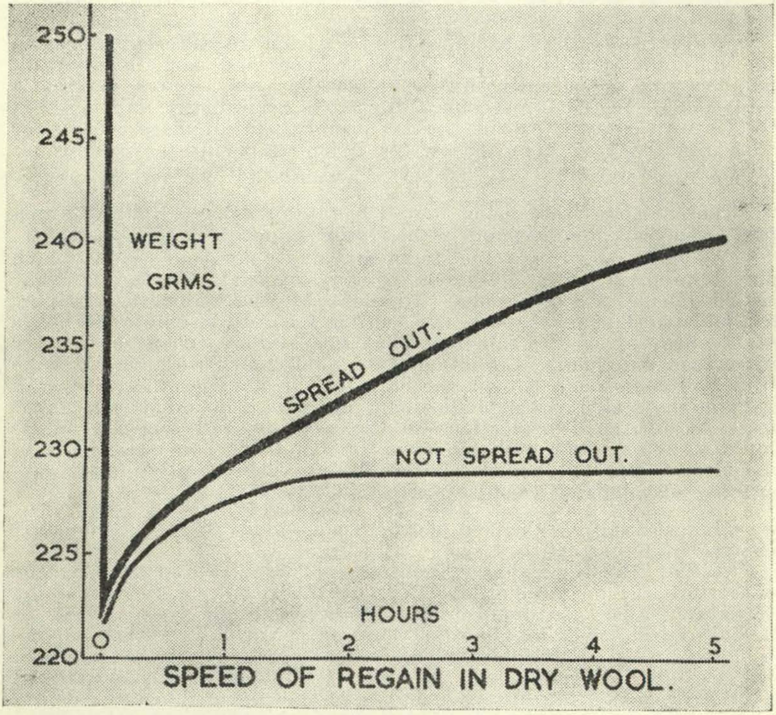


Fig. 2—Two 250 gram samples of clean-scoured wool were oven dried at 150° C. and the weight of each fell to 222 grams. One was spread out in a thin layer just over an inch thick, and the other left in a heap. The Relative Humidity in the room was approximately 60 per cent.

of oven-testing the sub-sample, the dry weight from which the condition or percentage of moisture can be derived—in this case 13.062 per cent. The assumption is made that the dry weight of the whole line of wool would be in the same proportion if all the bales could be dried in the same huge oven, i.e., that they would be reduced by 13.062 per cent. from a net weight of 9487 lb to a dry weight of 8248 lb. It is on to this dry weight that the stipulated regain is added, and the total dry weight plus the regain give the invoice weight, which is the amount of wool which is actually paid for. It will be seen that the invoice weight may be either more or less than the net weight except for the very rare occasion when it could be identical, if the moisture content happened to be exactly right. The significance of the certificate is that it is strictly fair to all parties trading in wool, provided they mutually agree to abide by the invoice weight.

Use of Wool Conditioning Certificates

In the early days when we commenced this testing service we met considerable opposition from wool firms and their organisations in Britain and Europe. They had quite a list of reasons why they objected to our methods, and the principal points and our replies to them were:

1. That the wool was not being sampled on our own premises or weighed on our own scales.

We normally draw samples from at least 16 different stores in ten different centres as far apart as Auckland and Invercargill. Samples are occasionally drawn at another nine stores making a total of 25. In the foreseeable future it is exceedingly unlikely that the Government will provide special premises in all these centres, or even a majority of them. The scales which we use are however regularly checked for accuracy by Government inspectors.

2. That samples were being moved by air or other forms of transport from the sampling point to the testing point.

We have shown by actual tests that any change in weight which may take place in a wool sample during transit is negligible. The sealed plastic polythene bags are sent by the quickest transport available, and usually reach the testing laboratory within 24 hours of the drawing of the sample. They are seldom carried by air for more than four hours. As an additional safeguard we have for some time now been using two plastic bags, one inside the other, and each individually sealed. These double bags are placed inside strong canvas bags as additional protection—so the wool is well guarded on its journey. There will probably always have to be some transport of samples, as testing facilities cannot be provided at all centres irrespective of volume of wool available.

3. That heating of the core-boring tool would affect the moisture content of the sample.

Actual trials on bales of scoured wool have proved that heating of cutters has no measurable effect on the result of the tests. No trials were made on dumped bales as we will not sample these on account of the risk of abnormal heating. Normally cutters do not heat up to any appreciable extent if kept sharp, but to simulate the worst conditions ever likely to occur with baled scoured wool we artificially heated the cutters and ends of the coring tubes to a degree never normally reached, and still failed to make any measurable difference to the test results, as compared with the same wool sampled with cool cutters. Presumably this is due to the fact that the wool is in contact with the heated portion for only a fraction of a second as it passes into the tube and as it is pushed out again. Even if some moisture was evaporated by the heat it could not escape—but would remain in the core sample.

4. That core sampling in general was not as good as hand sampling.

Core sampling is the only practical method that we know of which allows us to draw our samples in the limited time and under the conditions we have to meet. Hand sampling is ruled out, not only because of the time involved in cutting the packs in three places, extracting the sample, and then sewing up again, but because it is almost impossible to get a hand into our tightly pressed bales. For this reason core boring has a much better chance of drawing a truly representative sample than any hand-sampling method which fails to extract an adequate portion from the centre of the bale. The 18-inch core sampling tube cuts a continuous and representative cross section of the wool as it penetrates deeply into the bale—and is quick and easy to carry out. Hand sampling extracts only odd tufts of wool and unless it takes plenty of these, and extends inwards the correct distance towards the centre of the bale, it cannot give a true picture of the contents of that bale. The extra handling of the wool

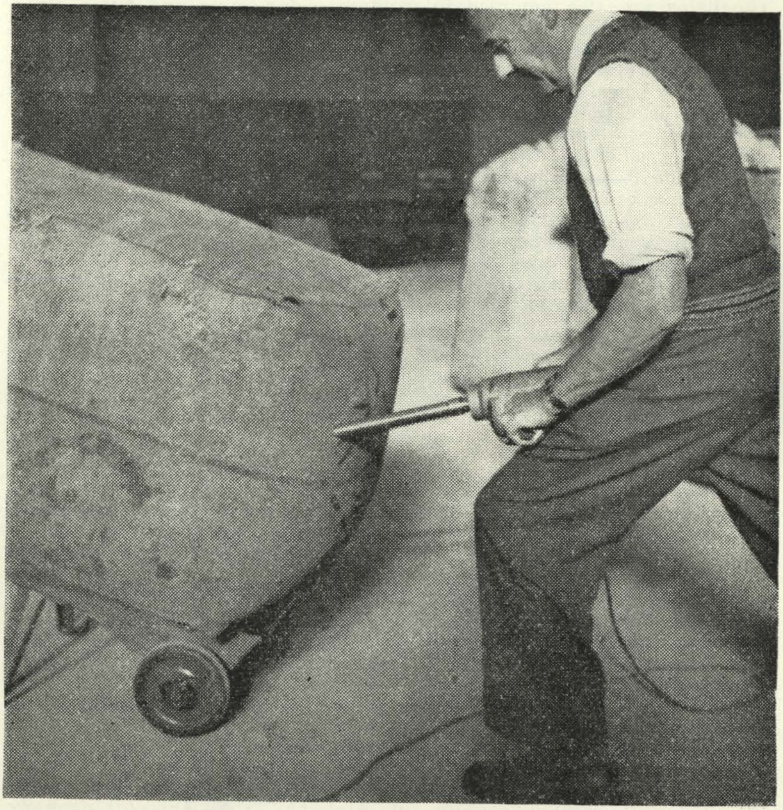


Fig. 3—Drawing a core sample from a bale of scoured wool.

and the time lag before it is closed up in a sealed contained are also not conductive to accuracy.

5. That samples drawn are too small.

There are strict practical limits to the number of cores which can actually be drawn from each bale in the very brief period during which it is usually available for sampling. Quite frequently the only chance to draw samples is between the unloading of the wool from the trucks in the port store, and its weighing, dumping, and loading on to the ship. Any undue delay could easily throw the whole wool-handling organisation out of gear, and entirely rules out the possibility of drawing hand samples as is done in Bradford. Considerable research on various sampling methods and their accuracy has been carried out at our Auckland Wool Laboratory by Mr A. R. Edmunds. He has shown that with our present methods there is a 95 per cent. probability of the sample coming within 0.2 per cent. of the true moisture content of the line of wool.

One important advantage we have over the European Testing Houses is that in the great majority of cases we draw our samples very soon after the wool has been dried and pressed, and before there has been time for a moisture gradient to develop within the bale. The bales are also sampled in random order, caps and butts alternately, so that we are getting a true random sample of wool with no bias in any direction. By the time the wool reaches Britain or Europe however, marked moisture gradients will have developed within the bales, particularly if the wool has been over-dried as has so often been the case here in the past. From figures we have for wool stored for several months in New Zealand we know that there can be a gradient of three or four per cent. in moisture content from the outside to the centre of the bale—the centre still being too dry. The reverse can also apply—the centre being too wet and the gradient being towards the drier outer layers. Our method of sampling four inches in from the outside of the bale strikes the average moisture content, whichever way the gradient may be. Hand sampling as practised in European countries may easily result in too much of the superficial layers being taken.

We feel therefore, that although our own tests are not 100 per cent. accurate, it is unlikely that any other testing authority achieves this degree of accuracy in routine tests either. Our present methods are not biased in anybody's favour and are at least an improvement on the hit-and-miss process of adding on a few pounds to each bale weight in the hope that it would gain this on the outward voyage.

6. That individual samples from each bale are not tested separately.

The question of carrying out individual moisture tests on each bale of wool in a line was discussed at a representative meeting of buyers in Wellington and it was unanimously decided that this procedure was neither justified nor practicable. The extra work and cost which would be involved, even if the method could be carried out in practice, would be out of all proportion to the benefits likely to be derived.

The outcome of all this was that we eventually received recognition from the two main organisations in the wool trade, namely the International Wool Textile Organisation and the British Wool Federation. I might at this stage clear up any misconceptions which may have arisen about the terms "Condition" and "Regain." For trade purposes it is usual to express the moisture content of wool in one of these two ways. "Condition" means the percentage of moisture contained in the wool, while "Regain" is the percentage of moisture the bone-dry sample regains or absorbs from the atmosphere. Although it is usual in commercial contracts to specify regain rather than condition, the two terms are mathematically related and one

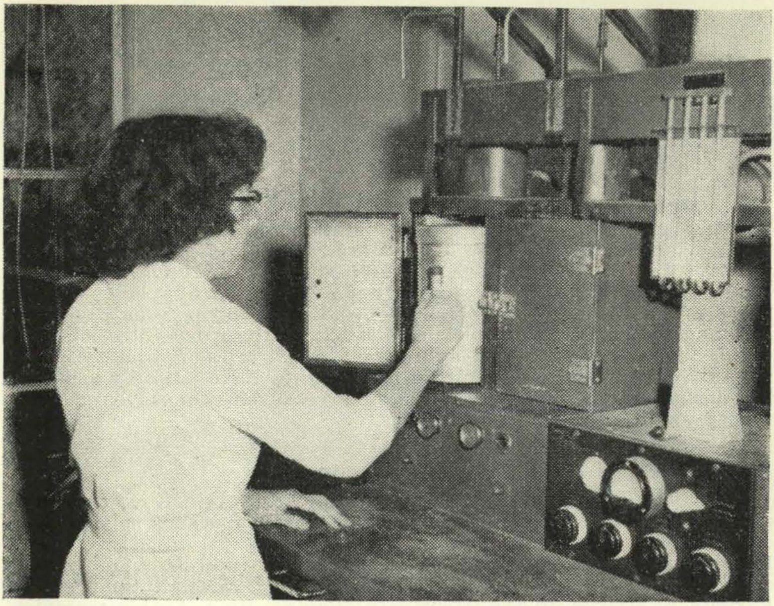


Fig. 4—Placing an accurately weighed sample of scoured wool in the oven for an official moisture test.

can readily be converted to the other by the use of a table such as the one I have given below, which covers the range of moisture content likely to be met with under New Zealand conditions.

The Relationship of Condition and Regain Percentages.

Condition %	Regain %	Regain %	Condition %
7.0	7.5	7.0	6.5
8.0	8.7	8.0	7.4
9.0	9.9	9.0	8.3
10.0	11.1	10.0	9.1
11.0	12.4	11.0	9.9
12.0	13.6	12.0	10.7
13.0	14.9	13.0	11.5
14.0	16.3	14.0	12.3
15.0	17.6	15.0	13.0
16.0	19.0	16.0	13.8
17.0	20.5	17.0	14.5
18.0	21.9	18.0	15.3
19.0	23.5	19.0	16.0

Impact of Moisture Testing on Wool Scouring in New Zealand

As previously mentioned, prior to wool testing becoming established in New Zealand most scoured wool was very much overdried, which was not only unnecessary but a waste of fuel. Since we really got properly into our stride in 1953 the wool scourers throughout New Zealand have got very much closer to the desired moisture content in the wool they have turned out. There has been considerable pressure on them from the wool buyers to do this, because even though a certificate might be issued, if it showed that the wool was, say, five per cent. too dry, it would be very difficult to get people overseas to accept it. They were not used to such big adjustments, and were frankly sceptical that the wool really was this amount overdried. The result of the pressure is clearly shown by the figure for 1953 compared with that for 1957. In 1953 the overall average for the scoured wool we tested from all over New Zealand was that it was 2.142 per cent., or nearly 6 lb per bale too dry. In 1957 it was —0.007 per cent., or the negligible figure of one-third of an ounce per bale too wet. So the wool scourers have not only got well on to the target but right in the centre of the bull—so they can hardly get any closer than this. They have done it chiefly by using various types of moisture-meters to tell them how the drying was progressing, and by fitting adjustable thermostats to their dryers to hold the temperature at the required figure for a given type of wool. All this they have found quite difficult. However they have not only achieved the desired result, but in the process have saved themselves a lot of money previously spent on coal.

Australia Follows New Zealand's Example

In 1956 the writer was invited by the Australian Government to go over and discuss New Zealand's wool testing methods so that they could consider the question of something similar for Australia. He found members of the trade there to be keenly interested, and as the outcome of their meetings a Bill was passed through the Federal Parliament setting up the Australian Wool Testing Authority which at the present time is just beginning to get under way. It should develop into a big organisation with the tremendous quantities of wool that are available in Australia for testing. South Africa has also been making tentative enquiries but at the present time there is no indication of how serious they are.

Moisture in Wool from the Farmer's Angle

Naturally a farming audience will be most interested in how moisture in wool directly affects the wool grower. The foregoing affects him indirectly in that wool testing has led to keener competition and better prices for scoured wool, so eventually the farmer does benefit. Directly however, moisture in wool has a bearing on farming activities in several ways. You all know the trouble that can arise at times when shearers are convinced that sheep are too wet to be shorn, and how these grievances may or may not be genuine according to many circumstances, not least of which is the prevailing mood among the shearers. There is no easy way to convince shearers that wool is not too wet, or farmers that it is, but it should not be unduly difficult for one of our scientists to devise a test or an instrument which can settle these disputes on a sound basis. The writer does not for a moment wish to condone the shearing of wet sheep, but it must be realised that as far as the wool itself is concerned, there is no harm in shearing it wet, provided it is spread out and given a chance to dry before it is pressed. If the wool is pressed wet, or if bales of pressed wool become wet through a leak in the roof or other causes, the wool will definitely deteriorate. In extreme cases it will heat up and the colour will be irrevocably spoilt. However there are no cases of spontaneous combustion which can be proved beyond doubt in so far as greasy wool or scoured wool are concerned. There are plenty of cases where pie wool from freezing works has gone up in flames, either in the works or subsequently on board ship, but these have all been traced back to the mutton-fat which pie wool contains, and which will very soon oxidise and lead to heating which in many cases is sufficient to set the wool alight. The heating in damp, greasy wool has never been known to go as far as this, but it is quite bad enough to ruin the wool and greatly reduce its value.

Moisture in Wool from the Broker's Angle

The graph which I showed you previously illustrates how wool can change its weight during storage. This is a normal case where an average bale of greasy wool was held under good conditions in a broker's store in Wellington. Now when wet wool comes into store the buyers have been known to refuse to accept it and the broker is forced to withdraw it from sale, open it up and dry it out before re-offering at a subsequent sale. If much wet wool comes into a store at once, conditions can become chaotic, and it is not surprising that both brokers and buyers take a very dim view of wet wool. The

Ag.—L. 1

WOOL CONDITIONING CERTIFICATE

FOR SCOURED WOOL

Nº 10285

DUPLICATE

DEPARTMENT OF AGRICULTURE,
P.O. Box 2298,
WELLINGTON,
NEW ZEALAND.

DATE: 15 November 1957

Composite sample drawn at time of weighing from the lot of wool comprised in the Declared Particulars.

DECLARED PARTICULARS				
Marks	Nos.	Gross lb.	Tare lb.	Net lb.
	Details as per weights and specifications from: The Ngaio Shipping Co. Ltd., NGAURANGA.			
BA C SE	420 to 433 445 to 464		9[8]	
TOTALS	34	9793	306	9487

Sampled by J.W. Grindell of the New Zealand Department of Agriculture.

(1)	Weight of sample tested	500.00 gms.
(2)	Result after testing absolutely dry	434.69 gms.
(3)	Or loss per 100 gms.	13.062 gms.

Or total dry weight 8248 lb. or 86.938%

Official Regain 17 % 1402 lb. or 14.779%

Invoice Weight as per tests 9650 lb. or 101.717%

xxx Gain 163 lb. or 1.717%

Original Weight 9487 lb. or 100·00 %

Tested at WELLINGTON.

Test number: 6916

Date test made: 14.11.57

WOOL SECTION N.Z. DEPARTMENT OF AGRICULTURE

We hereby certify that the return of the above tests (items 1–3) on the sample delivered to us is correct.

Signed R. A. Swan   J. E. Duncan.

TESTING OFFICER.   WOOL SUPERVISOR.

50 pads/4/56—62198 J

Fig. 5—A New Zealand Wool Conditioning Certificate, which states the moisture content and corrected invoice weight for a line of scoured wool. The names are fictitious but the figures are real.

buyer is interested in buying fibres which he can manufacture, and not water which will sooner or later evaporate. Brokers have to protect themselves against losses in weight which could be called normal and seasonal, because at the time of the year when wool is shorn, the humidity is generally higher than later when it is held in store and sold, so that the wool quite normally can lose several pounds between the time it enters and leaves the broker's store. Brokers of course are fully aware of this and have to take steps to protect themselves by adjusting inward weights accordingly.

Moisture in Wool from the Manufacturer's Angle

The manufacturer also has an interest in the amount of moisture contained in the wool quite apart from its effect on weight and what he is paying for. Excessively dried wool leads to all sorts of troubles in the mill. The fibres become charged with static electricity and are then referred to as "wild" and will not spin or behave properly while being converted into yarn. The standard practice is to humidify the atmosphere in the mill to overcome this problem. Another angle is that Tops, that is to say semi-manufactured wool which has been combed, are sold on a regain of 18¼ or 19 per cent., which are really artificial figures, and the Tops will not achieve these regains until they are stored under artificial conditions with an abnormal amount of moisture in the atmosphere.

Conclusion

Moisture in wool is normal and natural, but many people who trade in wool have turned it into either a problem or a profit. It should be neither; and the remedy consists of mutual agreement, tolerance, and common sense.

From the wearer's point of view, the ability of wool to change its moisture content can make it far superior to any other fibre in comfort, when worn next to the skin. Its old disabilities have been overcome, for wool can now be made non-shrink, non-tickle, and moth-proof. It remains only for all potential consumers to be made aware of this, and the trade to provide garments incorporating these improvements at a reasonable price.

Question: What happens to the samples?

Mr Duncan: They are not valueless; we used to get 4/- when the price was good, now we get 15d. They are not so valuable because they are so short but the wool scourer uses them by blending them.

Question: What sort of variations in weight occur in bales of greasy wool?

Mr Duncan: The graph is for a normal bale of greasy wool.

Question: Why isn't the service supplied for greasy wool?

Mr Duncan: This service is on an international basis and applies to scoured wool but is not recognised for greasy wool. To do greasy wool would be two or three times as much work as we would have to do yield tests as well. At present there is no demand for such a costly service.

Dr Henderson: If the price of wool rose to 5/- or 6/- lb would the testing of greasy wool, particularly the higher grades, be a worthwhile proposition?

Mr Duncan: We have done it on greasy wool on special request. The difficulty we are up against is the pressure for speed. Yield is one of the main factors which come into the valuing of wool. It could be done if someone is willing to pay for the charge which works out about £5/10/- for 35 bales of wool.

Question: Is the amount of water in wool affected by the amount of grease?

Mr. Duncan: Yes.

THE PROPER USE OF BULK FEEDS FOR DAIRY COWS

M. G. Hollard, Lincoln College

There is no precise definition of the term "bulk feeding" as it is applied to dairy stock, for it covers a range of nutritional circumstances. In general, however, it connotes a system of feeding where concentrated foods, such as cereals and oil-cake residues, are used sparingly or not at all, and the main reliance is placed on pasture, pasture products, and forage crops. New Zealand undoubtedly provides the best example of a dairying country where bulk foods provide the main source of nutrients for stock. Concentrates are seldom used in herds producing milk for manufacture, for the relationship between the costs of concentrates and the realisations for milk makes such a practice in general quite uneconomic. On the other hand, a climate particularly favourable to pasture growth has meant that there is a cheap source of nutrients which is the basis of this country's low-cost dairy industry.

A trend towards increasing use of bulk feeds and a reduction of concentrates in dairy rations has been most noticeable in other countries. Since the beginning of World War II, the amount of concentrates used per gallon of milk in the typical ration of dairy cows in Denmark and Sweden has been halved. Further, there has been a reduction in the quality of the concentrate ration, which now contains much less oil-cake residues; the reduction has been made possible because of the attention paid to the cutting of silage and hay at an early stage of growth to ensure a high content of protein and materials giving energy. In such an approach, there is a realisation that it is not the quantity of bulks in the ration that is important in determining levels of productivity, but the quality of these bulks.

In the Netherlands, reliance is placed on grass in its various forms to the extent of about 80 per cent. in milk production, and in doing so the country is able to maintain the highest, average yield of milk per cow in the world. Hence it is clear that the Dutch, too, recognise the importance of stage of growth of pasture in relation to its protein and fibre content, and output of nutrients per acre.

In Britain, dairy farmers are apparently well indoctrinated with the practice of feeding concentrates at high levels. This is probably because of the high price realised for milk in Britain relative to the cost of concentrated foods, especially in the period between the two world wars. A further contributing factor was undoubtedly a general statement by Professor Boutflour, made as long ago as 1925, that the feeding of excessively-bulky rations was the cause of low yields in many dairy herds. This approach advocated by Boutflour has been greatly reinforced by propaganda from firms marketing concentrated foods. It is not surprising that endeavours during the 1940-50 period to introduce bulk feeding met with limited success. In fact, the response of most farmers during the period when concentrated foods were rationed, was to endeavour to replace bought concentrates by home-grown and pulse crops. In recent years, and at the present time in Britain, mainly as a result of the National Milk Costs Investigations, emphasis is once again being placed on use of bulk feeds, for these investigations have shown that the highest profitability is recorded for herds with the lowest use of concentrates. Further, it has been shown in Britain, and could undoubtedly be shown in New Zealand too, that well-managed pasture can produce greater yields of nutrients for livestock, at a lower cost, than can be obtained from any other source.

In New Zealand, as I mentioned earlier, our dairy industry owes its comparatively low-cost structure to our climate which enables us to depend very largely on pasture and its products for the feeding of our dairy stock. In the years that lie ahead, it is clear that the challenge of declining prices for dairy products will have to be met, in part at least, by increased efficiency of production. This means exploiting even more fully than we have done in the past, the favourable natural conditions which we enjoy. In the long run, the country which will be most successful in international trade in dairy produce is that which can produce the highest-quality product at the lowest cost of production.

In feeding of dairy stock, I am certain that we can make vast improvements in the utilisation of bulk feeds. We can certainly produce very high levels of nutrients per acre from both grassland and fodder crops, but the major deficiency in our feeding practices, in my opinion, is in regard to appreciating the concept of quality in feedstuffs in relation to the requirements of dairy cows for food nutrients. Yet this lack of appreciation is easily understood, for ruminant animals, and cattle in particular, have achieved their present position in agriculture by virtue of their ability to convert rough, fibrous feedstuffs into human food. But there is a limit. With the selection of dairy cows which have been specially chosen for their ability to produce large quantities of milk and butterfat, quality in feedstuffs has become extremely important. The situation is simply this. A cow can, and will, eat only a certain amount of feed in a day, and for production to approach the potential level set by the breeding of the cow, there must be contained in this amount of feed all of the food nutrients that the cow requires.

The amount of feed a cow will eat depends on several factors. These include individuality of the cow, succulence and palatability of the feed, the amount of exercise the cow has had, whether she is in milk or dry, and the variety of feed she is offered. And, of course, larger cows will consume a greater amount of feed daily than will smaller cows.

However, when all of the above circumstances have been taken into account in regard to intake of feed, the fact remains that the bulk of feed eaten must contain sufficient nutrients to meet the cow's requirements for maintenance of the body, for production of milk and butterfat, for pregnancy, and for growth. If the quality of the ration is poor, then one or more of these functions of the animal will suffer. Usually, the first sign of inadequacy in the quantity or quality of the ration is a decline in the production of the cow and the herd. Numerous experiments have been carried out in New Zealand to measure and demonstrate the effects on production of underfeeding dairy cows either before calving or after calving, or both. Most of you will be familiar with the surprisingly-profound effects which have been measured. But the real problem arises when one endeavours to improve the feed supplies of the herd, in regard to both quantity and quality of feed, and at the same time ensure that the methods employed are within the labour and capital limits of the farmer. Nevertheless there is a great deal that can be done by every dairyfarmer to improve the feed supplies of his herd, but an appreciation of the factors which influence the quality and yield of our bulk feeds is essential.

After considering all that has been written and said about the feeding value of pasture, it is difficult to believe that there is still a general lack of knowledge of the techniques available to even out feed supplies and to keep pastures in a highly-nutritious stage of growth. Yet, it is clear from even casual observation of the feeding practices commonly employed, that many of you are inclined to forget that some feeds such as hay, although useful for wintering dry stock are comparatively valueless for purposes of milk production. Further even pasture itself can vary enormously in quality. Thus fresh, rapidly-grown, leafy material with a high energy and protein and a low fibre content is a splendid milk-producing feed, whereas grass that has been allowed to run to seed is low in energy and protein, high in fibre, and cannot be expected to support a high level of milk production.

Without doubt, the stage of growth of the pasture plants at which they are utilised for grazing, or for silage or hay, is the basic factor involved. As plants age, the protein, energy and mineral contents fall, the fibre content rises, and as a result of this, the digestibility of both the fibre and protein declines. The main effect of advancing stage of growth is through a change in the ratio of leaf to stem; for example, the percentage of leaf in hay is much below the percentage of leaf in pasture cut at four-weekly intervals. Hence the management of pastures should aim at utilising pasture for grazing or conservation when it contains a high proportion of leaf. This implies really-close control of the grazing of the herd by means of efficient sub-division, with the use of the electric fence if this is necessary to obtain the optimum control. Without adequate sub-division, it is impossible to adopt that system of alternate grazing and spelling of pastures which is essential to secure maximum yields of pasture and to effect efficient utilisation at a leafy stage of growth.

Ways and means of extending the growing season of pasture have been investigated on many occasions. It is not necessary here to elaborate the advantages, in this respect, of good drainage of pastures, topping and harrowing of pastures, and of a judicious top-dressing policy. These are all practices which have been thoroughly investigated and widely practised. But there do appear to be two ways of extending the growing season of pasture which could be used more widely, especially in Canterbury. That is, by irrigation and by the use of special-purpose pastures. I know that some questions have been raised by North Island workers as to the economics of irrigation. But in Canterbury, and especially on local town-milk-supply farms, there is no doubt at all in my mind that the use of efficiently-designed irrigation schemes does prove most profitable. After all, we must remember the vast difference in climatic conditions between the South Island and the "emerald isle" up north.

Similarly, we should not be unduly influenced by the results achieved elsewhere from the use of special-purpose pastures. Whereas it may well be satisfactory enough for a North Island farmer to wed himself irrevocably to general-pasture mixtures featuring perennial and short-rotation ryegrass, I am certain that the use of special mixtures containing in turn such species as timothy, cocksfoot, prairie grass, meadow fescue, together with appropriate legumes, could play a tremendous part in enabling our South Island dairyfarmers to better meet the feed requirements of their herds direct from pastures over an increased period of the year, especially in the summer and autumn periods. With the combined use of irrigation and such special-pasture mixtures, big advances towards the ultimate could be achieved. Factory-supply herds could be adequately fed almost entirely on pasture over the producing season, and town-supply farmers could reserve all their supplementary feeds for use in the winter period.

Under our New Zealand system of dairyfarming, it is certainly sound policy to conserve surplus spring growth in the form of silage and hay, and surplus autumn growth (if you are fortunate enough to have a surplus), as "cool-stored" grass. However, there is a tendency, in the enthusiasm to conserve surplus spring growth of pasture, to vastly over-rate the feeding value of the silage and hay produced. By and large, a very poor job is being made in New Zealand of utilising surplus spring-pasture. Silage and hay, as generally made in this country, are high in fibre and of low digestibility. They are both far from being first-class milking feeds. Considering the advanced stage of growth of the material from which silage and hay are generally made, this is not in the least surprising. A silk purse cannot be made from a sow's ear. Further, the methods of conservation used are, in general, exceedingly wasteful. Losses of nutrients in the making of silage and hay, though due to different causes, usually approach the 50 per cent. level.

Perhaps I would not be so critical of local fodder conservation methods if I did not consider that better alternative methods were available. In times of buoyant prices with little pressure on dairy-farmers to be really efficient in all aspects of their husbandry, perhaps I would not press the issue so hard. But, at the present time, surely every blade of grass should be regarded as a potential source of revenue, and every effort should be made to conserve, as efficiently as possible, every "whisker" of surplus pasture-growth.

Improved methods of silage-making and hay-making are available, as a result of extensive research work.

In the case of silage, it is obvious that crops should be cut when they are at the grazing stage, or very soon afterwards. If possible, the crop should be wilted. Then, to make good quality silage from this material, which is very high in protein, a preservative should be used. Sodium metabisulphite is the best available, and it should be mixed in the dry form with the crop at the rate of 10 lb bisulphite per ton of green crop. The material can be ensiled in stages over a period of six weeks or so, and provided each layer, as it is ensiled, is effectively sealed, there is nothing to be lost by this process. Finally, the silage should be adequately sealed against both air and rainwater. Losses of nutrients will be lowest if the silage is made in a trench with battered, concrete sides and a concrete bottom, and with a weatherproof roof.

In regard to hay-making, the most significant advance in recent years has been the introduction of the hay-crusher, which is of special value for thick-stalked crops such as lucerne and red clover. The basic steps which should be taken to improve hay quality are these. The crop should be cut while still at an immature stage of growth. Immediately following mowing, in the case of lucerne or red clover, the crop should be crushed to hasten drying. Tedding of the crop within 24 hours of mowing, whether the crop was crushed or not, will produce more-even drying and hence reduce leaf loss. Then, all you have to do is to complete the drying of the crop and get it baled and stored before it rains! Unless these steps are taken, it is certain that the resulting hay will be of value to dry cows only and only lowered production can result from feeding it to cows in milk.

In many districts of the South Island, climatic conditions are so unfavourable to pasture growth, that forage cropping is very desirable, and even essential in some cases, to provide supplementary feed for dairy herds. In such cases fodder beet is being used to an increasing extent each year. This is a very desirable trend.

Although all root crops yield heavily on suitable soil-types, all are low in protein and require to be used in conjunction with "cool-stored" grass or first-class hay or silage. Most farmers who grow forage crops use them in this fashion. In spite of the cost involved in growing and utilising root crops, there is little doubt that, on good land, they can play an important part in the feeding of dairy herds.

Finally, let me summarise the situation for you.

New Zealand dairy-husbandry practice is characterised, and must remain so, by heavy reliance on bulk feeds. The main virtue of such feeds is their cheapness. In the face of falling prices for dairy products, increased efficiency in the production and utilisation of such feeds is essential if returns are to be maintained at the highest possible level.

There is ample experimental evidence to show the value of good feeding of dairy cows at all times of the year.

Because well-managed, leafy pasture is the best and cheapest feed we have available, the main effort in the immediate future must be towards lengthening the period of the year over which we can rely exclusively on such pasture to feed our herds. Attention should therefore be given to judicious topdressing, to so-called "special purpose" pastures, to irrigation, and to saving maximum areas of surplus autumn-grass.

More efficient management of grazing and of pastures could in all cases lead to increased surpluses of spring grass to conserve as hay and silage, and hence allow for heavier winter-feeding. However, every endeavour should be made to reduce the losses inherent in fodder conservation. Then in the feeding of hay and silage, due account should be taken of the comparatively-poor feeding value of such feeds. This can be done by feeding them mainly to milking stock at the end of the season and to dry stock in the winter. To provide milking stock with rations better suited for milk production, the greatest possible bulk of autumn-saved grass should be provided.

In districts where pasture production is comparatively limited, more attention should be given to lucerne as a hay and silage crop, to green feed crops, and to fodder beet.

With all bulk feeds of low average-feeding value, such as silage and hay, the supplies available should always be sufficient to ensure that the herd's rations need never be limited. Unless herds are fed to absolute capacity on such feeds, the cows will in fact be underfed because of the low nutrient-content of such bulk feeds.

Question: How do turnips compare with green feed oats with regard to their food value?

Mr Hollard: More information on this subject will be given in Mr Greenall's paper to be read tomorrow. There is no comparison between turnips and green feed oats, turnips being far better than green feed, and even superior to silage. Soft turnips are suitable for milk production because of some substance in their chemical make-up.

Question: In a dry season is there more feed from special purpose pastures than from perennial and short-rotation ryegrasses?

Mr Hollard: In Canterbury short rotation ryegrass shoots away to seed at the beginning of summer. Although it was once popular at Lincoln, it is now losing favour. Short rotation cannot compare with the later seeders, timothy and cocksfoot, much better results having been obtained with these, especially timothy. Lately, particularly in Great Britain, meadow fescue is becoming increasingly popular, and at Lincoln a special-purpose pasture mixture of timothy, meadow fescue and white clover has given outstanding results.

Question: Is any work being carried out on autumn saved pastures? That is, the development of a pasture mixture suitable for autumn saving?

Mr Hollard: A short rotation ryegrass dominant mixture is used at Lincoln, some pastures receiving nitrolime. Meadow fescue also is used, though there is some frosting. On our heavy land nitrolime is used in mid-March.

Question: Does a timothy pasture produce as early as H.1 ryegrass?

Mr Hollard: H.1 is much earlier than timothy. Various species have been found to give approximately the same amount of dry matter, but at different times. H.1 ryegrass will produce most growth early in the season, but by varying the mixtures the period of grass growth can be prolonged, particularly where it is possible to irrigate.

Question: The use of bisulphite has been recommended to improve silage quality. Is there any possibility of spraying it on to the crop to get an even distribution?

Mr Hollard: A preservative is a "must" with a young crop to get the best silage. Bisulphite is the best, used as a powder. This can be spread evenly when using a buck-rake although it is not easy. Work is being done on an attachment for fitting on to a baler. Bisulphite is only justified with good silage—costing 10d per lb gives an initial cost of approximately £40 per 100 tons.

Question: Is this method of silage-making successful even without a roof?

Mr Hollard: Experiments have been carried out at Lincoln on all ways of making silage, with varying degrees of success. With a first-class clamp, sealed to keep out the air and roofed against rain, excellent results are possible.

Question: How adequately should the layers be sealed between fillings—particularly when cutting at intervals?

Mr Hollard: It is best to consolidate with the tractor, then cover with a plastic sheet. Don't postpone the cutting until some of the grass has reached the over-ripe stage.

HERD IMPROVEMENT

J. W. Stichbury, Director of Herd Improvement, N.Z. Dairy Board.

Today when the necessity to farm as efficiently as possible is being stressed, I feel I can well devote the time set down for this paper to discussing some of the ways in which the Herd Improvement Movement can help in raising farming efficiency.

Before doing so, however, I feel I should clarify what is meant by the Herd Improvement Movement. It includes not only your local Herd Improvement Association, with its testing and artificial-breeding services but also the various services provided by the Herd Improvement Department of the Dairy Board and the Board's Artificial-Breeding Centre. It deals with farm and herd management, improvement of herd quality and carries out a considerable amount of investigational work designed to focus attention on dairy-farming problems and highlight efficient farming practices.

The dairyfarmer's contact with the Herd Improvement Movement is normally through one of its three main aspects, Herd Testing, Artificial Breeding and the Board's Consulting Officer service. Each of these can play a significant part in raising farming efficiency and I will therefore discuss them in turn.

Herd Testing

Herd testing provides the dairyfarmer with information on the production of his cows. If he uses it to the full he can benefit in two ways. First he can improve the quality of his herd through culling, selecting replacement stock and proving his bull, and second he can improve the management of his herd and farm. Herd Improvement Associations now offer two systems of testing and the testing dairyfarmer can elect to have his herd tested under either the monthly or alternate-month system. Either test is perfectly satisfactory for finding out the high producers in the herd and therefore for improving herd quality, but because the testing officer calls more frequently under the monthly system this test provides more information to assist with problems of herd management. To obtain this extra benefit however, dairyfarmers must see that the test sheets they receive each month are not forgotten after a cursory glance; a careful look will often pay dividends.

One of the first clues to a milking problem is often obtained by studying the test sheets. Irregular milk weights and butterfat tests should not be ignored; they may indicate incomplete milking which in turn points to the need for checking the efficiency of the milking machine and perhaps the milking technique itself. Milking is one vital aspect of dairy-farm management where an inefficient technique can be very costly and where farmers do not have the opportunity of seeing other farmers' techniques. Think about your milking routine from time to time. Do you follow a definite routine designed to encourage a good let down and efficient milking? Do not forget that your test sheets can help to show up milking problems.

Studying your test sheets should also bring about another indirect benefit. I have frequently noticed that the most successful dairyfarmers are, almost invariably, intensely interested in their herd and in the production of each individual cow. This interest in the herd leads to more thought being taken in planning future farm-management and to some extent sparks the whole farming operation. Decisions on drying off cows, culling empty cows and late calvers, saving replacements, keeping the herd sire or going into A.B., planning feed supplies and setting calving dates, are all influenced to a greater or lesser extent by a knowledge of monthly and annual testing returns. These benefits of testing are all additional ones to its basic purpose, culling the low producers.

The aim in culling low producers is, of course, to raise the average efficiency of the herd by culling the least-efficient cows. Work carried out in recent years at Ruakura, however, has suggested that the low producers may not necessarily be the least-efficient cows. A cow's weight has a big influence on how much she eats and therefore a big cow must be a high producer to be as efficient as a small cow. Because of this we have recently measured the chest girths of cows in a large number of herds to decide whether herd testers ought to be supplied with tape measures to measure the cows as well as test buckets to measure their production. Fortunately for the herd testers' peace of mind it will not be necessary, as we found that with cows of the same breed in the same herd the variation in chest girth and therefore weight is so small that for all practical purposes it can be ignored. If you line your cows up in order of production you will also line them up in order of efficiency. Therefore, unless you happen to have a very mixed herd, you can rest assured that your high producers are your most efficient cows.

So far I have outlined some of the benefits which can be obtained from herd testing. The next question is, "Does it pay?" To answer this question we studied the factory returns of 1,000 herds over a ten-year period and found that these herds, in general, increased their production when they commenced herd testing. This production increase was maintained so long as the herds remained under test but was soon lost if herd testing was discontinued. Those herds which had been tested for at least six years increased their factory production by 29 per cent. over the ten-year period compared with 11 per cent. for the non-tested herds, convincing evidence that it pays to test.

I am fully aware, however, that most farmers have only a limited amount of money to spend on farm-working expenditure and must decide which of several alternatives is likely to be the most profitable. Therefore, I would also like to discuss some of the factors which should be taken into account in deciding whether it will pay to test when there are other profitable uses for the money involved.

It goes without saying that testing will be most profitable when the fullest use can be made of the information provided and conversely least profitable when circumstances are such that the information cannot be used.

Testing should receive high priority in the farm budget whenever you wish to reduce the size of the herd for example, to increase the scope of another farm enterprise such as cash cropping or sheep, or when labour costs can profitably be reduced by milking fewer cows. Whenever you anticipate having a good number of replacement stock available, testing will be well worthwhile to take advantage of the opportunity provided of heavily culling the low producers. When cull cow prices are high, the man who buys his replacement stock can make valuable use of testing by buying more replacements than he requires and culling the herd heavily when feed supplies dwindle. In this way, he will not only rapidly raise the quality of his herd but will also be in a position to take full advantage of heavy stocking during periods of maximum grass-growth, without placing himself in the embarrassing position of trying to winter more cows than the farm is really capable of wintering. Testing is a "must" when the current herd-sire has his first crop of daughters coming into the herd. The decision on whether or not to use him further may have a big influence on future herd-quality and therefore future profits against which the cost of testing will be very small.

Conversely, testing will be less profitable when the aim is to increase the herd size rapidly, when few stock are available for replacement or factors such as disease losses limit the culling of low producers. On some farms a low producer may temporarily be well worth her place if feed will be wasted and production suffer if she is culled. This should not, however, be a long-term policy.

Each farmer must decide for himself the correct action to take according to the circumstances on his own farm. I would suggest though that if you find it difficult to justify the cost of monthly testing on your farm, that you give consideration to the possibilities offered by alternate-month testing. This test has been shown to be quite suitable for indicating the relative merits of cows in the same herd and is a means of reducing costs without losing all the benefits that herd testing provides.

Artificial Breeding

A team-mate to herd testing on a great many dairy farms is the artificial-breeding service provided by the various Herd Improvement Associations and A.B. Societies with semen obtained from the Dairy Board's Newstead Centre.

Artificial breeding in New Zealand had its beginnings over 20 years ago, although its development and rapid expansion as a commercial service to dairyfarmers is much more recent. In 1951 less than 6,000 cows were inseminated, whereas in 1957 the number had grown to nearly 250,000 and there are indications that during the current year the figure may reach 300,000.

Farmers with large herds to feed and manage may like to consider the problems sometimes faced at the A.B. Centre which is at present carrying a herd of well over 150 bulls at the rate of slightly more than one to the acre. However, while the Centre may at times have problems in bull management to tackle, the fact that it is possible by artificial breeding for these bulls to sire several hundred thousand calves annually explains the reason for the Board's interest in providing farmers with this service.

Artificial breeding has developed because of the general acceptance of two highly-important facts in dairy-cattle breeding. First that the influence of the bull on the future quality of any dairy herd is many times greater than that of any individual cow and secondly only a small proportion of bulls are capable of raising production substantially. Sire survey enables us to locate the bulls which are real herd-improvers and for many years now farmers have been advised to select the son of a good proven bull out of a high-producing well-bred cow if they wish to increase their chances of obtaining an above-average bull. This advice, which can be considered the standard recipe Dairy Board for sire selection, has given good results and bulls with this type of breeding have, on average, lifted production. Unfortunately, it is not an infallible method of selection, even the best-bred bull can sometimes turn out a dud.

It is doubtful whether the gamble taken when selecting a young bull can ever be entirely eliminated. Accordingly, the farmer depending on one or two unproven bulls to sire his herd replacements is always faced with the possibility that the replacement stock coming into his herd will be disappointing producers. A proven bull will remove this gamble, but his purchase entails the risk of introducing disease into the herd and even if this risk is accepted, few farmers ever have the opportunity of purchasing one.

The services of such a bull can, however, be provided to dairyfarmers quite readily through artificial breeding and since the introduction of sire survey over 20 years ago the Board's Herd Improvement Council has actively pursued a policy of developing an artificial-breeding service.

The aim of this service is to improve the productive ability of the national dairy herd and hence the economy of production on dairy farms. The methods adopted can perhaps be best appreciated by considering the steps taken in selecting a bull for the A.B. Centre.

Annually, some 3,000 bulls are sire-surveyed and those with surveys with a rating of at least +15 (10 per cent. to 15 per cent.) are checked to see that the bull has not had an advantage through his daughters having been milked for a longer period than the rest of the herd. Then, provided the bull is not too old, an enquiry is made to see whether the bull is likely to be available. If so the farm concerned is visited and the bull and his daughters inspected.

This year the Board's Bull-Purchasing Committee inspected approximately 50 sire-surveyed bulls and thirty of them have been purchased. Prior to purchasing each bull, care was taken to see that his survey was not inflated through the daughters having had preferential treatment, that the bull had no physical abnormalities such as an undershot jaw and the daughters were of satisfactory dairy type, particular attention being paid to their jaws, feet and udders.

On arrival at the Centre the bull is placed in isolation and is not used until tested and found free from diseases which could be transmitted through his semen. During this period, which may take a month or more, the bull is accustomed to being handled and trained to serve into the artificial vagina used for the collection of semen. Many of these bulls have never been rung or handled before and a considerable amount of time and patience is required at this stage.

The growth of artificial breeding must inevitably result in fewer bulls being surveyed in the industry generally and consequently fewer Merit Sires available. To meet this position the Board is building up a team of young well-bred bulls which are proven through artificial breeding. The object with these young bulls, which are mostly yearlings when purchased, is to mate them to 1,000 cows during their first season at the Centre. They are then used as reserve bulls until proven at five years of age when the best are placed in the Merit-sire team and the remainder culled. So far, 27 bulls have been proved in this way and nine of them qualified as Merit Sires on the production of their A.B. daughters. Five of them are at present in the Merit-sire team with the prospect of several more in the coming mating season. These bulls have the most reliable survey it is possible to obtain; their daughters are milked under a wide variety of conditions and have by their production demonstrated their good milking temperament under these conditions. While an individual owner may, by careful milking, obtain satisfactory production from cows with a poor milking temperament this is unlikely to be the case when the cows are scattered through a large number of herds under modern conditions of milking. Do not be put off these bulls proven by A.B. because their daughter averages are lower than many of the naturally surveyed bulls; this is simply a reflection of the poorer conditions under which many of the A.B. cows are milked. The important figure in a survey is not the daughter average but the rating.

Artificial breeding will not, of course, be of immediate appeal to those fortunate enough already to have a good Merit Sire on their farm, but to the great majority who have not, it provides them with an opportunity to bring into their herds above-average replacement stock. The farmer who rears all the replacement stock he can, will then be in a position to benefit even more from his herd testing as well. In the knowledge that good-quality replacement stock are available he can use his testing returns to cull his herd more heavily than he would when his replacements are an unknown quantity. On the production of the 7,500 A.B. cows tested so far and the quality of the bulls at present at the Centre, I would estimate that future A.B. heifers will outproduce average heifers by at least 20 lb fat and while there will inevitably be some duds that testing will weed out, the possibility of obtaining a poor line of A.B. heifers is remote.

A.B. can also help when there is a breeding problem in the herd due to one of the diseases spread by the bull through natural mating. Quite a number of herds have come into artificial breeding for this reason and while it is by no means a cure-all for fertility problems it can be quite useful when a disease such as trichomoniasis or vibrio foetus is present in the herd.

The breeding of crossbred beef is another facet of dairy-farming which may become increasingly important during the next few years. In England, artificial breeding has played a big part in the breeding of beef cattle on the dairy farm and there is no reason why it should not be here provided there is a demand for it. A beef-bull service was actually operated by the Newstead Centre for two years but was discontinued owing to the small demand for it. However, as it is anticipated that the demand for beef-bull semen may increase, it is intended to recommence the service this year and nine polled-Hereford bulls have recently been bought for this purpose.

In addition to its primary function of herd improvement therefore, artificial breeding can also play a part in assisting dairy-farmers to increase their economic efficiency in other directions. Herd improvement will, however, continue to remain its prime function and while it has not yet developed here to anything like the extent reached in some other countries it is firmly based and the production improvement shown by our artificially bred stock has not been exceeded by any other country.

The Consulting-Officer Service

The Board's Consulting Officers play a major role in the work of the Herd Improvement Movement and their services are available free of charge to any dairyfarmer. A telephone call or letter to your local officer is all that is required to bring him to your farm and, in the 18 years that this service has operated, dairyfarmers from one end of New Zealand to the other have talked over their problems with one of these officers. It is worth noting that in talking over his problems with a Consulting Officer it is quite frequently the farmer and not the Consulting Officer who comes up with the solution. The Consulting Officer has, however, played a big part in arriving at that solution by reason of the principles he has expressed and points he has made from his training and experience in the field. He has very frequently seen the same problem on other farms under similar conditions and knows how it was tackled and the results achieved. His primary function is, therefore to bring to farmers the results of other farmers' experience. A classic example of this approach is provided by the almost universal adoption of no hand-stripping. This technique was studied and recommended by the Board's Herd Improvement Department as a result of reports from Consulting Officers in the early 1940's that a few farmers had adopted this procedure without any apparent loss in production. This is also a good example of the way in which farming efficiency can be increased without spending money and in practice it is rare to find a farm where the "costless" improvement of better farm or herd management cannot be applied in some direction or other.

The Board's Production Improvement Project, which was operated some years ago to study the factors limiting production on low-producing farms and the extent to which production could be raised by the type of advisory service provided by Consulting Officers, demonstrated not only that production could on average be raised substantially on such farms but that generally little capital expenditure was involved in doing so.

The project also pointed to two other factors of particular importance under today's conditions. First is the need to examine farm expenditure to decide whether available finance is being spent to the best advantage and second the need to examine all aspects of farm management in order to pin-point the weaknesses. Emphasis on pasture improvement, for example, may not show the improvement expected if the milking routine is faulty or the quality of the herd is poor.

Your Consulting Officer can help you to answer these questions and decide the part that can be played by herd testing and artificial breeding in raising your farming efficiency.

Question: Is there any way to increase the number of heifer calves?

Mr Stichbury: It does sometimes happen that there is a bad run from A.B. It has been found that with natural mating the proportion of bull to heifer calves is 52 per cent. : 48 per cent.—and the same result is obtained from A.B. It seems to be a matter of luck.

Question: Is there any chance of doing better?

Mr Stichbury: Yes, there is a chance, but no-one has yet been wholly successful. It is known that sex is determined by the sperm type, and work is being done to try to separate the types by various means.

Question: Is the conception rate with A.B. higher or lower than with natural mating?

Mr Stichbury: This year the conception rate has been 59 per cent.—that is, about 3/5 of the cows held to A.B. For natural mating the figure is 62 per cent.—it has been lower. Both figures are subject to variation.

Question: The beef breed chosen for A.B. is Hereford. Why is this, and what about the other beef breeds?

Mr Stichbury: Putting the Hereford over dairy cows gives a slightly higher growth rate, and the resulting white head shows up the beef-cross animal. There was practically no difference in the calvings, from Jersey cows, between Aberdeen Angus and Hereford, though one case in ten had to be assisted. Birth weights also were found to be the same.

Question: How is it that some cows exhibit frothiness of the rumen contents even before going on to a "bloat" pasture?

Dr Johns: In a herd all eating the same pasture, it is found that some animals will bloat, and some will not, therefore there must be some difference in the animals themselves. Proneness to bloat correlates with the frothiness of the stomach contents before feeding. (This has been found in experiments using fistulated cows.) The causes are being investigated, work being done on slime producing bacteria, and also the composition of the saliva. There are three types of saliva, of which the submaxillary saliva is foam-producing. The proportions and composition of the saliva of bloating and non-bloating animals are being investigated.

SOME CAUSES OF INFERTILITY IN CATTLE

G. G. Thomson, Lincoln College.

As I was asked to talk on a veterinary problem I have chosen the subject of infertility in cattle. I am not an expert in this field of veterinary medicine and so I hope you will not expect to hear about any sensational observation or discovery. What I aim to do is to illustrate the general nature of this complex problem and to mention some specific conditions which prevent cows from calving in a normal manner.

Infertility is an important cause of wastage in New Zealand. Because of it a large proportion of our cows are culled. About 20 per cent. of the annual culling is due to some kind of breeding failure. This state of affairs is about the same each year and fortunately there are no indications that it is becoming worse. It is unfortunate however that the position is not improving.

There is not much improvement because we know so little about the causes of infertility. As I said this is a complex problem and while past research has provided a wealth of information it would appear that we need to know a great deal more before we can hope to make progress. The forces which influence reproduction are many and varied. For example breeding can be affected by the food the animal eats. Either there is not enough or the food fails to supply substances needed for reproduction. Sometimes the human element of management is concerned. Sometimes harmful bacteria affect the reproductive organs and pregnancy is upset. Often the failure occurs inside the cow due to the improper functioning of some part of the reproductive organs. For instance, the ovary may fail to produce enough hormone to cause a heat period or it may produce too much with the result that the cow is continually on heat.

Before commencing this talk I sought the advice of the New Zealand experts. They made the following comments with regard to the problem. They think that in this country we know comparatively little about the overall causes of infertility. For example, they estimate that we know the reason for only half of the abortions which occur in cattle during late pregnancy. To diagnose even this number it has been found necessary to examine the aborted foetus, the membranes or the vaginal discharges and to take at least two blood samples from the aborting cow. The known causes of these late abortions are Brucellosis, Leptospirosis and certain fungi. A few abortions however can be caused by the eating of macrocarpa leaves. With regard to the failures which occur soon after mating we know even less and the same applies to the breeding problems associated with artificial insemination. One cause may be due to infections already present in the cows before they are inseminated. I was interested to note too, that the experts thought that faulty inseminating technique played only a minor role in these failures to breed. With natural mating, sterile bulls account for some of these early failures. Each year about five per cent. of the bulls in New Zealand are found to be sterile.

Infertility is a condition which may affect whole herds or only an individual cow. In herds, a breeding problem is said to exist when 50 per cent. of the cows fail to hold to the first service and when the average number of services for each pregnancy is more than two. To investigate this problem a great deal of time and work is needed. Often the first step is to examine the breeding records. These are most valuable as they frequently show that a particular bull is at fault or that the trouble in the cows is confined to a particular age group. Farmers should therefore keep good records of calving dates, heat periods and times of service. In addition the bull must be examined and the cows tested for the organisms known to cause trouble. Only when this has been done is it possible to question the effect of management or nutrition.

We do not have sufficient time to deal with herd infertility so I propose to deal with some of the conditions which prevent normal reproduction in an individual cow. To do this it is necessary to understand the anatomy and physiology of her reproductive organs. These consist of the external opening, the vagina. This is a muscular membranous pouch into which the sperms are deposited at the time of mating. There are only a few instances when vaginal conditions alone can be blamed as a cause of infertility. At the interior end of the vagina there is a well defined valve-like structure called the cervix. This is usually closed but it is open during heat periods and at calving. Attached to the cervix is the Y-shaped uterus or womb. The two arms of the uterus are called uterine horns and in these the young calf is nourished and protected while it grows to normal size. Bacteria can invade these horns and cause death to the foetus or it may cause it to be expelled or aborted. From the end of each uterine horn a thin coiled tube leads to the ovary. These fine uterine tubes can sometimes become blocked and this blockage causes sterility by preventing the passage of both sperms and eggs. The ovaries are important structures and their job is to produce both eggs and hormones. When the ovaries fail, ovarian dysfunction is said to occur. This is one of the known causes of infertility. To understand these failures of the ovary it is necessary to describe how the ovary works in the normal cow.

The ovary is under the control of the pituitary gland which is situated in the head. At intervals it releases hormones which stimulate different kinds of activity in the ovary. After the pituitary releases the follicle stimulating hormone, the ovary grows a balloon-like structure called a follicle. The follicle has two functions. One is to produce an egg and the other is to produce a hormone called oestradiol. Oestradiol leaves the follicle, passes in the blood to the genital organs and prepares them for mating. It is also responsible for the oestrus or heat periods during which the cow allows service to occur. When the follicles are mature and heat has occurred the pituitary gland liberates a second hormone, the luteinising hormone. This substance when carried in the blood to the ovary causes the mature follicle to burst and release the egg for its passage to the uterus. This bursting of the follicle is called ovulation and in cows it occurs some hours after the end of the heat period. The sperm usually fertilises the egg as it passes down the uterine tube. A second function of the luteinising hormone is to cause the growth of the corpus luteum. This is a small mass of yellow tissue about the size and shape of a pea. It grows in the space once occupied by the now ruptured follicle. The corpus luteum secretes progesterone. The functions of this hormone are to assist the passage of the egg down the uterine tubes and to prepare the uterus to receive and nourish the young embryo. It also ensures that no further follicles or heat periods occur while a fertilised egg remains in the uterus. If fertilisation has not been successful the corpus luteum disappears in about 14 days and the whole cycle of events is then repeated.

Both of the ovarian hormones oestradiol and progesterone can affect the functioning of the pituitary gland. It is possible therefore that the indiscriminate use of the synthetic hormone stilboestrol could adversely affect it. In the normal animal the pituitary is also influenced by the amount of sunlight it receives, the state of its nutrition and by conditions inside the uterus. If this becomes distended with pus or contains a dead embryo the pituitary gland mysteriously ceases to function. It fails to release its hormones and heat periods do not occur. It can be seen therefore that the ovaries can be influenced indirectly by external forces such as nutrition acting on the pituitary and by internal forces arising within the animal itself. These internal forces may be due to the state of health or they may arise from the state of affairs inside of the uterus. Ovarian dysfunction then is frequently the result of changes occurring elsewhere than in the ovary.

When the ovary fails the cow can exhibit a variety of conditions. One of these is cystic follicles. It often affects high producing cows of middle age at the peak of their production. It can occur from one to four months after calving. This condition is thought to be due to the pituitary gland failing to release sufficient luteinising hormone after a heat period to ensure that the follicle is ruptured. Definite symptoms then appear. The cow often remains continuously on heat. She becomes a "buller" or nymphomaniac. The vulva becomes enlarged and sometimes there is a marked discharge of mucous from the vagina. After some time the pelvic ligaments relax and the cow develops an elevation at the base of the tail. In a few cases she develops a steer-like conformation and may roar like a bull. These cows can be treated successfully if it is done early. It consists of injecting into the blood-stream about 1,500-2,500 international units of luteinising hormone. This is usually successful. Heat periods follow in about 15-30 days and it is advisable to mate the cow at this time. Conception rates are less than normal, but satisfactory. It is also possible to rupture these offending follicles by hand. This works quite well, but is unsuccessful in a number of cases.

Cystic corpora lutea can also be produced by a low output of hormone from the pituitary. This condition is less common than cystic follicles. It results in a state where no regular heat periods are seen and the stock owner may assume the animal to be in calf. Spontaneous recoveries occur and if the condition is detected it may be treated.

Sometimes a slow release of the egg from the follicle causes a breeding failure. This is called delayed ovulation and it too is probably due to insufficient luteinising hormone. When this occurs the egg reaches the uterine tube too late for fertilisation. When this state is diagnosed in an individual cow it is possible at the next heat period to hasten the ovulation by injecting luteinising hormone.

If a cow produces more than one egg there is some evidence that the conception rate is lowered. Perhaps these two eggs are in some way "weaker" than single eggs. Sometimes eggs can be defective or abnormal. One research worker has shown that heifers produce a percentage of abnormal eggs. Many of you are aware that Mr Hart of Lincoln College has shown several types of abnormalities in eggs produced by sheep. He found that about 18 per cent. of all eggs produced developed some abnormal change. These changes appeared sometime during the nine days after release from the follicle. At the present state of our knowledge it is impossible to assess the incidence and importance of weak or abnormal eggs in cattle.

Probably the most frequent state observed by farmers is the failure of cows to come into heat. This may occur for several reasons. Of course the cow may be in calf and the owner may not be aware of a mating having taken place. He imagines some upset and frequently sends the cow for slaughter. It would no doubt pay farmers to have their cows examined for pregnancy before taking such a step. In some cases heat periods cease because a corpus luteum fails to disappear and is retained. This can occur when an embryo starts to develop in the uterus and then dies. Or there may be some pus or a mummified foetus in the uterus. This often causes a vaginal discharge as well. Treatment of this condition aims at increasing the muscular activity of the uterus so that it will expel its contents and so allow normal cycles to proceed. This is done by injecting oestradiol or by the manual removal of the offending corpus luteum.

Occasionally a retained corpus luteum may occur when there is no abnormality within the uterus. This sometimes happens in high producing cows during the first few months after calving. It is possibly due to a high production of prolactin by the pituitary of these cows. Prolactin has a luteinising action and tends to retain the corpus luteum. The condition may recover spontaneously in a few weeks or it may take several months to do so. Manual removal of the corpus luteum however hastens the onset of heat. It occurs three or four days after the removal and about 50 per cent of cows conceive if mated at this time.

When the ovary does not function at all and no heat periods take place the animal is said to be in a state of anoestrus. Heifers are often affected, probably due to a poor state of nutrition. Adults react similarly if they become emaciated or severely ill. This condition is probably due to a pituitary failure. Cycles commence when the primary cause is corrected.

Other factors which are known to influence fertility are mineral imbalances of calcium and phosphorus, deficiencies of minerals such as copper and infectious organisms. The most common organisms are *Brucella abortus,* Leptospira and Trichomonads. Others also cause trouble but only after something has prepared a way for them. For example after a cow has aborted due to Brucella she may be difficult to get in calf again. This is because secondary organisms have probably invaded the uterus and caused harmful changes. Infertility resulting from faulty nutrition, bad management or mineral deficiencies can only be considered after eliminating the infectious causes.

Brucellosis is common and is the principal cause of abortion in New Zealand. The overall incidence is not known but in individual herds up to 25 per cent. of cows may be infected. The organisms usually enter the cow by way of the mouth and in late pregnancy they cause damage to the foetal membranes. This either leads to the birth of a weak calf or to the premature expulsion of it. The part played by Brucellosis in sterility is not yet clear. Some experts say that the sterility associated with these abortions is due to the invasion of the uterus by bacteria which normally would not be a problem.

The disease is diagnosed in several ways. The organisms may be found on the membranes, in the foetus or in vaginal discharges. Antibodies may be found in the milk, in the vaginal mucous or in the blood. Once a cow becomes infected she probably remains so for the rest of her life. She rarely aborts a second time. Control is based on the isolation and disinfection of aborting cows and upon vaccination with S.19 vaccine. A good immunity is obtained when both male and female calves are injected with it between six and eight months of age. It must be pointed out however that vaccinated heifers can still become infected and may abort. A few bulls are said to spread the disease in their semen so care is taken with A.B. bulls to see that they are not infected.

Trichomoniasis is a venereal infection giving rise to infertility and abortion. It is rare in New Zealand so I do not propose to deal with it in this talk.

Vibrio foetus is another venereal disease. In the bull the organism lives in the lining of the sheath and no symptoms are seen. On being transferred to the cow these organisms invade the uterus and in some way prevent conception or implantation. This necessitates many services to get each cow in calf and up to 50 per cent. of the cows may show longer than normal intervals between heat periods. Abortions also occur at any stage in the pregnancy. Cows have the ability to throw off the infection, but bulls remain permanently infected. In herds affected for a long time it is often found that the older cows breed normally, but the younger ones do not.

Diagnosis is made by the identification of the organism on the foetus and freshly collected vaginal discharges or by the demonstration of antibodies in the vaginal mucous of a number of cows. Blood tests give too many false reactions to be reliable.

In the bull the diagnosis is more difficult. The examination of sheath washings is unreliable. It is therefore necessary to test mate the bull with a clean heifer and look for the organism in her vaginal mucous. Vibrio infection can be treated. In cows it simply consists of injecting streptomycin into the uterus 12 to 72 hours after mating. Bulls are treated by the infusion of antibiotics into the sheath. If treatment is not feasible then control can be had simply by discontinuing natural services and breeding artificially. A clean bull must be used in the virgin heifers.

Leptospira also cause abortions. Up to 30 per cent. of a herd can be affected. Some cows show no symptoms while others become quite ill. The abortions and foetal deaths usually occur during the last two months. Fortunately in adult cows the disease is rarely fatal and they only abort once. In an outbreak isolate those cows which abort and vaccinate the remainder of the herd. Leptospira can affect man, so farmers should be careful to wash their hands after handling aborted calves.

I have dealt with some of the known causes of infertility, but the field is a large one. Much more information is required to complete the picture. If this talk has contributed anything I hope that at least it does make it quite clear that in many outbreaks of infertility it is not always possible to provide either a quick diagnosis or a rapid effective solution. I would therefore ask farmers to be patient with their veterinary surgeon when it becomes necessary to examine a problem connected with infertility. Given time a solution can usually be found.

Question: Is the incidence of grass staggers or magnesium deficiency increasing? It appears to be doing so in the North Island. How can it be differentiated from milk fever?

Mr Thomson: It does occur here, but is much more prevalent in the North Island. It can be differentiated from milk fever by the nearness to calving, milk fever cases occurring within three days of calving, while grass tetany occurs later.

Mr Stichbury: A survey shows that the incidence was quite high in one year. It is, however, hard to say whether or not there is a general increase.

Question: Should heifers and bulls be vaccinated with S.19?

Mr Thomson: There are two schools of thought, and it was once considered better not to vaccinate. Vaccination is now, however, generally advocated.

FORAGE CROPS AND FARM MANAGEMENT

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The farm manager aims for the maximum satisfaction off his holding and from his way of life. In periods of depression the maximum satisfaction is associated with the maximum net income. This also applies to most young farmers whose first objective is to lower the heavy burden of debt they usually have to carry for the first few years. Where farmers have been established for some time, and especially as their age increases and their ability and inclination to work declines, the emphasis shifts over to somewhat less output per labour unit and a more comfortable life. It is within the framework of available finances and supply of labour that the problem of fodder cropping and indeed every other problem of farm management should be examined.

Animal production is no exception to the general rule and good management on livestock farms sets out to fit the available feed supplies around a number of animals in a manner calculated to produce somewhere near the maximum net return with a reasonable degree of comfort and convenience to the labour force on the farm.

New Zealand is a famous example of a system of animal production based on the consumption of animal fodder as it grows in the soil. This system is taken to its ultimate degree of perfection in our high quality semi-permanent grasslands. This permanence and near-permanence at high levels of output is assured by the fixing of the atmospheric nitrogen by the symbiotic bacteria on the roots of the clovers stimulated by small doses of the relatively cheap but vital phosphate and sulphur compounds. The grafting on to this system of time and work-saving designs and methods, especially in the cowsheds, woolsheds and sheepyards, has enabled a true low-cost pastoral industry to be established in this country—it is to be hoped that conditions in the future will allow it to continue competing in the world's markets on a fair basis.

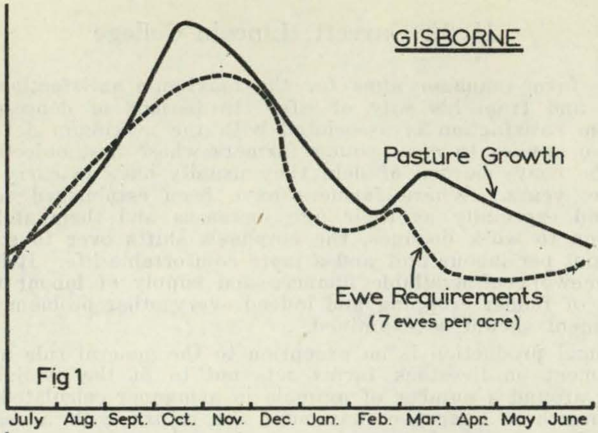
The Problem Varies from District to District

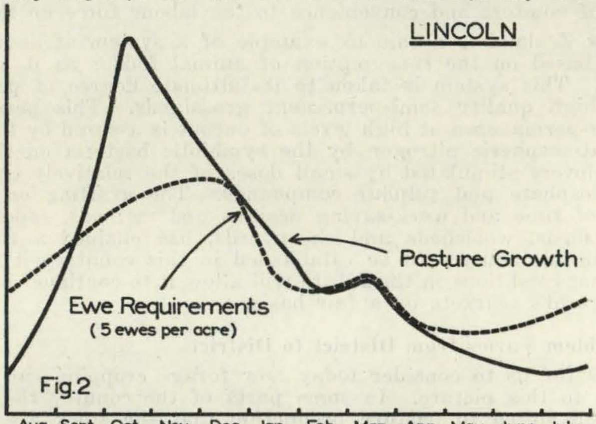
It is for us to consider today how forage cropping can best be fitted in to this picture. In some parts of the country the climate is so well suited to pasture production that the stock are able to obtain their whole requirements all the year round from the permanent pastures. This is of course the simplest method for the farmer to adopt and sounds like a "heaven on earth" to the South Island farmer.

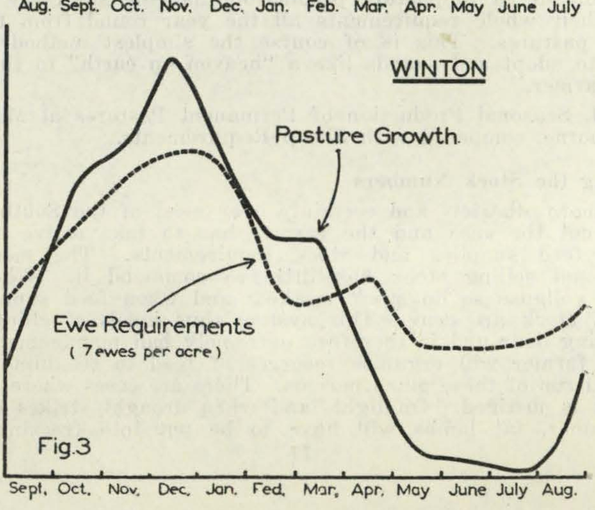
Figure I. Seasonal Production of Permanent Pastures at Manutuke, Gisborne, compared with Sheep Requirements.

Changing the Stock Numbers

In many districts and certainly over most of the South Island, this is not the case and the farmer has to take active steps to balance feed supplies and stock requirements. The method of buying and selling stock has little to commend it. When feed supplies collapse so do stock markets and when feed supplies are plentiful stock are dear. This system thus involves selling cheap and buying dear and is therefore extremely bad management. The prudent farmer will organise reserves of feed to see him through the usual run of these pinch periods. There are cases where disposal of stock is justified. On light land when drought strikes early in the summer, fat lambs will have to be put into freezing works


GISBORNE
Pasture Growth
Ewe Requirements
(7 ewes per acre)
Fig 1
July Aug. Sept. Oct. Nov. Dec. Jan. Feb. Mar. Apr. May June


LINCOLN
Pasture Growth
Ewe Requirements
(5 ewes per acre)
Fig.2
Aug. Sept. Oct. Nov. Dec. Jan. Feb. Mar. Apr. May June July


WINTON
Pasture Growth
Ewe Requirements
(7 ewes per acre)
Fig.3
Sept. Oct. Nov. Dec. Jan. Fed. Mar. Apr. May June July Aug.

at very light weights. So far we have not been able to produce a supplementary dry feed at an economic price that is much good for lamb fattening. Accordingly when the succulent feeds are about to collapse lambs must be quickly pushed into the works or they, too, will fall away with the feed and prove an impossible burden on the property.

Working on Reserves within the Animal

As a natural process stock will store feed reserves in the body whenever the feed supply and the commitments of the animal permit.

There is a limit to the extent to which this sort of thing can be used in efficient production on most of our farming land. It can, however, be fitted in at certain periods to save feed and postpone its consumption to a time when it is of more value. As far as the breeding ewe is concerned the flock can be limited as to feed supply, even to the extent of being forced to lose some condition, only at two periods in the year. If weaning is early this process can be applied for a short period with some advantage but should on no account be taken too far or for too long or it will counter some of the effects of subsequent flushing and so affect the lambing percentage. When the rams have been round at least twice and the ewes safely in lamb the pressure can again be applied in many cases with advantage. Keeping the ewe flock somewhat on the short side at this period allows a competent manager to conserve feed for the vital period just before lambing and also prevents the breeding ewe from becoming too fat over the pregnancy. Over-fat ewes, especially if under-exercised, are more prone to troubles prior to and during lambing and as a rule take more shepherding during lambing itself.

In any restriction of the feed supply there is an associated drop in the wool growth but it would be negligible under the kind of management advocated here. Any collapse in supplies of feed prior to and during lambing or with the milking ewe is extremely poor management and results in much lower output and higher mortality.

As far as the dairy cow is concerned a great measure of success is tied up with good feeding over the whole 365 days. There is only one period when rationing can be applied with advantage—this is at the end of the normal lactation for a few weeks until the cow approaches calving. The skilful feeder can keep the animal in medium condition at this stage, boosting her along just before and just after calving on a bit of good hay or silage and some autumn saved pasture or new grass rationed with the electric fence. This keeps the calf down to a size which the cow can handle in comfort and avoids the diseases and troubles associated with too high or too low a plane of nutrition.

Useful as the adjustment of feed supply along the above lines may be, it is not of major significance in balancing the yearly feed supply against the animal's requirement.

The Size of the Problem

The prudent manager will organise his feeding to cover the usual variations although he may be caught by extremes of climate.

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The question of the moment is just how the manager should supplement the pasture growth to meet the needs of his stock. A lot depends on how much is required and where it is required. Figures II and III indicate some typical variations dependent on the difference in locality.

Figure II. Production from Permanent Pasture in Canterbury compared with Stock Requirement.

Figure III. Production from Permanent Pasture in Southland compared with Stock Requirement.

It will readily be seen from these figures that some active measures are required to balance the needs of stock and the feed supplies in the South Island. The various systems of balancing are discussed in the following pages.

Top-dressing and Autumn-saved Pasture, Special-purpose Pastures

A certain amount of balancing can be done by carefully-timed top-dressing. Superphosphate applied early in the autumn does boost autumn and early-winter growth. It also brings the spring growth away more strongly and at an earlier date. There is no doubt that on most grasslands it is an important factor lightening the winter load but in the areas of low winter temperatures it can go only so far.

Special pasture species can be grown which will produce over summer drought periods and carry forward into the winter cold. For instance it is clearly established that to achieve the greatest efficiency up to 50 per cent., and in some cases even more, of the total area of farms on light plainsland should be in lucerne or lucerne mixtures. It should be remembered that there is a limit to the productive capacity of these special purpose pastures and skilful management including carrying forward some standing growth can go just so far and no more, when climatic conditions are unfavourable.

The saving of pastures in the autumn is now standard practice on most farms geared to high levels of efficiency. There are a number of aspects which need to be appreciated. The best use for this feed is of course for the breeding animals just before and after lambing or calving. It is relatively easy to achieve this where winters are not severe. Under these conditions the biggest danger is from rust and from "mushiness". There will be variations in the speed and total quantity of growth from season to season. Accordingly pastures should be closed at intervals over a period of four to six weeks; in any case this suits the grazing needs of most properties. Where the pastures are closed early in growthy seasons, long feed results. This tends to go partly rotten or "mushy" underneath, especially if conditions are wet, and there is a big loss in quantity and quality. If closed too late there is simply not enough bulk although quality is good. The happy medium of reasonable bulk and good quality is the aim and by closing over a period there is always the guarantee that a fair proportion of the feed will be as desired. Rust is an enemy of autumn-saved pasture and does reduce its value appreciably. Once again it is associated with wet conditions but also appears mainly on ryegrass growing under low fertility. If a rise in soil fertility can be achieved rust will be only seldom encountered.

Where the winter is severe, autumn-saved pasture is much less successful. The clover does not stand the frost at all well and as the frosts get harder even the grass burns off. If the fertility and the nitrogen status is high, it is remarkable what the autumn-saved grass will come through if it is at just the right stage, but there is a limit. It is still worth saving but is better fed early in the winter with reliance for lambing-time feed being placed on saved new pasture or turnips and grass.

The Spring and Summer Surplus: Small Seeds, Silage, Hay

You have seen in the diagrams the large surplus of spring and early summer feed on most South Island farms. It is an obvious starting point for supplementary feeding. In normal years it is a surplus even with the highest prudent carrying capacity.

A method of balancing the year's feeding is to take the surplus growth off in the shape of crops of small seeds. Where the harvesting period is fairly dry this practice can be fitted in perfectly to balance the situation and in the past it has also produced high net returns per acre. Even at reduced prices farmers operating their own headers will find it hard to beat in districts which suit small seeds.

Failing small seeds or, for that matter, as well as small seeds, feed supplies can be equated with stock requirements by conserving the surplus growth in the spring as hay and silage. Under the correct management silage is a high-quality feed. It also has the advantage that over the average of crops less loss of nutrients takes place than with the making of hay. Another great advantage is that it can be stored fairly satisfactorily for several years at low cost. However, little of the water is removed before the material is carted, making the process fairly laborious even with the latest mechanisation. So far no really satisfactory machinery exists for carting out silage and this, combined with the smell, makes it relatively unpopular. It has a definite and important place but this is confined to the areas of higher rainfall where it is really difficult to make hay. It can be applied with real advantage to some of the lower rainfall areas when the periodical wet springs descend upon these districts. The extra growth is far better conserved as silage than made into poor hay which finally rots into compost quietly behind some pine or gum plantation. Silage deserves the position it has acquired in the dairy industry. It is only surpassed by saved pasture or special forage crops as a feed for the milking herd in the early spring and in the summer, dry period. One cannot foresee the displacement of the two or three tons per cow made in the major dairying districts of the north.

Good hay has everything to commend it; the problem is to make it. When the weather co-operates with a period of dry, yet not too north-westerly, conditions even the inexperienced can produce fairly good, and even on occasions, excellent quality hay. In very dry conditions the expert can produce it by working in the night and early morning hours. In showery weather, by making every post a winning post, the expert can sometimes still produce fairly good hay but there comes a stage when the best of men are beaten. The resultant product is mediocre. In periods of long continued wet the hay is poor and may be even a complete write off to the extent that money must be spent to clear the paddock. However it will be a bad season indeed if all the hay is spoiled, especially with lucerne where hay is made several times a year. The average picture where reasonable efficiency prevails is some excellent, some good and some poor hay. It has been demonstrated during periods of snow that good quality hay is a complete feed for sheep and cattle. There is no doubt that the use of hay alone as a supplement to well managed pastures is a satisfactory system of feeding. The process of making hay into bales is satisfactorily mechanised, the storage in barns is satisfactory and the transport from field to barn is reasonably satisfactory. This latter is still fairly arduous and some further developments on tractor lifts and smaller barns would seem to be a logical development.

Although there is some deterioration as time goes on, hay stores well if adequately protected from the weather. Both hay and silage have the great advantage of being able to be carried forward for a few years. This has marked advantages in districts where the annual rainfall and the total growth fluctuate widely from year to year. In these drier areas little fault can be found with hay as a normal winter supplement and, in droughts, a summer supplement. In districts of uncertain rainfall the provision of large storage facilities and the build up of substantial reserves in the normal and wetter seasons is an essential before output should be pushed up near the limit.

Forage Cropping

Ideal pastures are high-producing and permanent; where the rainfall is reasonably high they can be achieved by proper establishment and correct fertiliser treatment. Where rainfall is below 30 to 35 inches per annum, and especially where soils are thin and weak, the permanent pasture conception remains just an ideal. Pastures deteriorate in productive capacity as they age. The inferior soils especially, and even good soils, revert quickly to weeds and weed grasses such as browntop, hairgrass, sweet vernal and old man twitch. These can be cleaned only by cultivation. This works in particularly well with the growing of forage crops, especially roots. As management becomes better the quality of pastures improves and the period of high production lengthens. At the same time the period of cultivation required for a good seed-bed for new pasture is reduced. The ideal is the quick, six-weeks grass to grass of the North Island dairying districts. It has not yet been reached to any appreciable extent in the South Island. Cultivation for forage crops can however be delayed until the spring, where fertility is high, without appreciable loss of yield. A light-yielding winter-forage crop can even be grown by the previously unheard of method of grubbing pastures around Christmas time and sowing in the end of January to mid-February. Pastures can be established in the autumn after fattening crops and if carefully nursed in the early stages come right. Under high fertility and on land clean of weeds cultivation practices are being adopted with success which would have been rank bad farming 10 or 15 years ago. These methods do add to the pasture area and so the stock-carrying capacity by reducing the area under cultivation.

Looking at the forage crop itself, what are its strengths and weaknesses? First and foremost it has the great advantage of providing feed for sheep to eat on the ground where it grows. Certainly to obtain the maximum benefits it should be fed off in breaks of a size to last the animals a week or ten days only and this involves some labour in fencing. This is not particularly great however and there is nothing really irksome about the daily chore of putting the stock on and off the root crop. It is a nice quiet job at which even grandfather won't come to any harm—that is on a fine day. If there is much wet weather and especially on ground with a heavy tight subsoil, the root crop does not look so good. Gateways soon become quagmires and the stock definitely suffer after a certain degree of wetness is reached. Under these conditions there is a fair degree of wastage of feed.

The amount of animal food produced in a decent crop of roots is particularly high. As an aid to high production on farms in districts suited to them they are without peer. For best results they do require fairly damp conditions over the summer and autumn growing period. Under dry conditions they tend to be attacked severely by insects. The worst effects of these can be warded off by one or two sprayings with the appropriate insecticides at a cost of about £1 per acre per application for materials only. This usually ensures a fair crop which is specially valuable following the dry summer. A real difficulty at present with turnip cropping is the mosaic disease. But like other "calamities" which have preceded it, no doubt a solution to the situation will be found before long.

Roots in general are low in protein so should not form the main bulk of feed for ewes approaching lambing or with lambs at foot or for cows in full milk-production. This does not prevent them from fitting in well with the pattern of feeding throughout the year. One of their most useful attributes is the way they allow a flock of ewes to be confined to one or two paddocks when they receive a run on the root crop for an hour or two a day. In some systems of feeding they also receive some hay—in others, operated with success, no hay is fed. This feeding system keeps the ewes well nourished and contented and has the extremely-valuable associated aspect of spelling the major portion of the pasture area. This area of spelled pasture comes into its own as the ewes near lambing, and is an essential feature of really high carrying-capacity.

There is no doubt that in districts which are at all suited to root growing the best managers will grow them as a part of the cultivation programme on all properties which contain areas of inferior grassland. Where pastures are practically all of a high standard the case for growing roots is much more doubtful. The great increase in the area of pasture which can be spelled is a major factor in favour of roots but the costs must be considered. So long as the total area under cultivation is not excessive it is almost certain that the existing farm staff can handle any cultivation for roots in the ordinary swing of the farm operations. On the farms of the South Island the tractor and the implements are there already so that the depreciation and interest charges are going on whether roots are grown or not. Particularly if pastures are of high quality and free from bad weeds, the amount of cultivation required is not great and so the associated tractor fuel and repairs and maintenance charges are also only moderate. Therefore under most conditions roots are not an expensive crop to grow.

Fattening Feeds

The question of the best way to fatten lambs is often discussed. The right answer depends on the district and the stage of development. There is no doubt that in general as the quality of the pastures improves the percentage of lambs which can be drafted off the mothers increases. On grassland of real high-quality the relatively small proportion of lambs which remain after weaning can be usually fattened satisfactorily on areas of saved permanent pasture or perhaps on small areas of newly established pasture. There is no need for fattening feeds. In general terms this has been the story of the development of much of Southland over the last 25 years. There are of course some notable exceptions to this pattern of operations—examples where improvements in pasture quality have resulted in large scale lamb fattening troubles. Under conditions where only a proportion of lambs can be drafted satisfactorily off the mothers, crops of fattening feed appropriate for the district can be grown. The area devoted to these is dictated by the number of lambs to be fattened and the usual number of lambs fattened per acre on the crop. These areas of fattening crops are relatively expensive in terms of actual cultivation costs and the fact that the area is out of production in terms of carrying the flock of breeding ewes. Where pastures are inferior and percentages of fats off-the-mothers necessarily low these fattening crops must be grown but good farm management dictates a reduction in area as soon as possible.

Concentrates

Concentrate feeding is a controversial subject. There is no doubt about one feature—it is expensive. Experience suggests that where sales of winter milk can be made at quota price, feeding concentrates to give up to an additional half-gallon per cow per day is worthwhile. As far as sheep are concerned, apart from studs, the price of dry feed has to rise much above normal levels to warrant concentrate feeding to ordinary flocks. Such situations have occurred, for instance, in Canterbury during the drought three years ago.

Summary

To sum up the situation from the management point of view it is my opinion that where somewhere near the maximum output is the aim the following methods are the best to use to balance the feeds available with the needs of stock in the South Island.

Stock can be bought and sold to suit the fluctuations in feed supply but prices are normally right against such operations resulting in no profits. The feed supply can be left as it grows and the stock make their own provisions. This works satisfactorily where pastures grow fairly evenly but where wide seasonal fluctuations occur the results for the animal and the farmer can be disastrous. Up to a small extent this system can be used at the right time of the year with advantage.

Manurial top-dressing should be applied regularly to most of our grasslands and be associated with a policy of reasonable areas of autumn-saved pastures. Special purpose pastures have a very definite place on a small proportion of farms and hay and/or silage have a valuable place on nearly all farms. In districts which suit them forage crops fit in particularly well where the quality of some of the pastures is poor and the property is undergoing development. They are so productive, so convenient and their real cost is so low that they are worth retaining in smaller acreages even when pasture quality is good. Fattening crops cost money to grow and take up land more profitably employed in carrying breeding ewes. Hence management should be directed towards eliminating them. Where good management cannot improve the quality of pastures sufficiently to raise the number of lambs fat-off-the-mothers, crops of suitable fattening feeds are at present the most suitable alternatives. Concentrates have a very limited but valuable part to play.

SUPPLEMENTARY CROPS FOR MAXIMUM RETURNS

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In this paper I have dealt with supplementary crops as they affect production on the mixed farms of Canterbury. Any discussion on this subject must consider pasture management and the food requirements of breeding ewes and their lambs.

The following table illustrates the trend of farming in Canterbury during the period 1934/35 to 1954/55.

	1934/35	1954/55
Supplementary Crops . .	280,000 acs.	275,000 acs.
Grain and Pulse Crops . .	393,000 „	140,000 „
Area cut for meadow hay and silage	35,000 „	51,000 „
Lucerne	6,000 „	48,000 „
Area topdressed . . .	73,000 „	736,000 „
Breeding Ewes . . .	3,500,000 „	4,700,000 „

When we consider the improvement in our grasslands during the period, it is difficult to understand the relatively-small increase in ewe numbers. We can take it that the quarter of a million acres that have gone out of cash crops is now in pasture capable of carrying at least two ewes per acre or the equivalent of half the ewe increase. There has been a decline in carrying capacity on some hill properties but a corresponding increase due to topdressing and oversowing on others. There is still room for considerable improvement of pastures on the arable land but they are vastly superior to those of 20 years ago. The widespread use of improved strains of pasture plants and the increased use of lucerne coupled with adequate topdressing with lime and phosphates and in some cases trace minerals, has lifted the production and extended the growing season of our grasslands. Why are these improved pastures not carrying more stock? The answer is that much of our grass is wasted.

The usual rate of stocking on the mixed farms of Canterbury results in two main periods when grass growth is beyond stock requirements. Our pastures give more than half their annual production during three months in spring and early summer, and surplus growth also occurs in autumn. Shortages are experienced in May, June, July and August when pasture plants are more or less dormant, and again in late summer when the weather is usually too dry to promote the type of growth ideal for lamb fattening.

In spite of these seasonal variations in production, grass is our most important crop, for a sward well balanced in good strains of grasses and clovers is undoubtedly the cheapest and best of all stock foods.

If the total production of our improved swards was used to the best possible advantage many farms could support the number of stock they now carry without the aid of the annual forage crops they grow today. The growing of annual supplement is profitable only where all the pasture growth surplus to immediate stock needs and small seed crops is stored for later feeding in the form of hay, silage or saved grass.

In recent years the most common method of controlling surplus pasture growth in spring and early summer has been to close some paddocks for small seed production and others for hay. With a fall in prices for wool, meat and small seeds the area in annual cash crops will increase, so if stock numbers are to be maintained or increased ewes will be concentrated on a smaller area with consequent difficulties at the two seasons when pasture growth is below stock needs.

Crops of small seeds will be harvested only from paddocks which give promise of high yields and all other surplus growth should be saved in the form of hay or silage.

There is still a common belief that silage making is an extremely arduous undertaking but in this climate of ours it is doubtful if the making of good quality silage is more laborious than the making of poor quality hay or compost.

The advantages of ensilage are obvious. The closing of some paddocks in early spring simplifies pasture management for it facilitates controlled grazing by a heavier concentration of stock on other paddocks. If an early cut of silage is taken while the grass is still young and leafy, the crop is off the paddock before dry weather sets in and the aftermath gives ideal fodder for lambs at weaning. Silage is stored in pits or clamps and can be held for a number of years without appreciable loss of quality. It provides a nutritious fodder during periods of shortage, whether they occur in winter or the dry summer months.

It is not suggested that silage should replace hay but rather that it should be made early in the season when climatic conditions are unfavourable for hay making. It should also be made in wet summers when thousands of acres of grassland are now allowed to run to rank growth and substantial quantities of feed are wasted. More attention to silage making, particularly in wet summers, would not only add to the store of stock food for use in less-favourable periods, but would also provide a profitable method of pasture control with a resulting improvement in the autumn productivity of pastures and a consequent reduction in the area cultivated for annual forage crops. All autumn surplus should be allowed to stand for use in late winter and early spring.

Pastures are practically dormant for about one hundred days during winter and frequently produce an unsuitable type of growth for lamb fattening in the late summer. Increased carrying capacity per acre for the rest of the year means more supplementary feeding during these pinch periods. Though hay, silage and autumn-saved grass will go a long way towards bridging these gaps there are few mixed farms in Canterbury where maximum stock numbers can be maintained on grass products alone and therefore the growing of annual forage crops is necessary. The economics of growing these crops is often questioned, but costs must be spread over all crops in the rotation of grass back to grass and not considered in relation only to the forage crop. Supplementary feed crops fit into a rotation by paving the way for cereal growing and pasture renewal and a systematic programme of pasture renewal is essential to maximum returns.

With the exception of special-purpose pastures such as lucerne-grass mixtures, pastures on light to medium soils are usually deteriorating after four or five years and even on the heavier land it is difficult to maintain them at their best after six or seven years. The importance of planning a suitable crop rotation for the renewal of these pastures is therefore obvious.

Crops and acreages sown for winter forage will vary from district to district and from farm to farm. Swedes find favour in districts with higher rainfall while turnips, chou moellier and green feed cereals are grown in other areas. Though soft turnips, chou moellier, kale and, more recently, Borre lupins are grown to supplement grass and lucerne for lamb fattening, rape is still by far the most popular crop for the purpose.

In spite of the ravages of cauliflower mosaic and such pests as diamond-backed moth, white butterfly and aphis, turnips are widely used for winter feed because of their high yield and the fact that they thrive on the lighter soils where swedes would fail. It is generally found that January and February sowings give best results, and although the advantages of a winter fallow are fully realised there is much to be said for the practice of feeding hay over winter on the paddock selected for turnips thus raising soil fertility by heavy stocking prior to ploughing as soon as spring growth commences. This permits more lenient grazing of other pastures which consequently come away more rapidly in spring.

The area sown in chou moellier either alone or with turnips has increased in recent years. Its dry matter content is much greater than that of turnips, it is resistant to club root and mosaic, it loses little in quality over winter and is especially valuable when other crops are covered by snow.

Provision of greenfeed for ewes in late winter and early spring is important and the choice lies mainly between temporary pasture or young grass, autumn-saved pasture and the cereals oats, barley and ryecorn or combination of these.

The most valuable greenfeed is undoubtedly a young pasture well balanced in short-rotation or Italian ryegrass and clovers. Sown on well-prepared land after a summer fallow these pastures provide a substantial bulk of nutritious feed so essential to ewes in late pregnancy and early lambing. On farms where these grasses are not favoured because of fear of contamination of perennial ryegrass seed crops, a young stand of perennial ryegrass and white clover will fill a very useful place.

However if green feed is to be sown late in the season or when soil and moisture conditions are unfavourable, any of these grasses may give disappointing results whereas a green-feed cereal would thrive.

Algerian oats are the most common choice though Duns are more hardy and do well over a wide range of soil types. Cape and Black barley establish more quickly than oats but run to seed in early spring. Ryecorn is the most hardy of the greenfeed cereals but unless conditions are favourable it is slower to establish. Any of the cereals may be sown with short-rotation or Italian ryegrass. This gives better quality fodder and a longer productive season for the cereal provides early grazing and the grass gives high-quality fodder well into the spring.

In recent years prairie grass has been grown on a number of farms in North Canterbury and so far its winter and early spring production has been extremely high.

In North Canterbury the first experimental area of prairie grass was sown in the Woodend district in the autumn of 1949. The seeding rate was 70 lb per acre with 3 lb of white clover. The grass established well and made rapid growth during the first season but in subsequent years its production was practically nil.

Since then prairie grass has been sown as a companion grass to lucerne and results have been much more promising. The first paddock in this mixture is now five years old and for the past four seasons growth has been almost continuous with prairie grass taking up the running when lucerne is dormant over the winter. Ten pounds of lucerne and eight of prairie grass is about the ideal seeding rate.

It is still too early to recommend the widespread use of this winter growing grass on all land suitable for lucerne but results to date are very promising and the prairie grass-lucerne mixture may go a long way towards replacing greenfeed on thousands of acres of our well-drained soils.

The place of forage crops in the rotation will vary from farm to farm. There is little doubt that the wheat acreage will increase very considerably over the next few years but stock numbers should also be gradually increased. This will demand full utilisation of all pasture growth and a larger area in supplementary feed-crops. In some cases early sown wheat will provide a green bite for ewes in spring. Where soil fertility is high and in seasons when moisture is adequate, wheat stubble will be burned off and the land surfaces worked before sowing to grass. Under less-favourable conditions sowing down will be delayed for a year and the wheat crop will be followed by greenfeed and a summer fallow.

Roots, chou moellier and kale are usually sown after old pasture and on suitable land may be followed by a cash crop of oats, linseed or barley. Rape is commonly fitted into a rotation directly after pasture and is followed by wheat, a greenfeed cereal and summer fallow before sowing down. Although greenfeed cereals usually follow a cash crop they are occasionally used on the first furrow and frequently are sown into disced rape stubble when the combination of second growth rape and cereal gives a useful bulk of feed at a comparatively low cost. All these supplements may also be sown at the other end of the rotation by adding light seedings of roots, cereal greenfeeds or rape to the permanent pasture mixture.

UTILISATION. Let us now consider the most profitable useage of stock food on the lamb-fattening farm throughout the year. During the period from weaning to flushing when the ewe is producing nothing but wool, only a maintenance ration is required and the flock can be run on relatively-bare pastures and fed threshed ryegrass straw or poor-quality hay if necessary. Ewes which have reared twin lambs may be rather low in condition and need somewhat better fare but should not be improved beyond good store condition.

For a period of six weeks, three weeks before mating and three weeks after rams go out, flushing feed is necessary. Second-growth rape, saved grass or lucerne are commonly used though in dry seasons silage being a succulent could be equally effective.

From mating to late pregnancy the flock can again be kept on a fairly tight ration and roots, chou moellier, hay and silage are fed in quantities sufficient to keep the flock in good store condition.

On properties where flock replacements are bred the turnip tops are usually fed to hoggets before the ewes are turned on to eat the bulbs. All turnips should be fed in breaks, and to maintain the flock in healthy condition and avoid crop wastage it is advisable to provide a run off to pasture on which hay is fed, for although sheep are sometimes left on turnips or swedes for weeks on end, this frequently results in digestive disorders and always in crop wastage.

Lambing is timed to have the maximum number of lambs away as fats before dry weather sets in. This means that ewes are lambing while pasture growth is still backward. The feed supply should be gradually improved in both quality and quantity for the four or five weeks prior to lambing and it is over this period that the farmer who has planned his feeding programme wisely reaps his reward.

In late pregnancy the condition of ewes can be improved by a generous ration of good-quality hay or silage while they are still on turnips, but in normal seasons and with wise planning the turnips will be finished before the latest mob of ewes commences lambing. Greenfeed, young grass or saved pasture, supplemented by good hay and silage, is the ideal fodder to carry the flock until pasture growth is adequate.

Research has demonstrated the substantial saving of grass when early weaning is practised. Lambs which are not drafted fat-off-the-mothers will be turned onto clean pasture. In some cases they will be finished on rape but with an improving system of pasture management the area sown to rape is likely to decline.

I have endeavoured to give a broad outline of the place of supplementary crops on the mixed farms of Canterbury and to show the importance of hay, silage and autumn saved grass as supplements.

Winter carrying capacity on the average farm has been estimated as follows:

1 acre old pasture—¾ ewe.
1 acre young grass—3 ewes.
1 acre chou moellier—17 ewes.
1 ton hay—5½ ewes.

Let us consider what is actually being done on a well-managed North Canterbury farm.

The area of the property is 190 acres with an unimproved value of £32 per acre. It carries 570 Corriedales bought in half as two tooths and half as four-year ewes. Lambing begins in mid-August and the lambs are weaned in mid-December. The percentage tailed is always between 130 and 140, 40 per cent. of which go fat-off-the mothers. The average wool weight is 11 lb and the cropping programme is as follows:

14 acres rape.
14 acres wheat after rape.
14 acres wheat after grass.
1 acre chou moellier.
25 acres young grass.
6 acres lucerne.
12 acres lucerne and prairie grass.
28 acres small seeds.

Last spring a paddock of 18 acres was closed for an early cut of hay before being saved for a white clover seed crop which yielded 160 lb of machine dressed seed per acre. Ten acres were saved for ryegrass seed but this was cut for hay because of blind-seed disease.

With a carry-over of 400 bales the total hay this year was 3,000 bales, 2,000 of which were sold.

The flock of 570 ewes were wintered on 140 acres of grass, 1 acre of chou moellier and 33 tons of hay.

Working on the basis given for the average Canterbury farm this property would carry 423 ewes as follows:

103 acres old pasture	78
25 acres young grass	75
12 acres prairie grass	72
1 acre chou moellier	17
33 tons of hay	181
Total	423

If we agree that the 33 tons of hay and 1 acre of chou moellier carry 200 ewes the balance of the flock, namely 370, are wintered on 140 acres of grass, a stocking rate of 2.6 ewes per acre.

The farmer concerned would be the first to admit that production on this property has by no means reached its potential but he has undoubtedly illustrated what can be achieved by careful management between weaning and flushing.

At least 40 acres of good pasture are closed from stock each autumn and this, together with 25 acres of young grass and 12 acres of prairie grass and lucerne, is rationed, with hay on a run-off, during winter. The acre of chou moellier which yields about 40 tons, is cut and fed out as required in exceptionally bad weather. Wool weights and the lambing percentages demonstrate the efficiency of this flock management.

In conclusion I would like to stress these points. Over the last 20 years, pasture growth surplus to immediate stock requirements has been controlled to some extent by closing some paddocks for small-seed production and others for hay and silage, but much of the surplus has been wasted. At certain seasons breeding ewes are being overfed and this is fairly general in the period between weaning and flushing. If we are to take maximum returns from our mixed farms more attention must be paid to flock and pasture management.

With an increase in cereal cropping, stock will be concentrated on a smaller area of the farm, small seeds will be harvested only from paddocks which promise high yields, and more hay, silage and autumn grass must be saved. It is only where full use is made of all pasture growth that the growing of annual supplements becomes profitable.

There are few mixed farms in Canterbury where maximum stock numbers can be maintained on grass products alone and therefore annual supplementary crops should be grown. These can be fitted conveniently and cheaply into a rotation with cash crops paving the way for pasture renewal.

Question: When we feed chou moellier to ewes in the spring, if there is too much leaf left on it the lambs will slip. What methods would you suggest in feeding in breaks not to have leaf on it in the spring?

Mr Smith: Feeding chou moellier in the spring can bring with it troubles. It is largely a matter of management in not leaving your stock too long on chou moellier and giving a generous ration of hay and silage. Your supplementary crops should be finished before the ewes start lambing. The mixture of turnips and chou particularly will carry higher stock numbers than any other supplementary crop, and it is largely a matter of management in not giving too generous a ration of chou.

Question: When chou moellier starts to go to seed, say, about the end of August and September, it is dangerous feed for stock. That has been proved in Southland. The ewes do not do any good if it is not fed off by the end of August and cows get red water.

Mr Garrett: We do know that late in the season you can get red water in cows on chou moellier if the ration is at all large. I would say that if the farm management was geared as it should be on most farms there should be enough saved pastures and new pastures to push sheep on to at that stage. There might be a week or two of trouble. You should be finishing off the root feeds and passing on to saved-pastures at that time. Sometimes it would be better to plough in the roots rather than feed them off at certain stages in the spring.

Question: Just how far can we go in growing special-purpose pastures for late summer feed or winter feed? How far can we go in using them to avoid saving so much hay?

Mr Garrett: It depends on the environment, soil and climate. The North Island can do it. I do not know how far you can go with special-purpose pastures and hay and some new grass on really good soils; on the Coast you can do it. By and large our pastures are poor, a few are good enough to last a long time, most, say, 99 per cent. require replacement, so it is easy to swing to agricultural farming which includes crops.

THE USE OF CONCENTRATES AS SUPPLEMENTARY FEED

A. Crichton Wright, Dunsandel

I would like first to give you a brief description of my farm as it will help to make clear to you my reasons for resorting to the feeding of concentrates in certain years and at certain times of the year.

The farm of 1,718 acres of light-plains land was taken over in the latter part of 1948. At that time it was typical of thousands of acres of similar land in Canterbury—browntop, sweet vernal, gorse and a small area of starved subterranean clover. In 1948 I sheared 800 sheep for a yield of 20 bales of wool.

My rotation up to the present has been turnips-rape-greenfeed (approximately one hundred acres of each) and back to grass. Along with this has been the policy of surface working 100 to 150 acres of subterranean clover paddocks and re-introducing grasses and clover (10 lb. H.1, 5 lb. perennial, 2 lb. white clover and latterly 2 lb. cocksfoot). Over the years the acreage of lucerne and lucerne/grass mixtures has been increased and now amounts to 415 acres. Our aim has been to build up a reserve supply of hay to enable me to tide over periods of shortage.

Due to climatic conditions and low fertility we had our share of failures with our supplementary crops. It must also be remembered that during the early years we had no paddocks from which we could cut hay. Indeed during the dry years of 1954-1955 only about 300 bales of hay were made.

It was for these reasons that I wanted to find something that would take the risk out of my type of farming. So in May 1954 I turned to feeding of concentrates in the form of sheep nuts.

My first problem was how to get the sheep to take to them. We picked out 20 strong ewe hoggets and locked them in a yard with a trough of nuts and with water. After five days one died, of pure frustration, I think, so I turned them out and started feeding a little good-quality hay; after they had taken to the hay we put a handful of nuts on each piece of hay. After a week we were able to withdraw the hay. The wethers were started the same way with hay in a bare paddock. The ewes were introduced to them the same way, but we found it was better to place the nuts underneath the hay. (We had found that if the nuts were placed on top of the hay the ewes would toss the nuts all over the place and trample them in. If the nuts were placed underneath the hay some of the leaves would filter down among the nuts. While eating these leaves the ewes would find the nuts and take to them.) This way they took to them readily in three days.

Now I teach the ewe hoggets to eat nuts soon after weaning by placing a few in a trough round a hay feeder, after they have taken to the hay. Once sheep have been taught to eat nuts no difficulty is experienced if you wish to feed nuts at any time later.

Young sheep may be taught to eat nuts by placing with them some older sheep which already are used to nuts. As with all forms of supplementary feeding, a small proportion (with us from five to ten per cent.) of sheep will never take to nuts. They are easily drafted off and can be put on to other feed.

There is a great saving of time in feeding nuts. One sack of 100 pounds will feed 530 sheep; compare the time spent in loading and unloading an equivalent amount of hay. A further point is that nuts do not require the outlay of any special capital cost for storage such as hay does.

It has been claimed that nuts are a balanced ration. So they are, but I have found from experience that sheep must have some roughage. If there is not sufficient in the paddock then it must be supplied to them in the form of grass-seed straw, oat straw, inferior hay or even good hay.

During the drought of 1955-56 we were not forced to sell any stock. We kept them in good store condition by feeding 2 ozs. of nuts per head per day and one bale of straw to 100 sheep. This was increased to 3 ozs. per day three weeks before tupping, then reduced to 2 ozs. after the rams had been out three weeks. As we had no hay or straw available on the place we bought in thousands of bales of anything we could get hold of. This material ranged from good pea and H.1 straw down to oat straw.

Nuts are also fed in some years to the ewes about three weeks before lambing, depending on the amount of greenfeed available. If the amount of greenfeed is in short supply I would sooner step up the supply of nuts and reserve the greenfeed until the ewe has lambed.

During the winter of 1954 we kept 400 wethers on a very bare paddock on a ration of 2 ozs. of nuts per day and three quarters of a bale of very poor hay per day (it was browntop with a little lucerne sprinkled through it). These wethers came out of the wool very well and the wool was in excellent order. They required very little finishing off on greenfeed and the report from the works was that they were an excellent line, with the right proportion of fat to lean.

During a dry pinch we have fed nuts to hoggets with lambs at foot. Being hoggets I did not want them to be dragged down too much by the lambs, and they came through very well until the feed came away in sufficient quantity.

My next experiment was to try to creep-feed some lambs. This was not a success owing to an abundance of grass, but I think it could be done during a dry year.

A friend of mine has fed his ewes nuts from the air. He has his own plane and owns two farms 14 miles apart by road. His method of starting the ewes was to drop the nuts on to a line of hay.

I often fed nuts to lambs fattening on rape or some other supplementary crop. Whether I feed nuts or not depends very largely on the way they are fattening.

Now as to the economics of feeding concentrates. The cost is a good deal cheaper than other foodstuffs in the form of bought-in hay you can bring on to the farm, or turnips or grass which you take your sheep to off the farm. In years of shortage, hay, turnips or grass are usually fairly dear, but the price of nuts is reasonably constant. Besides this you are bringing somebody else's fertility on to your farm. At £35 per ton, the cost of feeding 2 ozs. per day is 5½d-6d per week, or under 1d per day.

Wheat or barley can be worked out in the same way. Wheat at 12/- per bushel, feeding ½ lb. per day, works out at 1.2 pence per day. Barley would be cheaper. But pure grain is dangerous to feed on its own as some sheep gorge themselves. I have lost sheep on grain but never with nuts. Nuts are a balanced ration whereas grain in itself is not.

Providing the cost of these nuts is kept at a reasonable figure the venture is economically sound and a definite asset in times of shortage.

My sheep numbers have steadily increased until at last shearing 3,765 sheep were shorn. They comprised 2,448 ewes and 1,327 dry sheep. In addition to the above, 810 replacement ewe lambs were shorn. The total wool clip was 128 bales of a total weight of 41,500 pounds.

Question: How do you get on with sleepy sickness with the ewe flock when you feed so much dry feed?

Mr Wright: I get on very well. We have always some sleepy sickness, but provided the ewes get plenty of exercise they are alright. If they are not getting sufficient green feed I step up the supply of nuts.

Question: Have you any experience of different types of nuts?

Mr Wright: I have only tried one type. Provided the composition is reasonable I do not see why there should be anything the matter with any type.

Question: You have about 300 acres of turnip, roots and green feed and 150 acres new pasture, that is about 450 acres under cultivation a year and 2,500 ewes have been mentioned. How many tons of nuts do you feed in a year?

Mr Wright: We do not use them every year. After the drought we used 40 tons the following winter. In regard to hay we feed fairly large quantities. If we've got hay we use it. I have tried to build up a reserve of hay so I do not have to depend wholly on nuts.

Question: Have you any experience with ill-thrift in lambs with the feeding of concentrates?

Mr Wright: None whatsoever.

Question: You have had a big increase in wool on the place and there must be a big increase in the number of lambs?

Mr Wright: For the last five years we have been breeding our own replacements, before that we bought in. From the 1949/50 season to the 1956/57 season the number of lambs sold increased from 1,845 to 3,917. Some of these lambs were bought-in wether lambs.

RECENT DEVELOPMENTS IN PRODUCTION OF SUPPLEMENTARY CROPS

A. F. Greenall, Otago Catchment Board
(Previously Crop Research Division, D.S.I.R., Lincoln)

Supplementary crops may be defined as annual forages which are sown to provide feed at a time and of a kind not usually available from pasture. With few exceptions, those grown in the South Island may be grouped under three headings, Brassicas, Cereal Greenfeeds and Lupins. The Brassica group includes swedes, soft and yellow turnips, rape, chou-moellier and kale, and are the most important. Wheat, oat, barley and ryecorn varieties are sown for cereal greenfeed which occupies an average area of 50,000 acres, half of which is grown in North and Mid-Canterbury. Lupin varieties occupy only a small acreage between Christchurch and Timaru, but there is a potential for much greater use.

Developments in the production of these forages come from the introduction of breeding of new varieties, from selection within existing ones and from a better knowledge of their growth requirements and a better understanding of the way in which these can be obtained by improved husbandry practices. As well, improvement may be obtained by finding the best methods of utilising forages and by matching their food value against the nutritive requirements of the animals for which the feed was grown. The main criterion of success in production of supplementary crops must inevitably be the level of animal production they can support.

If I am not to exceed the time allotted, my contribution must be confined mainly to some results of work at Crop Research Division.

Rape and Sweet Blue Lupins

Lambs in store condition at weaning were once fattened mainly on rape. Though in recent times increasing use has been made of lucerne for lamb fattening, rape has stood the test of time and is still grown extensively in spite of blight and low yields in dry seasons and of scouring, slow fattening and scald under wet conditions. A mixture of rape with Borre sweet-blue lupin shows considerable promise of overcoming some of these problems, at least in Canterbury (Greenall 1956). This mixture should be sown at the rate of 1¼ lb of rape and 1 bushel of Borre lupin. The rape should be mixed with reverted superphosphate, or its equivalent and drilled in the same row as the lupin sown through the grain box. In several experiments at Lincoln followed last year by eight block trials on farms in Canterbury, the mixture yielded an average of 30 per cent more than rape. This yield increase together with digestibility studies (Allison and Thurston, 1952; M. J. Crampton, 1957) and grazing experiments at Crop Research Division and one rate-of-liveweight-gain trial carried out in co-operation with Canterbury Agricultural College permit the conclusion that the mixture is likely to be 20 per cent better on the average than rape. Feeding off should commence as soon as one component of the mixture is ripe for grazing. This condition is well known for rape, but for lupin it is at the early green-pod stage when lower leaves are just commencing to drop. Earlier grazing of lupin does not permit full development of dry-matter yield. Later, grazing runs the risk of lowered digestibility due to the rapid increase of fibre content.

Results of experiments in districts other than Canterbury have been inconsistent and there have been one or two reports of unpalatability though in my experience the mixture is preferred to rape.

Aphis-resistant Rape Hybrids

The problem has been attacked in another way by Mr Palmer of Crop Research Division. Using swede-turnip parents as a source of aphis resistance, he has bred rape x swede hybrids resistant to blight. Several field trials were carried out last season by him in co-operation with the Department of Agriculture, and it is evident from the results that he has produced a valuable addition to our rape varieties. At least three of the hybrids out-yielded B.L.E. II under blight-free conditions; they were very palatable and their recovery after grazing was good. An acre of each of the three best has been sown at Crop Research Division to provide seed for farm sowings in 1960.

Problems of Fattening Lambs on Rape

Slow fattening and scald of lambs on some rape crops on heavy land or in wet seasons have also received attention. While it is a popular pastime of some farmers to blame New Zealand-bred varieties for poor fattening, I am of the opinion that this is more the consequence of the progressive build-up of soil nitrogen levels in recent years.

In two experiments we found that additional water and/or nitrogen considerably delayed ripening and substantially reduced the dry-matter percentage of rape varieties. Lambs eating this immature rape scour and may also be physically unable to eat sufficient dry matter to make good gains in weight. We have, however, been unable, by using additional water and nitrogen, to induce conditions favouring nitrite poisoning which is often blamed for fattening trouble on rape. Admittedly, there was luxury uptake of nitrogen by the rape with a consequent doubling of normal nitrate content. This level was, however, much lower than is usually considered necessary to cause nitrite poisoning.

Yield Responses of Rape to Nitrogen and Water

The application of an additional eight inches of water from spray irrigation increased the dry matter yield of rape by 70-100 per cent. Where there was adequate soil moisture, good yield-responses resulted from the use of nitrogenous fertilisers. However, the yield of short-rotation ryegrass, sown after the rape was cut and discarded, was lower where nitrogen and water had increased the rape yields. Club-root-resistant rape yielded poorly under dry conditions but with water its yield was as good as other varieties. It seems that the use of this variety should be confined to club-root-infected soils or to districts of high rainfall. Broad Leaf Essex rape was the variety that responded best to high nitrogen levels. The response to nitrogen was dependent on adequate soil moisture.

Utilisation of Rape by Sheep

We have found that normal practices used to fatten sheep on rape were accompanied by a lower utilisation of poorer-quality feed than was anticipated. Only about 60 per cent of the rape grown was used. While there is theoretically scope for improved utilisation by devising better management systems, most fattening sheep, unlike cows, can, in my opinion, be over-managed. Lambs in particular are sensitive to disturbance and the effect of a system designed to improve utilisation could be offset by a resultant slower rate of fattening.

Lupins

Varieties of sweet lupins previously available had defects such as hard seed coats with slow emergence, slow early growth or low seed yields with consequent high cost of seed sown. Borre, the sweet-blue variety introduced from Sweden, has none of these faults and in many experiments it has not only out-yielded other sweet varieties of lupin (Van Steveninck, 1956) but also rape. It should be used in place of other sweet varieties of lupin, preferably in a mixture with rape but, failing this, by itself, particularly on dry soils. Mr Van Steveninck, who is in charge of lupin breeding at Crop Research Division, has also bred a Sweet White x Bitter Pink hybrid which is sweet and which is in advanced yield trials and may be superior to Borre.

Soft Turnips and Lupins

Experiments to find if mixtures of soft turnips with Borre lupins yield better than either grown separately have also been carried out. A mixture of this kind is, of course, already used by some farmers, but by replacing N.Z. Bitter-Blue lupins by Borre the slowness with which young sheep begin to graze lupin may be overcome. While enough experiments have not yet been completed to advise with conviction, there are already indications that the mixture is higher yielding. Furthermore, the addition of lupin to soft turnip is a very good insurance against complete loss of many turnip crops recently caused by cauliflower and turnip-mosaic viruses.

We have also noticed that lupin ground comes up in better order than either rape or turnip ground. Miss Austin, Soil Physicist attached to Crop Research Division, has made one series of soil analyses, the results of which support these observations.

Cereal Greenfeeds

In a country over most of which ryegrass and white clover are the main pasture species and where one wheat variety occupied over 80 per cent of the total wheat acreage, it is refreshing, if a bit puzzling, to recall the twenty or so varieties of cereal greenfeed in use. This number is to some extent explainable by the large number of types of use which, from a survey completed, about four years ago, can be grouped into seven classes. Habit, availability of seed, differences in soil and climate and the difficulty of measuring forage yield of cereal greenfeeds and, hence, of determining the best varieties also offers a partial explanation for the large number of varieties used.

Much of our work on cereal greenfeeds was aimed at finding ways of measuring the animal-producing capacity of different varieties and the effect of crop-husbandry practices. By far the largest acreage is sown at the end of the rotation after a grain crop and before a summer fallow for weed control and moisture conservation prior to sowing in permanent pasture. Crops are usually grazed several times, mainly by sheep, from autumn to spring, and are managed as special-purpose pastures. It is clear from our work that the forage yield of varieties, for example, Winter Gray oats and C.R.D. ryecorn, behave quite differently under a mowing method of measuring yield than under a hand-cutting method or a grazing method. Even yields determined under a grazing method are not necessarily good measures of carrying capacity or of weight gain. Sheep eat more dry matter of C.R.D. ryecorn per day probably because of its higher dry-matter percentage; consequently, the same yield of dry matter carries less sheep but their intake above maintenance is higher and consequently they put on more weight.

Sowing Times of Varieties

Cereal greenfeeds may be sown from November until April. However, only a few varieties will not flower if sown early until they have gone through a cold period. Dreadnought wheat and Wong barley are probably the best to use. Dun oats is all right at Lincoln if sown no earlier than December. When sown in November, Dreadnought wheat and Wong barley have yielded by the following August over 7,000 lb of dry matter per acre and have produced well in February, March and April which are often critical months for feed for dairy cows in some parts of Canterbury.

Most other varieties will flower if sown before Christmas and not grazed. So care must be taken to select a variety suitable for the time of sowing. For late sowings, the barleys are usually best. While the varieties Cape and Black Skinless are the most commonly used, Research produces very well though its yield may not be well sustained. Wri-Yielder wheat also produces well, even when late sown.

Varieties to Use

It is risky to generalise about the yield of varieties, however, as one needs to know the type of soil, climate, the time when feed is needed as well as the type of stock and intended grazing management. From a study of the experimental results available, I am of the opinion that one or other of the following varieties best suits the range of conditions and uses of the South Island.

Ryecorn . . .	C.R.D.
Oats . . .	Winter Greys—Gartons
Barley . . .	Cape—Research—Wong
Wheat . . .	Dreadnought—Wri-Yielder

Response of Cereal Greenfeeds to Nitrogen and Clovers

Because of their position in the rotation, cereal greenfeeds are often sown in soils low in available nitrogen. Yet these crops are expected to make good initial growth and recover well after grazing during the period of low soil temperature when the nitrification rate is low. Consequently, responses to nitrogen would be expected and have been examined. As clovers are recognised as the most economical way of supplying nitrogen in New Zealand, the effect of their inclusion in a mixture with cereal greenfeeds has been investigated. Four experiments have been completed and in two of these where broad red or crimson clover established well, their addition increased yield by about 500 lb of dry matter, equivalent to the average response from 1½ cwt of sulphate of ammonia. In the remaining two experiments there were only slight increases in yield. This is thought to be caused by failure to establish a good clover stand because of dry conditions, combined with the use of a technique which did not provide for the return of urine from the animals grazing the nitrogen-rich clover-cereal mixture. Whenever greenfeed is being sown early in a moist climate or year, broad red clover should establish satisfactorily and, in my opinion, a worthwhile benefit to yield should be obtained. In addition, good crops of cereal-clover hay have been grown for harvesting in the October/November period.

In several experiments, first at Crop Research Division and then on co-operative experiments carried out by the Department of Agriculture on farms, there have been good responses to nitrogen fertilisers. The application of 1 cwt of sulphate of ammonia or nitrolime has increased dry-matter yields by an average of 3½ cwt per acre. This is an economical response for out-of-season greenfeed. In some cases, an additional 1 cwt of nitrogen fertiliser has given the same yield response as the first 1 cwt. The response pattern for nitrolime has been different from that of sulphate of ammonia. Applied at sowing, sulphate of ammonia has given an immediate response which disappeared within three months. The response to nitrolime was less marked but more sustained. With April applications, the two have behaved similarly, their effect being mainly to increase late winter and spring growth.

Seed Rates

Most farmers will have noticed the additional early growth where greenfeeds have been double drilled and may have attributed this to extra fertiliser. We have found that increasing the seed rate results in a much higher yield, at least to the stage where plants are beginning to compete with each other. Beyond this time, seed rates above normal have little effect; in fact, with some varieties poor recovery or death may occur unless management aims at early, frequent and light grazing. In dry seasons, when feed is urgently needed, heavier seed rates should be used. In normal seasons, the increased yield from heavier-than-normal seed rates may barely cover the cost of additional seed and the more careful management required to maintain a dense stand.

Time of Sowing and Interval between Grazing

The results of experiments investigating time of sowing and interval between grazing show that delays in sowing cause yield losses out of proportion to the time involved. For maximum yield after a grain crop, sowing should be made as soon as a suitable seed bed can be prepared.

With most greenfeeds, except the dense prostrate ones, increasing the interval between grazing will increase the forage yield, but the nutritive value of this will be lower. Cereal greenfeeds grow at a maximum rate for a much longer period than grasses before the growth rate falls off. However, unlike most grasses their ability to recover from grazing may be reduced considerably by an overlong period between grazings, particularly if close-grazed. The decline in feed value may become rapid because of an increase of crude fibre and decrease of crude protein.

Recovery of Cereal Greenfeed

With many varieties poor recovery or even death of plants after grazing is responsible for poor and unreliable yields. C.R.D. ryecorn is one of the best and Garton oats one of the worst varieties in this respect, but the recovery behaviour of all varieties is thought from our experiments to be influenced by several factors—seed rate, soil moisture, soil nitrogen, closeness of grazing, stage of grazing, length of grazing period and grazing when growth is at a standstill following rapid growth. It is thought that these conditions reduce root reserves to a level critical for continued survival in rigorous conditions, but experiments to study this are still under way.

I am of the opinion that methods of grazing management for highest yields of cereal greenfeeds may be much less flexible than previously thought, except perhaps for prostrate, dense-tillered varieties such as C.R.D. ryecorn. The evidence of experiments to date points to the highest yields of greenfeeds of satisfactory feed value being obtained by grazing off the top few inches of a crop at frequent intervals. This has yet to be proved conclusively and a grazing system devised to achieve this. Frequent, light grazings for short intervals by high concentrations of sheep may be the best method, but the degree of loss by tramping and dirtying would need to be watched.

Diseases of Cereal Greenfeeds

In some seasons in some districts leaf-rust infection is severe on susceptible varieties such as C.R.D. ryecorn and Dun oats. Our experiments have shown that an infection of normal severity reduced forage yield by about 25 per cent. Furthermore, sheep find rust-infected greenfeed unpalatable. However, the rust-infected forage contained more protein and less fibre which implied higher nutritive value (Greenall, 1957). This suggestion of higher feed-value was largely confirmed for guinea-pigs by Hall (1955) who used Dun oat forage grown by us. He could not find evidence of a short-term toxic effect; in fact, everything pointed to leaf rust improving feed value, at least for guinea-pigs. This does not prove that sheep will thrive better on rust-infected forage as their digestive systems differ from guinea-pigs. However, I am satisfied that leaf rust reduces the yield and palatability of susceptible cereal greenfeeds. This, in turn, is likely to affect adversely daily intake of dry matter, carrying capacity and weight gain. The loss is probably large enough to justify the use of control measures either by developing or using rust-resistant varieties or by grazing management. If grazing begins when pustules appear and is rapid and hard, the supply of spores for continued reinfection is largely cut off.

We have also found that mildew may cause severe yield reduction or even death of susceptible barley varieties. Where mildew is prevalent, varieties such as oats which are not susceptible should be grown.

C.R.D. Ryecorn

Continued selection and progeny testing of this variety has led to an increase of about 15 per cent. in forage yields as well as a small increase in seed yield. This has been obtained without losing the desirable features of this variety.

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Question: In view of the diseases in soft turnips Mr Greenall suggested including Borre lupins. What rate of sowing do you advise for the lupins?

Mr Greenall: In our type of work we have endeavoured to adjust seeding rates of the soft turnips and of the lupin so that we get a 50 per cent. stand of lupins and 50 per cent. soft turnips. This cannot always be obtained with certainty. If conditions are wet, soft turnip may germinate only about 40 per cent. We suggest 8 oz soft turnip and 1-1¼ bushels Borre lupin.

Question: Most discussions have been on a basis of comparison of dry matter produced per acre. Shouldn't we compare palatability too? We have had a lot of trouble in the past through reliance on bulk of dry feed produced per acre. What we want to know is how much wool, meat and milk is produced off live animals per acre.

Mr Greenall: I think a good deal has been achieved in doing just what Mr Little mentions in respect of pasture work at Ruakura. Forage crops have been the poor relation and there is not the extent of ground available nor the staff to do the type of animal work on forage crops that you speak about. I have done sufficient to realise how necessary it is to do digestibility work and weight-gain experiments before reaching a final conclusion.

Question: Are the Borre lupins superior to bitter ones and what is a comparison of the cost?

Mr Greenall: In numerous trials in both islands the Borre lupin is almost identical as far as forage and seed production goes with New Zealand bitter blue. The cost of seed is considerably larger per bushel than New Zealand bitter blue; we expect that should its use increase, the price of seed to the farmer will fall to the same as the New Zealand bitter blue.

Mr Samson: I received some Borre lupin from the Department for a trial. I sowed Borre lupin and bitter lupin in alternate drill widths. When I turned the sheep on they chose Borre, eating it right down to the ground and leaving the bitter blue standing.

Question: Is the Borre lupin any more resistant to frost than the blue?

Mr Greenall: I have not heard that it is any more susceptible to frost injury. I think it is pretty well identical.

PASTURE ESTABLISHMENT WITH THE AID OF CHEMICAL WEEDKILLERS

L. J. Matthews, Weeds Research Officer, Department of Agriculture.

I do not propose to talk on the "pros" and "cons" of supplementary feeding but to outline the possibilities of establishing pastures and crops without resorting to conventional methods of cultivation. The east coast farmers of the South Island are noted for being wed to cultivation. What I have to say may sound like rank heresy.

Over the past five years officers of the Extension Division of the Department of Agriculture have accumulated considerable evidence to show that pastures and some crops can be established without prior cultivation. Most of the evidence has been accumulated in the North Island where cultivation is not featured to the same extent. Well over 50 trials and demonstrations have been conducted to date.

Technique for Pasture Establishment

One or two specific weedkilling chemicals are used to destroy the existing species. Under normal conditions the area is oversown the same day or several days later. The weedkilling chemicals used should be varied according to the species present. Let us take examples. If the area is dominantly browntop with the odd trace of Danthonia or chewings fescue, a rate of 5 lb dalapon per acre has proved satisfactory. If the area contains more than a trace of Danthonia, chewings fescue or sweet vernal, 1 lb of amitrol should be added to the dalapon. If the area is dominantly chewings fescue, a rate of 10 lb dalapon plus 2 lb amitrol may have to be used. Areas that have had some previous topdressing usually contain a percentage of clover. Most of this clover is sure to be annual clover and poor strains of white clover. This clover has been found to be quite a competitor to grass establishment. It can either be checked with the dalapon/amitrol mixture above or eliminated by the addition of 2 lb 2,4,5-T to the dalapon. Many other examples could be taken but suffice it to say that each area should be tackled on its own merits and one or more chemicals applied accordingly.

It sounds easy enough to call in an aeroplane and apply the weedkillers, seed and fertiliser from the air, but as for other agricultural practices many factors have to be considered.

Correct Manurial Requirements

We have been brought up in the belief that for hill country too steep to be cultivated, pasture improvement is a gradual process. Initial applications of fertiliser usually increase the clover percentage but it is only after many years that low-producing grasses are partially replaced by high-producing grasses. With the chemical method, high-producing grasses and clovers are introduced at the same time. It is essential then that the correct fertility requirements of the particular soil type are known and met. If anything, fertiliser application should be liberal. Inoculation problems should be taken care of if they exist.

Seeding Rate

If all existing vegetation cover is destroyed a full seeding rate should be employed. A seeding rate of 15-25 lb has proved satisfactory provided all other factors have been considered. Usually the seeding rate is of less importance than other factors such as correct manurial requirements.

Length of Herbage

This is an important factor. Seed will not survive after germination on dry, bare soil. Under adverse climatic conditions there should be a complete ground cover of dead litter at the time of oversowing. Under dry conditions dead sparse litter 3-6 inches high is not considered excessive. Under moist conditions, litter an inch or so long has proved satisfactory. If the litter is excessive a period of decomposition should take place before the seed is sown. This has proved necessary for tall fescue, sedge species and Nassella tussock. It may also be necessary for rank browntop or chewings fescue that has not had previous topdressing. Local experience is necessary but the seed, if anything, should be sown early after chemical application rather than letting too long a period elapse. This is particularly so if the area has been previously topdressed.

Time of Sowing

This depends on local conditions. Most grasses are more readily killed in autumn and early winter months. Oversowing at this period in general has been more successful than spring oversowing.

Comparison with Normal Cultivation

The trial and demonstration areas so far conducted show that the two essential requirements of cultivation are met—that of removing inter-plant competition and preparing a seed bed. Inter-plant competition is more readily removed with chemicals than with cultivation. Dead litter has proved a suitable seed bed. In fact the germinating seedlings are protected by a micro-climate and do not suffer rainwash, wind blow or desiccation or even frost damage to the same extent. In many areas spring sowing of pastures is not practised owing to excessive weed growth. With the chemical method, germinating weed growth has never proved a problem except once when the seed was not sown for 20 days. Existing weeds, depending on the type of weed, if not destroyed do create a problem. Flatweeds are no problem. Ragwort and Californian thistle would create a problem if not dealt with (1 lb amitrol in the mixture will control these).

Few data are available comparing pasture establishment by cultivation and pasture establishment by the chemical method. It is known that the best soil structure exists under a pasture. This structure is destroyed, worm population is decreased and surface nutrients are turned under by cultivation. Further, only one-third of the agricultural land in New Zealand can be cultivated either by giant discing or ploughing. Cultivation either by giant discing or ploughing is considered more costly than the chemical method. The land is probably out of production for a longer period although, on low-fertility land, improvement by the chemical method usually requires a period of 6-12 months before full establishment is complete. One criticism is that with the chemical method in low-fertility areas a mono-type sward is not produced. Usually a small percentage of browntop and *Poa trivialis* will survive but die out with gradual sward improvement.

Comparison with Overdrilling

Overdrilling is successful where inter-plant competition is nil or slight. It has the advantage that seed and fertilisers are placed together. It has the disadvantage that quicker-establishing grass species tend to compete with the establishing clover. In high-producing clover-dominant areas it has proved advantageous to check the clover with a weedkiller before overdrilling high-producing species. Where inter-plant competition is severe overdrilling is not successful. Data are available comparing overdrilling into a chemically destroyed turf with broadcasting into a destroyed turf. The work done to date indicates that the species drilled into a destroyed turf establish more quickly than when broadcast but a more balanced pasture results from broadcasting. Even in very dry areas, successful establishment has occurred where the chemical method has been employed. Further there is some indication that insect damage is more severe in areas overdrilled than in areas chemically treated. The same seems to apply to damage by slugs.

Comparison with Normal Oversowing

In general, normal oversowing is not over successful. Small-seeded clovers tend to strike and establish. Large-seeded clovers and grasses usually do not establish well, particularly under low-fertility conditions. Fertilising low-producing areas usually increases the percentage of clover but does not materially increase the percentage of desirable grasses. With the chemical method both grasses and clovers have established well and produce balanced swards.

Other Aspects

On the same soil type where production has been raised at least four times by oversowing after chemical application in trial work, one farmer spent £83 on three acres having the area regularly gian disced prior to sowing the pasture. Another farmer bought 800 acres of the same type of land on the same soil type for a sum of little over £5,000. His next step was to purchase cultivation equipment at a price of twice the cost of the farm. This equipment is capable of cultivating approximately one-third of the purchase property. Admittedly he does a little contracting. An average figure for interest and capital depreciation per annum on equipment is 12½ per cent. If this figure of 12½ per cent. on capital equipment were spent on fertilising, seed and weedkilling chemical, over 100 acres of land could be developed annually. Another example could be cited of a new manager expending the sum of £30,000 on equipment to develop an 8,000 acre hill property. These examples may be isolated cases but the average capital cost of equipment for hill-country units of up to 500 acres is usually £3,000 to £4,000. Depreciation and interest more than equal a figure of £500 annually or sufficient to improve 25 acres of land annually by the chemical method.

Crops

I have not been asked to talk on crops but I would like to instance some of the work that has been done. On high-producing land no difficulty has been experienced in obtaining swedes and turnips either broadcast or drilled into chemically-treated turf. The technique is to supply sufficient weedkiller to kill all vegetation except possibly clover, say, 10 lb dalapon and 2 lb amitrol. Immediately after application the seed is broadcast or drilled (this is essential). Weeds are not a problem, the bulbs sit on top of the ground and mud is a limited problem when feeding off.

On poor-fertility land the problem appears one of fertility, particularly for broadcast crops. The applied fertiliser appears to stay on the surface and is not made available to the crop. Even so a swede crop of seven tons per acre (green weight) has been recorded after destroying a browntop/chewings fescue sward of 1-ewe equivalent per acre.

Practical Consideration

I have not laboured trial detail in this talk but tried to present an overall picture of the results so far obtained. I consider the method has broken the barrier between land that can be cultivated and land that can not. It even issues a challenge to cultural methods. Much further work is required to obtain knowledge of local conditions of soil type and climate on a New Zealand basis. To adopt the method with success a farmer probably requires a deeper knowledge than is necessary with cultivation. Before a farmer calls in an aeroplane or helicopter which are capable of spraying, seeding and fertilising an acre of land every five minutes, he should make sure that he knows the best time to oversow, the fertility requirements of the soil type he is to treat and have sufficient finance to fence the area and to purchase extra stock necessary. He should familiarise himself with the method before attempting large-scale work. It must be remembered that the chemical only aids the establishment of the seed. Full success will only be obtained by the proper management of the treated area.

Question: How much water has to be applied with dalapon per acre? I understand quite a lot which might make the cost of application higher. Have you any trials in the dry areas of Canterbury on the use of dalapon on browntop?

Mr Matthews: Fifteen to 20 gallons of water per acre is adequate provided the water is put on under pressure. Thirty pound pressure to the square inch through nozzles will give adequate cover. At the head of the Rakaia Gorge there are some trials but there is little competition from browntop and the chemicals have not proved as advantageous as elsewhere.

Question: How would you deal with barley grass around the fence lines, also nodding thistle?

Mr Matthews: The barley grass story is not a happy one in that the better the farmer the more likely he is to have barley grass. As we build up the fertility in New Zealand the more likely we are to get barley grass. The best chemical treatments to date are T.C.A. 15 lb in late autumn or early winter months and dalapon applied in early spring months at the rate of up to 1 lb per acre. Dalapon is toxic so do not put on too much. Nodding thistle is on the increase as we build up fertility. We must resort to chemicals I think and the best control is to spray very early in the autumn or after germination has taken place. Do not let nodding thistle get too big. N.C.P. 214 at fairly low rates is good provided you get in early enough. Control measures should be practised on seedlings, not when in full flower.

Question: What is the approximate cost of material for a complete kill of a browntop sward before the sowing of the grass?

Mr Matthews: If the application is made in the spring 5 lb dalapon per acre is usual; the cost of the material at wholesale rates for packages of 50 lb is 10/-, say, about £2/10/-. If putting on in late autumn you can get a kill with 2 lb dalapon per acre, say, about 30/- to £2.

Question: Is there any sign of residual effects of dalapon on young germinating grass?

Mr Matthews: If you apply dalapon and get a period of dry weather, even a few hours, say, 10 hours, it is fairly safe and you would never notice a residual effect. If you apply the dalapon and it rains immediately and is all washed off into the soil, and you are sowing the seed at the same time, then a residual effect would be noticed. When applying material do it on a fine day; if it does rain before you have finished the application, do not sow seed for several days or a week. Dalapon is not as toxic in the soil as amitrol, but even after rain amitrol does not harm the seed to any large extent. The cropping side is fairly safe. With grass species watch for rain.

DRY-ROT INVESTIGATIONS

Harvey C. Smith, Plant Diseases Division, D.S.I.R., Lincoln.

Although Dry-Rot disease will affect many Brassicas such as soft turnips, rape, kale, chou moellier and even the wild turnip it causes serious damage only to swedes.

Southland and Otago are the only two provinces where Dry-Rot disease causes serious losses and uncertainty in the swede crop, so this talk will be of particular interest to farmers from there. However, I shall try to make the talk of fairly general interest as it is a good example of the work which is carried out by the Plant Diseases Division on other field crop diseases.

Now there are two main reasons why Dry-Rot is a serious disease in Southland and Otago. First, because there is a very large acreage of Brassica crops grown there and, second, because this area has a fairly high rainfall. Dry-Rot disease occurs throughout Canterbury but is rarely serious because there are few swede crops grown and the climate is usually fairly dry. As far as the North Island is concerned Dry-Rot used to be a serious disease, but more recently, the area of swedes grown has declined greatly, and the disease has consequently declined in importance.

Thus we can learn from the North Island that the first obvious control for this disease is to cease growing swedes. This control would not be acceptable in Southland, however, because although a few farmers in Southland have been able to winter their stock without a swede crop, the great majority still rely on swedes and it is mainly for these farmers that we have been carrying on the research work on Dry-Rot disease.

The Research Programme

There are four lines of research which have been followed to find the best control.

1. First, there is the investigation of seed infection. This was first shown to be of importance by Dr. G. H. Cunningham, the first Director of Plant Diseases Division.

2. Second, there is the study of the life history of the Dry-Rot fungus. In this work we were primarily concerned with the survival of the fungus after the swedes have died until the new crop was planted. This obviously is the weakest link in the survival of many crop diseases, and control of many diseases can be achieved by attacking the fungus at this stage. This work led to the discovery of the windborne spores arising from old Brassica crop residues, which included swede, turnip, kale, chou moellier, rape and wild turnip and showed that this disease was more difficult to control than we had previously realised.

3. Third, we had to investigate the possibility of finding varieties of swedes which were more resistant to Dry-Rot and which would grow and give a good crop even where the disease was severe.

So far we have found a few varieties which have fairly good resistance and it look as though the plant breeders may be able to make some of the existing varieties resistant by crossing them with the best resistant ones we have.

4. Last, the possibility of controlling Dry-Rot with chemical sprays or fertilisers has been investigated. The first trials with fertilisers were tried in the 1920's by Mr Cockayne but it was decided that no worthwhile benefit could be obtained. The first spray trials

were at Balclutha in 1955 and these did not give much promise of control either, but because the work was largely exploratory further trials were continued in succeeding years.

The different lines of investigation will now be discussed in more detail and the more important results and applications given.

Seed Borne Infection of Dry-Rot

All Brassica crops may be infected from seed. With turnips and swedes the infected seed will directly cause Dry-Rot in the crop; but with kale, chou moellier and rape the seed infection causes "black-leg", i.e., Dry-Rot infection at the base of the stem. This "black-leg" later develops into the wind-borne spore stage of the Dry-Rot fungus, on the old dead stem residues and is responsible for the long distance spread of the disease. I do not think seed infection in mustard is quite as important as that in the other Brassicas because these plants do not usually form very persistent residues such as occur after chou moellier or kale.

Now you may well ask what has been done to control the seed infection. Well, ever since New Zealand has been growing its own swede and turnip seed the Government-approved lines have been tested by the Plant Disease Division for Dry-Rot infection; and usually these Government-approved lines of seed have been found to be free from infection or have very little infection in them. The Seed Testing Station also is now testing all certified crops of chou moellier, kale and rape for seed infection, because recently after the wind-borne spore stage had been found on the chou moellier residues, we turned our attention to chou moellier and kale seed and found that many lines of these also carried infection. In the first tests we tested only 200 seeds from each sample and found three infected chou mollier seed lines in about 20 tested. When the infected seed was sown in sterilised soil, the young seedlings became infected with Dry-Rot. These results gave proof that chou moellier seed could spread Dry-Rot disease, so the next year further tests were continued and this time 1000 seeds from each line were tested. One thousand seeds were tested because in the previous tests only a few seeds were infected in the 200 sample. The results from these tests showed that there were again a large number infected with Dry-Rot. Again there were quite a few samples with only a small number of infected seeds so it was decided to test an even greater number of seeds. The present tests are done on 5000 seeds and this gives us a much better assessment of the different severities of infection.

The importance of taking a large sample to test for infection is obvious when you consider the number of seed sown per acre. For example, with 2 lb of chou moellier seed per acre there are about 200,000 seeds sown. Now if there is an average of only one infected seed per 1000 this means that 200 seeds infected with Dry-Rot are sown per acre. A fewer number of swede seed is sown. Ten ounces give approximately 100,000 per acre and at the same rate of infection (1-1000) means that 100 infected seeds are sown. Even allowing for infected seeds not germinating this level seems to be the maximum which could be permitted, so one in 1000 has been decided as the limit of tolerance of seed infection. Trials are at present in progress to determine the practical significance of Dry-Rot seed infection. The first trials with chou moellier seed sown in a swede crop has shown that the amount of "black-leg" infection in chou moellier in the field, is directly related to the level of infection in the seed. It also showed that hot-water treatment combined with chemical dusting of infected seed controlled the seed infection and prevented field Dry-Rot. One line of chou moellier seed which had been found clean in the laboratory test was also quite free from Dry-Rot when sown in the field.

This trial has not yet been completed because we still expect to get information on the spread of Dry-Rot from the infected chou moellier plants.

We are accumulating a large amount of information on the amount of Dry-Rot infection in all lines of Brassica seed and are carrying out trials on the possibility of controlling Dry-Rot with seed dusts.

It is hoped that eventually an easy test for Dry-Rot in seed will be developed and that disease testing will be carried out in addition to purity and germination. The sowing of healthy seed will thus also help in the control of Dry-Rot. The alternative course of importation of healthy Brassica seed from Australia was examined but a visit to the most likely areas in Australia showed that Dry-Rot was present on the seed pods even where the annual rainfall was only 14 inches. This pod infection had apparently been spread by insects. Thus it looks as though the best way to ensure healthy seed in New Zealand is to grow our own under certification.

The Second Major Part in the Dry-Rot Work is a Study of the Life-history

(Illustrations were used to show the following points.)

1. Represents the typical Dry-Rot infection of swede. On swede the fungus causes a leaf spot (not usually conspicuous) and a bulb-rot. It is the bulb-rot that is responsible for the greatest economic loss from this disease.
2. On chou moellier there also occur leaf spots and "black-leg," i.e. infection at the base of the stem. Neither of these infections cause serious disease in chou moellier. The main importance of this infection is that it provides additional sources of infection for swedes.
2. Also shows the spread of infection from the first infected bulbs in the paddock.
3. Here one spore-producing stage of the fungus is shown magnified. The spores produced by this fungus disperse in water.
4. They are readily spread by slugs and rain.
5. This shows how slugs spread infection in the seed crop and shows a seed pod infected with Dry-Rot.
6. Here the old residues and dried up stems, bulbs and roots of previous Brassica crops are shown lying on the ground.
7. Shows a magnified drawing of the second type of spore. This develops on the old residues and can travel quite long distances by air and infect the leaves of Brassicas.
8. This shows the two methods by which young swede plants may be infected, i.e. by seed infection and by wind-borne spores from residues.

These are all the present known stages in the life history of the Dry-Rot fungus.

A study of this life history shows that for Dry-Rot control we must **use healthy seed,** and take special precautions to eliminate residues from other brassica crops. The windborne spore stage has been found on old dried stems and roots of chou moellier, kale, rape, turnip, and swede, so after growing all these crops they should be fed off as thoroughly as possible, and, in particular, all stemmy residue should be either ploughed as deep as possible or harrowed and burnt.

As a matter of interest you may like to know how and when these windborne spores are released from the residue. The mechanism is quite simple. The spores are all held tightly in their containers until there is a shower of rain or heavy dew. Then provided they do not dry out, the spore containers swell, the top opens, and each spore is shot out in succession into the air. I have observed that in still air the spores only travel a very short distance but if there is a wind they may be carried hundreds of yards and probably even for miles.

I have so far proved that the spores will travel 200 yards by catching them with a spore trap, but as yet I have not found the maximum distance that they will travel. However this is largely of academic interest because it must be readily apparent that the nearer the crop is to the source of infection the more spores that will land on it, and the sooner they will arrive.

Therefore, the most important source of Dry-Rot from residue is on **your own farm** and the second most important source is in your neighbour's paddocks. So it is a wise precaution to sow your swede crop as far as possible from paddocks which have recently been in other Brassica crops. Late sowing has also been found on many occasions to reduce the Dry-Rot. This is probably due to a delay in primary infection and shorter time for spread.

Quite commonly in Southland I have found in swede crops abundant dry-rot infection which has only had to "jump the fence" from the adjoining paddock which had chou moellier the previous year. These chou moellier residues had not been ploughed in but just lay on the surface, producing Dry-Rot spores. There are probably good arguments against ploughing after rape, chou moellier, kale, and swede crops but I do not think that adequate control of Dry-Rot will be achieved unless ploughing after Brassica crops becomes general practice. The common practice of sowing rape with grass is another bad feature of farming in Southland. The rape invariably becomes infected with the Dry Rot fungus and then after the rape plant dies there is no way of getting rid of this residue, which will continue to spread airborne Dry-Rot spores for about a year. If rape is required it should be sown on its own, or with another Brassica, but never with grass if Dry-Rot is a problem. You will probably hear the next two speakers also condemn this practice of rape and grass because the rape can harbour other pests and diseases apart from Dry-Rot

The Search for Resistance to Dry-rot in Swedes

This work has been in progress for about four years and in that time we have not made very rapid progress. The search for resistance among the varieties at present grown in New Zealand was commenced by Mr Cruickshank and Mr Palmer, and they found that one variety N.Z. Wilhelmsburger had much more resistance than other varieties, but it could still become severely infected under some conditions. Wilhelmsburger is a very late variety with a green top, so is not liked by many farmers. Therefore a breeding programme at Crop Research Division was started to transfer the resistance of Wilhelmsburger to Grandmaster, which is a more popular purple-top variety.

The second search was made among overseas varieties last year by inoculating 150 bulbs in each of about 90 different strains and varieties and then counting the number of bulbs which remained healthy. In this trial we found that another two varieties, Doon Spartan, and Cullen's Perfection were as resistant as N.Z. Wilhelmsburger. We also found that N.Z. Crimson King was fairly resistant while the same variety imported from England had much less resistance. This result showed that it was quite practical to increase the resistance of the present New Zealand varieties and that there were possibly some varieties grown overseas which would be suitable for New Zealand. These three varieties are at present in trials in Southland and Otago and if they are satisfactory, they will be multiplied for general release.

The present method of selection is by injecting a large number of bulbs with a spore suspension of the fungus. The injector used is a commercial weedkiller injector called the "Killer Kane." This enables a rapid testing of the bulbs. The survivors from this inoculation are counted and the best selected for further multiplication.

Within about six years we should have available several different varieties with resistance to Dry-Rot.

The Final Line of Research is that Dealing with Sprays and Manurial Treatment to Control Dry-Rot

This work is described last because it has so far given the least-promising results. However our techniques of spray treatment are changing and it is quite possible that we will eventually find a successful method of chemical control.

The spray trials were commenced four seasons ago in 1955 at Balclutha before we knew that there was a windborne dry-rot spore; consequently the spray treatments were applied too late and there was no control whatsoever. The next year the sprays were applied with machines using low and high volume at Invermay, Gore, and Winton, and again no worthwhile control was achieved. Last year only one trial was laid down at Invermay using the latest type of low-volume sprayer. Here we also sprayed according to the weather and achieved some successful control. The sprays were applied frequently throughout the season but even so the control was only half effective. The present trial is at Crop Research, Lincoln, but no results are yet available.

There is quite a possibility that slugs and small insects are more important in spreading Dry-Rot than we have realised and consequently, in future trials we will have to see if the control of slugs and insects will also control Dry-Rot.

The other method of possible chemical control is by the use of fertilisers. Previous trials have been carried out comparing the use of reverted super with commercial turnip manures, but the results showed only a small reduction in Dry-Rot in the plots having reverted superphosphate. In this year's trials we have a comparison of two different rates of nitrogen and two rates of potash and hope to be able to find some differences here.

Conclusions

Successful control of Dry-Rot Disease in swede crops depends on the following:

1. Neighbouring farmers co-operating in eliminating all residues of previous brassica crops—particularly old roots and stems of chou moellier, kale, and rape.

2. The sowing of the best seed available (i.e. the Government Approved turnip and swede and certified chou moellier, rape and kale seed, preferably treated with seed dust).

3. Sowing swedes in new ground as late as possible and as far as possible from paddocks which have recently had Brassica crops to delay the appearance of airborne infection.

4. Sow at least one part of the crop with a more-resistant variety such as Wilhelmsburger.

5. Do not sow chou moellier with swedes or rape with grass. Keep these crops separate.

INSECT PESTS OF BRASSICAS

A. D. Lowe, Entomology Division, D.S.I.R.
Ashburton.

It is not possible to consider losses in winter forage crops without referring to insect pests, for these affect the crop not only by direct feeding, but also by the transfer of virus diseases.

Such crops are affected by insects at their three main stages—as seedlings, as growing or mature feed crops, and as seed crops, and though we might consider direct insect damage in isolation at each stage of the crop, it is necessary to look at the whole complex of winter forage crops if we wish to understand the activities involved in the spread of virus disease. For such a condition comes about through the activity of aphids, and in particular the grey cabbage aphid. It is necessary therefore to consider firstly insect damage as such, defining those pests which are responsible at each stage of the crop, and outlining measures necessary for their control, and, secondly, to try and assess the damage done by aphids both directly and in spread of virus diseases. Only when we have this whole picture can we understand fully the question of crop damage.

The following insects have been observed as damaging **Seedling Brassicas** under practical field conditions:

Springtails: *(Bourletiella hortensis* Fitch, *B. arvalis* Fitch, and *B. arvalis* subsp. *dorsobscura* Salmon). Though they may feed on other portions of seedling plants, their chief damaging activity, leading to the death of plants, is the eating of the growing point before the emergence of any true leaves.

Thrips: (Various species). These small insects rasp the leaf surfaces of seedling brassicas, leading to leaf distortion, sometimes quite severe, but rarely to the death of the plant.

Wheat bug: *(Nysius huttoni* White). This insect possibly with other closely related species, is recorded by Gurr (1957) as responsible for widespread death of young crucifers. It possesses sucking mouth parts, and damages plants from seedling stage to maturity by feeding at the point where the plant meets the soil surface. In very young plants the stem is weakened and becomes calloused and brittle, when it is easily broken by even light winds. In older plants there is considerable sap loss through the feeding punctures, and though most wounds callous over, secondary organisms occasionaaly rot the bulb, especially in areas of high rainfall. Death of the plants has also been observed from feeding when the bulbs are just forming. At this stage, where feeding is severe, the top-weight of foliage causes the plant to topple over and die. The young nymphs of this insect are wingless and of an orange hue. They are very small, and may collect unnoticed in numbers up to 12-15 per plant. Their chief enemies appear to be ladybirds, which cluster around the damaged area where feeding is taking place. This has sometimes given rise to the idea that the ladybirds are doing damage, since the small orange nymphs are visible only on close inspection of individual plants.

Weevils: The wheat stem weevil (*Hyperodes griseus* Hust.) is a general feeder on succulent plant material in the adult stage and has frequently been responsible for the death of seedling crucifers. Kelsey (1958) records the adults as present throughout the year, so this insect may do damage in almost any crucifer planting. It has been observed more particularly as causing death of rape plantings in Canterbury, and has been known to lay its eggs on seedling plants of this crop. The adult is a small hard-backed brown beetle a little over ⅛in. long, and is very similar to a second type (*Catoptes* spp.) responsible for exactly the same type of damage in seedling crucifers. Very little is known of the life-history of this second species, but since control measures are identical for both species, the actual identity of the species present in an infestation is not important to farmers.

Wireworms: Several species of wireworms including *Lacon variabilis* (Condêze) have been taken damaging young crucifers, their effect being most noticeable on very young plants, but still important up to an age of 10 weeks from sowing. These insects are normally found only when sowings are on paddocks out of old pasture. Plant damage occurs just below the soil, and in bad cases up to a dozen wireworms of various ages may be found attacking the root of a single plant, resulting in early wilting and death.

Cutworm: The greasy cutworm (*Agrotis ypsilon* (Rottemburg)) is responsible for damage to crucifers during the first few months of their life. This insect is a grey to black caterpillar about 1½ in. long when fully grown, and is usually found coiled up just below the soil surface. It is a nocturnal feeder, and when feeding "cuts" the plant right through the stems an inch or two above ground level. It will inflict such damage on individual leaves even when they are fully formed and after bulbs have commenced to form. The caterpillar pupates in the ground, and the adult moth will lay its eggs on almost any succulent plant material. It is a pest of home gardens and farms in most countries.

Grass grub: The common grass grub (*Costelytra zealandica* (White)) and possibly other closely related species cause damage both in the larval and adult stages to young crucifer plantings. Adult beetles have long been known to feed on these plants, and some alleviation of the problem may be possible by avoiding planting at the dates which coincide with major emergence and flights in the latter half of November. Kelsey (1951) however has shown that this beetle emerges and feeds in fair numbers throughout December and even in January.

While the larvae of the common grass grub is not normally feeding in the surface soil from September to January, it has occasionally been responsible for damage to roots in young crucifer plantings up to the end of January. Other closely related species are present in some areas in the larval form, however, during this period, and could also be responsible for such damage.

Bronze beetle: The bronze beetle (*Eucolaspis brunnea* Fabr.) is frequently found in numbers as an adult feeding on foliage of young crucifers. The larval stage is spent in the soil during winter, and the adults—similar in appearance to the common grass grub beetle, but only half its size—feed from November to January. Damage to crucifers can hardly be claimed to be of pest proportions.

Green vegetable bug: *(Nezara viridula)*. This insect has been taken occasionally in turnip plants in the North Island and in Marlborough.

Aphids: Several species of these insects infest crucifer plants from the time of emergence of the earliest spring plantings, and growers should be watchful for the presence of such insects. The winged adults fly on to first plantings of rape about the end of October from crops which have been infested in the previous autumn, including crops kept for seed as well as those "left over." From then on a continuity of winged adults infests new plantings until late

March, when colder conditions reduce the intensity of flights. Hence, aphids may be expected to infest seedling crucifers at any time from late October to March and should accordingly be watched for during this period. The species of most importance is the grey cabbage aphid (*Brevicoryne brassicae* L.), but the green peach aphid (*Myzus persicae* Sulz.) is also important. Occasionally the false cabbage aphid (*Lipaphis erysimi* Kltb.) is found in a field scale infestation, while a fourth aphid (*Macrosiphum euphorbiae* (C. Thomas)) is also recorded by Cottier (1953) from cruciferous plants, being recorded on cabbage. The present author has also found this last species colonising young cabbage, cauliflower, and brussels sprouts in a home garden.

Numerous other insects including several plant-bugs, some beetles, many flies, and a few caterpillars are present in varied numbers in almost all young crucifer plantings, but at this stage of our knowledge are not looked upon as causing any considerable damage.

Slugs, though not strictly insects, are responsible for some damage at all stages of leafy crops. Their feeding is not confined to leaves at ground level as is often supposed, and the damage inflicted consists usually of ragged holes about ½ in. across. This damage is most severe in young plants. Slugs may occasionally give attention to the growing point of the plant, but this is rather rare.

Though other insects may cause some damage in **developing crucifer crops,** three well-known pests are still the most important. These are:

White Butterfly: (*Pieris rapae* L.), **Diamond-backed moth** (*Plutella maculipennis* Curtis) and the Aphids referred to earlier. The activities of these insects have been summarised by several writers, including Lowe (1956A).

Other insects causing some damage include the **native Grasshopper** (*Phaulacridium marginale* Walk.), which may invade plantings from nearby dry grass paddocks. It appears to be attracted by the succulence of the leaves, in which it eats ragged holes very similar to those seen in damage by the white butterfly caterpillar. A typical case of damage by this insect was reviewed by Lowe (1956B). The **grass grub** is also responsible for some damage to roots of these crops, eating hollows in the base of the bulbs. In seasons or areas of high rainfall, such damage can allow entry of secondary organisms which occasionally cause rotting of the bulbs.

Slugs, and some other pests, including several species of caterpillars, are seen from time to time eating the leaves of these crops, but do not appear to be of economic consequence. Slugs occasionally attack the bulbs, leaving ragged hollows in the epidermis.

Only one insect is normally found infesting these crops at the **seed head stage.** This is the cabbage aphid. It commences to build up from about mid-August, the populations doubling within 22-52 days. In a season favourable to the aphid (1956) it was found to double itself in 22 days, rising from an initial population of 75 aphids per plant to 150 by early October, and then to 300 in a further 15 days. A further 11 days doubled this population again to over 600 per plant by 1 November. These counts show the recognised speeding-up of the life-cycle in this aphid with the approach of higher temperatures. It seems likely that there are something in the vicinity of twenty generations a year.

The insects spend the winter as live females on sheltered parts of cultivated cruciferous plants, and except for wild turnip, which is hardly to be regarded as a pest weed in New Zealand, weeds appear to play little part in the overwintering stages. Root-crops are of course normally fed off and the aphids thus destroyed, but those plants left to go to seed, whether by carelessness or design, carry the nucleus of the new season's infestation over into the spring. About mid-October, winged individuals begin to appear in reasonable numbers in the population of such seed-crops, and usually not later than 1 November flights occur by which the winged females transfer to new sowings of rape. It will be seen therefore that the over-wintering of this aphid is all-important in the initial spring infestations, and that crops kept over from before the flights of the previous autumn (February-March) are the key to new infestations in the spring. Since this insect has been shown to be able to carry the two important virus diseases of crucifers, its flight behaviour is all-important in a consideration of these diseases and the losses they cause.

Flights and reproduction: From the time of the initial flights referred to above, a continuity of crops is present throughout the warmer season, and flights take place at intervals. As crops mature or dry off the winged females transfer to more succulent plantings, as suitable weather conditions permit. In the late autumn, mass flights cause a general re-distribution of the population (mid-February to end of March), and it is from these winged females that the over-wintering colonies arise. Indications are that there is no egg-stage in New Zealand, and so there is no delay in the reproductive cycle, once flights take place. On counts on a single plant taken two days after flights in late February at Ashburton, 259 females were still alive and reproducing after 48 hours, and had already given birth to 2,383 additional individuals, an average birth-rate of four to five per alate per day. This activity continues for four or five days, and individual colonies frequently reach 20 to 25 young, and under Canterbury conditions have been known to reach 35.

Virus diseases: Virus diseases affecting farm crops of brassicas in New Zealand are commonly referred to under the term "turnip mosaic." It is as well however to note that this all-inclusive term means little from a scientific point of view, when used in this way. Virology is still relatively in its infancy and until a standard classification evolves there will doubtless be some confusion of terms. Broadbent (1957) records five distinct viruses from crucifers in Great Britain, and regards cauliflower mosaic and cabbage black-ring-spot as belonging in the same group, and being the important aphid-transmitted viruses in this plant group. He refers to the number of strains which may be found under field conditions.

A summary of New Zealand records of such diseases by Chamberlain (1954) uses the term turnip mosaic to refer to a disease in both market garden and agricultural plantings of crucifers. This author also records cauliflower mosaic as present in market garden crops and states that both viruses are transmitted by the three aphids commonly present on crucifers in this country. Since this time, and especially following a heavy outbreak of virus disease among turnips in the autumn of 1956 it has been generally accepted among scientific workers that cauliflower mosaic is also commonly present in New Zealand in agricultural crops and is being transmitted thereto by aphids.

Markham (1957) in a review of viruses notes the common "break" in wallflower blooms as being one of the results of infection by cabbage black-ring-spot virus. This symptom has been evident in New Zealand for many years and these records should serve to remind us that in the use of the term "turnip mosaic" to refer to virus diseases in brassicas we may be guilty of over-simplifying a very complex question. Whatever terms may be used, however, it appears certain that such diseases as are present in New Zealand are being spread in these crops by aphids.

Susceptibility: It is not possible to leave the question of aphid infestations without referring to the question of susceptibility of the various cruciferous crops to damage by these pests. Three factors are involved in the survival of these crops in the field—susceptibility to damage from direct aphid feeding, from virus diseases, and from drought. These factors undoubtedly interact, and no opportunity has occurred of effectively differentiating between the various types of damage. It is certain however that some varieties can withstand conditions in the field, and the following facts are noteworthy.

Chou moellier and Calder and Sensation swedes appear to be able to withstand considerable aphid attack and consequent virus inoculation. Reasonable resistance is shown by Wilhelmsburger swede and kale. It is of interest to note that the swede varieties named may be sprayed for insect control and will later recover from the combined attack of both insect and virus. This ability to recover is not shared by varieties like Superlative and Grandmaster which though sprayed and rid of aphids, will often continue to deteriorate and eventually die. This would seem to point to virus diseases as the eventual cause of death, and these facts are mentioned here because of their distinct bearing on questions of insect control and its economics. Rape suffers severely from high aphid populations, and many plants slowly die from the viruses which are present. No resistance is shown by any of our present varieties of turnips to virus diseases.

Though these facts represent observations under general field conditions rather than close scientific work, they are the basis meantime of practical recommendations to farmers to combat the diseases present.

FACTORS IN CONTROL

Biological Control of the various pests present has been the subject of study over many years, and certain introductions of beneficial insects, have been made to supplement those already present. As a result considerable reduction of populations has been made, and in some areas and in most seasons many pests are held in reasonable check. The following are the best known effects of the activity of beneficial insects:

Parasites and Predators

Aphids are parasitised by two very tiny hymenoptera, *Aphidius rapae* Curt., and *Allotria brassicae* Ashm. The parasitised aphids may be seen in the colonies as swollen specimens having a "brown-paper" appearance. Small holes in such specimens indicate the point at which the parasites have emerged. The term predators is used to distinguish those insects which simply eat the pest rather than parasitise it. The chief predators of aphids on crucifers are the ladybirds *Coccinella undecim-punctata* L. (11-spotted) and *Adalia bipunctata* L. (2-spotted). Both adults are brick-red in colour, with bluish-black larvae, and both stages are voracious feeders on aphids. It is to be noted however, that they seem little attracted to such food during the spring when aphid colonies are mostly found on the tall seed-heads of crucifers. Possibly they obtain dietary satisfaction at ground level, since they are general feeders on all types of small insects. Their almost total absence from these seed-head colonies may be a substantial factor in the rapid increase in aphid numbers in the spring. A further point in the understanding of biological factors at all stages of aphid infestation is the delays occasioned by the egg and pupal stages of the ladybird. No such delays occur in aphids on crucifers, since the young are born alive and develop through several feeding stages directly to the adult form.

Some other ladybirds are occasionally taken from crucifer aphid colonies, but not in any great numbers. They are mentioned by Cottier (1953).

Syrphid flies *(Syrphus novae-zelandae* Macq. and *Melanostoma fasciatum* Macq.) are also effective predators in the larval stage. Both adults are shiny black insects with yellow markings, which hover over the plants and move with short darting flights. The larvae —yellow to greenish slug-like creatures about ¼ in. to ½ in. in length —are commonly found among aphid colonies on crucifers and are undoubtedly a factor in control.

The brown lace-wing (*Micromus tasmaniae* Wlk.) both in the larval and adult forms is a voracious feeder on aphids and is found in small numbers on crucifers.

The Reduviid bug (*Reduviolus capsiformis* Germ.) is found in considerable numbers on aphid-infested crucifers in Canterbury from December onwards and has been observed eating aphids with considerable speed. It is a thin stick-shaped insect from ¼ in. to ½ in. long, light fawn in colour, and moves very quickly when disturbed, usually to the undersides of the leaves. When fully grown it has conspicuous dark-red eyes.

In spite, however, of the presence of these several biologically important factors, aphids remain an important pest of crucifers. The problem, however, needs to be kept in proper perspective. In the absence of their natural enemies, aphids can, theoretically, double their numbers in 24 hours. At the worst period of the year, counts already referred to indicate that they take 10 days to do this. This indicates that 90 per cent. control is being recorded at the height of the season. At some other periods, it would appear that about 98 per cent. control is being exercised, and though it is necessary that we find an effective control for the small but important residue, an examination of these facts should help us to see the problem in its proper perspective. For theoretical reasons nature will never favour us with 100 per cent. control, so that we are really aiming very high in this problem.

The white butterfly is parasitised by both a larval (*Apanteles glomeratus* L.) and a pupal parasite *(Pteromalus puparum* L.). Diamond-backed moth has also a larval (*Angitia cerophaga* Grav.) and a pupal parasite (*Diadromus collaris* Grav.). The effectiveness of such parasites varies according to district and season, and though Robertson (1948) showed that all of these insects are themselves parasitised at times by a hyperparasite (*Eupteromalus* sp.) it must be conceded that compared with earlier times before such parasites were introduced, present biological control is reasonably satisfactory. Outbreaks which cause heavy damage are occasional rather than regular.

A number of predators play a minor role in the control of both eggs and caterpillars of these two insects.

Diseases are a factor playing a significant part in the reduction of insect pests of crucifers. They are capable of causing very heavy reductions in aphid populations. Similarly a fungus disease attacks the caterpillars of diamond-backed moth, and a virus disease those of white butterfly. Effective outbreaks of these diseases, however, appear to be confined to the autumn season, and it is obvious that their spread will depend on a high density of population. Though they are an important factor in the periodic reduction of insect numbers, this is usually only possible when a high population has already built up.

Climate is another factor bearing on the build-up and reduction of insect numbers. Its effect has been noted most in aphid infestations. Though little work has been done on detail, general field observations indicate that warm dry weather favours these insects, while humid conditions are unfavourable. It is also evident that rainfall and wind play some part in the dispersal between plants of the wingless forms. The winged forms are assisted in their local and wider dispersal by a combination of suitable temperature and winds, while it is evident that actual rain is somewhat detrimental to this stage of the insect.

The balance between soil moisture and the onset of the wilting of plants is also considered to be an important factor in the precipitation of flights by winged aphids.

The balance between plant growth and insect damage should not be overlooked, it being obvious that a plant which ceases growth under drought conditions will be much more vulnerable than one which can be kept growing steadily. This effect is particularly noticeable in aphid infestations.

It is probable also that climatic factors are chiefly responsible for the conditions favouring spread of the diseases affecting insects, once these organisms are present in the population.

Management. Arising from the considerations set out above, it seems evident that there are four things which farmers can do to assist in preventing losses in winter forage crops from insect pests.

(1) Watch for soil pests when sowing crucifers in paddocks ploughed out of old pasture. This is particularly the case with larvae of cutworm and wireworm, and both larvae and adults of grass grub.

(2) Destroy residues and left-over crops infested with aphid in August or September. This prevents such insects multiplying and flying from mid-October on to fresh crops, to which they can convey virus diseases.

(3) For similar reasons, all crops saved for seed should be treated even for low infestations of aphids. Under the Regulations, this must be done before 1 September, and a more useful approach would seem to be to spray such crops where necessary during late autumn. Present knowledge indicates that there are no major flights of aphids between the end of March and mid-October, so treatment with a systemic insecticide in April-May should be effective in preventing spring build-up.

If this and point (2) above were observed by all growers a substantial break in the present continuity of aphids and their associated plant viruses would occur, to the substantial benefit of all.

(4) It seems obvious that growers of winter feed should concentrate on those varieties which have continually demonstrated their ability to survive both aphid and virus infestations, and which are referred to above.

Chemical Control

Lowe (1956A) has listed the most effective chemicals available at that time and discussed fully the question of alternative methods of application. Lowe (1956B) also indicates the most likely control for grasshoppers.

Essentially these recommendations are that 1 lb of p.p.i. DDT per acre will control most insects affecting crucifers, with the exception of springtails and aphids, both of which are killed by ½ lb lindane per acre. This latter material has since been shown to be the most suitable material tested for control of the wheat bug, wireworms, and cutworms. DDT is generally accepted as a suitable material against bronze beetle and the vegetable bug.

Undoubtedly the most difficult pests to control on crucifers are aphids, and because of their role as virus vectors it is important that they should be controlled. The chief problem with a contact material in an immobile insect like an aphid is to get adequate coverage of both sides of the leaves. This is not normally possible with aerial spraying, and in any case does not overcome the problem of curled leaves in which the aphids shelter. Systemic insecticides which enter the sap and poison it for a short period after application are an obvious advance, but until recently all such preparations were highly toxic to man and animals. For this reason, they were not available to aerial operators or to farmers under health regulations.

However, the recent appearance of metasystox, a systemic material classified by health authorities both here and in Great Britain as a reasonably-safe preparation, is now available for application from the air (by permit from Civil Aviation authorities) or for farmer's use. It is very useful against aphid at 16 fluid ounces per acre. It is harmful to bees if applied to flowering crops but has very little harmful effect on other beneficial insects. Its label carries full instructions for safety, and farmers should read and rigidly observe these. It has little if any effect on caterpillars, and stock should be kept off sprayed fodder for at least 14 and preferably 21 days especially if they are in milk or being prepared for slaughter. Like all other preparations it requires a permit between 1 September and 30 March if being applied to flowering crucifers or legumes. It is a very promising material which being systemic, gets over the coverage problem, and when used according to labelled instructions, should greatly assist farmers without the creation of any dangerous hazard.

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SUMMARY OF CONTROL OF INSECT PESTS IN BRASSICA CROPS

Biological Control

1. Beneficial insects (parasites and predators) play a large part in the control of white butterfly, diamond-backed moth, aphids, and possibly other insects damaging these crops.

2. Diseases among insects are also a big factor in the control of natural populations.
3. Climate is a main consideration, affecting both build-up (e.g. warm weather and aphids), and reduction (e.g. incidence of disease, and direct effect of rainfall).

Management and Control

1. Destroy unwanted residual crops before spring temperatures rise appreciably, certainly before flights begin (aphids mid-October).
2. Spray seed crops in autumn or before 1 September, if aphid-infested.
3. Grow resistant varieties of crops where such are available. (Chou moellier, and Calder and Sensation swede stand up well under field exposure to aphids and virus, and Wilhelmsburger swede and kale moderately well.)
4. Watch for soil pests, which will attack seedling stages, when sowing out of old pasture (grass grub larvae and adults, and wireworms).

Chemical Control

1. LINDANE will control all insects affecting brassicas. It has a good residual life in the absence of heavy rain, but for a good kill of aphids, very good coverage is essential. Dosage: ½ lb 100 per cent. per acre; cost: 15/- to 20/- per acre.
2. DDT will control white butterfly and diamond-backed moth, weevils, and both larvae and adults of grass grub. It is inferior against wireworm, wheat bug, and grasshoppers, and not recommended for springtails and aphids. Dosage: ½ to 1 lb p.p.i. per acre; cost: 10/- to 20/- per acre.
3. ALDRIN is the recommended material against grasshoppers. Dosage: 4ozs 100 per cent. per acre; cost: 7/- per acre.
4. METASYSTOX, a systemic insecticide, gives superior control of aphids. Available only as a liquid, it conserves most of the beneficial insects. Being systemic, it gets over the coverage problem, hence suitable for aerial application. (The operator requires a permit from Civil Aviation.) Short residual life (7 days) against flying insects re-infesting the crop, but unaffected by rain within this period. Requires care in handling because it can be absorbed through the skin. Dosage: 16 fluid ozs 50 per cent. material per acre; cost: 27/- per acre.

Residues

None of the above treatments is dangerous to stock health after seven days, but the following precautions should be observed to avoid contamination of animal products; which would be contrary to health regulations.

1. No animals in milk or being finished for slaughter should be fed on insecticide material until 21 days after treatment, or until heavy rain has fallen to wash the insecticide off the foliage.
2. Other animals may be fed on any of the above treatments after 14 days provided good growth conditions are being maintained to give a bulk of new untreated leaves. This dilutes the effect of the treatment.

Permits are of two kinds:

1. Between 1st September and 30th March, farmers may not treat crucifers or legumes (seed crops) in flower, with materials harm-

ful to bees, except on permit from the Dept. of Agriculture. This regulation is to protect beekeepers, and applies to all the above materials.

2. Certain materials considered dangerous to operators may only be applied by air on a permit from Civil Aviation, to be obtained by the aerial operator. This is to protect operators, and in the interests of public safety. Of above materials, this restriction applies to Metasystox meantime.

Safety

Always follow label instructions to the letter, especially those covering safety precautions.

TURNIP MOSAIC

I. D. Blair, Lincoln College

Many farmers have been taking a beating in the past two years through the turnip losses arising from this disease. In 1956-57 the countryside literally was "lousy" with aphids—this year they were less prolific at least in the early part of the season when turnips and swedes were in their first stages of development. In December last there was a marked absence of aphids. The cool, damp conditions of early summer did not favour them and it was thought that the disease would be less severe. I do not know whether you will agree that turnip mosaic has been less severe this season. At any rate it is clear that, despite a slow start, the aphids made up for their early reluctance to reproduce and in March there was a tremendous density of them. Directly correlated with this came reports of more mosaic, though a few months later than in previous years.

Thus those of you disposed toward quick generalisation or ready to accept simple explanations may say "Turnip mosaic causes losses only in a bad insect year" (or from their point of view—a "good" year for aphids). That is not sufficient in comfort or reason for a forum like this kind of gathering. As I am one of a profession whose paid function is to impart information derived from critical observation, I want to use this opportunity in addressing farming intelligentsia to present facts, some unashamedly fundamental; these to be set against the fair amount of practical observation already known. The outcome may be that we can then answer the questions: "Do the facts of this crop disease indicate that we must develop a new farming technique by way of a replacement for turnips, a crop occupying 400,000 acres that has become vastly important in sheep farming economy?" "Or is this just a sporadic hazard that we can contend with by ignoring it, taking our losses on the chin in one or two seasons. Then say, in our characteristic fashion that 'She'll be jake; she'll be O.K.—next year will be better'." There are other questions.

This turnip mosaic has been identified in the world literature for 35 years—in New Zealand for 25 years. "But why has the disease suddenly changed from an obscure entry in a research report to a field epidemic that in 1956-57 certainly had much of the farmer community by the proverbial ears?" Turnips have regularly failed in the South Island—you will all remember poor crops at one time or the other. So is "turnip mosaic" and the academic facts implied by the term just another way of describing something like the dog's fleas, always with them and ever likely to be.

Anyhow, why grow turnips at all? Somebody has said "Turnips are a habit." You can put them in when you feel like doing so—anytime over a long period from October-February. They fit in admirably in rotation planning when you are aiming to re-sow grass pasture. Out of old grass, into turnips for winter feed, then rape (even wheat perhaps), then fallow before re-sowing in grass. They are easier to feed than hay or silage, cheaper and higher yielding or producing. That's most of the argument for them and furthermore, on much of the light land it is difficult to grow any of the possible alternatives. As Doug. Wraight, formerly of the Department of Agriculture, Timaru, said at last year's Waimate Farm School:

> "Some farmers who have accepted grassland farming more than perhaps others have done are inclined to want to dispense

with the growing of brassica crops as their winter feed supply, particularly now that they have become increasingly difficult to grow. I would not agree with this from two points of view. I do not know of any other crop which will carry up to 30 sheep to the acre for 10 to 12 weeks and will do them well. Some preparatory crop is needed in the regrassing and crop rotation programme and on the "all-grass" farm. I do not like renewing grass straight out of old grass without some preparatory crop."

Shortly I shall relate something of the facts of Turnip Mosaic specifically, but seeing that all living organisms are susceptible to some form of virus, any listeners to a discourse of this kind should have a basic comprehension of the fundamental nature of viruses in general. After all, we are contending with that "something" ranging from smallpox, measles, mumps, influenza to polio in man; rabies, distemper, foot and mouth in domestic animals; birds suffer from pox and psittacosis; insects and bees from sac-brood; cheese-starter bacteria are destroyed by bacteriophage; while as for plant viruses there are scores of them. In short, if anything goes wrong and is unexplained in the textbook, your medico will be inclined to think you have a virus infection, or the white-collared agriculturalist will also likely shrug his shoulders and pronounce the last rites on crop failure with the words "virus disease."

Those who have studied animal viruses incline to the view that they are dealing with a disease agent that must be an ultra-microscopic organism. Much more research has been done on the inherent nature of plant viruses. From this we conclude that they are an infectious principle accumulating in plant sap; of size beyond the resolving power of ordinary microscopes; composed mostly from protein derived from the nucleus of plant cells and able to develop only in living tissues. There are three possibilities to speculate on regarding their origin. First, that they may be degeneration products derived from a retrograde evolution from larger organisms. Second, that they are chromosome fragments that have escaped into the cell from nuclei and are able thereby to multiply in body tissues. Thirdly, that they are autocatalysts increasing in susceptible cells through accidents in protein metabolism.

These abstruse points deserve mention to convince you that we are concerned with something very difficult indeed and you can see that the problem of control must be more intricate than that prescribed by the "dose-of-salts" type of recipe.

Getting back to our topic, we can say that the dominant characteristics of most plant viruses are species and strain variation within the virus protein; transmission by mechanical or insect carriers; survival on a wide host range; increasing infectivity with the influence of environmental factors. Let us bring these properties to bear in regard to Turnip Mosaic:

1. The disease in New Zealand is caused by two forms of virus—Cabbage Ringspot virus (formerly Turnip Mosaic) and Cauliflower mosaic. The former produces a bright leaf-mottle in turnips, with blistered or crinkled surface-texture and ultimate stunting of growth. Cauliflower mosaic in the turnip host starts off with vein-clearing, then yellowing of leaves, followed by stippling or necrosis. Leaves become twisted and at that stage bulb development is stunted, or if they are then well formed, the skin separates from the centre and black, bacterial decay begins. According to Dr Smith, who has just addressed you, at least 90 per cent. of this trouble in South Island crops has been caused by the Cauliflower mosaic strain of virus. We determine this for test purposes by introducing virus infected sap into two differential or screening plants—Green Globe turnip

and White Burley tobacco. Cauliflower mosaic produces symptoms in the turnip variety but not in tobacco, whereas the turnip or ring-spot strain produces symptoms in both of these hosts.

2. In turnip fields there are no mechanical operations of handling that could introduce the virus from another area. There is nothing in the turnip comparable with the hand plucking of tobacco or tomato that serves to introduce virus by sap transmission from diseased to healthy plants. In turnips though once the disease has become established it could be further distributed within the field by the browsing animal. Aphids carry the turnip disease and Mr Lowe has discussed them. They are adapted to the Brassicas and multiply on some of these in summer and autumn, carrying virus infected sap from plant to plant as they puncture leaf surfaces. The two epidemics of 1956 and 1957 have been attributed to favourable season for carry-over of aphids on kale, chou moellier, or regrowth rape. Then after the maturity of these in September the virus-laden insects migrate to newly-sown rape. They build up there until the rape dries off in December-January, whereupon they migrate in their winged form to the next Brassica sequence, swedes and turnips.

3. The all-important turnips show the consequential disease effects more severely than any of the other host or carrier plants. There are in all 14 of the well known Brassica species that carry both these viruses, while in addition there are 16 garden species or weeds that act as reservoirs. Further, there are five other plant species (than Brassicas) that will carry Cauliflower mosaic and 48 other plant species that carry the Cabbage Black Ringspot form of turnip mosaic. So the disease must ever be present but on our farmland it seems to build up its potential first in chou moellier, and then in rape. My own part in the integrated research programmes last year was to record the incidence of Cauliflower mosaic virus in chou moellier crops standing over winter. Seventy-five tissue samples were received through officers of the Extension Division, Department of Agriculture. Sap expressed from the tissue samples was inoculated into seedlings of the screening plants, Green Globe turnip and White Burley tobacco. After two months' growth of these sap-inoculated plants, symptoms of Cauliflower mosaic were scored and from the results the distribution of virus-carrying samples was as follows:

TABLE 1

Carry-over of Turnip Mosaic

	Number Chou moellier samples tested	Number positive mosaic carriers	Number suspect (not confirmed)	Number negative
North Canterbury	3	3		
Malvern	8	7		1
Ellesmere	2	2		
Ashburton	17	14	1	2
Timaru	9	8		1
Waimate	4	3		1
North Otago	4	4		
Dunedin	6	6		
South Otago	19	12	3	4
Gore	3	3		
Totals	75	62	4	9

It is clear, therefore, that there is turnip (Cauliflower) mosaic in chou moellier, that crop plant not being noticeably affected by the virus. As intimated, it seems that the first spring flight of aphids would carry the infection from chou moellier and regrowth rape to the main rape crop. Second growth or regrowth rape is a menace and in this context is truly a disease-reservoir. Thus in January of this year when turnips were not then showing mosaic, the disease was however detected in second growth rape surviving from a summer sown rape (January, 1957) and grass mixture. In April severe mosaic broke out in two turnip crops near Dunsandel each within a short distance of some 12-month-old rape pickings left on a neighbouring farm. The rape was 100 per cent. diseased and clearly had been the source of infection from which carrier aphids had migrated to the turnips. This points to the primary origin of the threat to the turnip crops. We have great hopes, therefore, for the outcome of the work Mr T. P. Palmer has been doing at the Crop Research Division in breeding for aphid-resistance in rape. If this aphid-resistant rape becomes universally used through the South Island and confirms its agronomic value, the disease potential of the insect vectors of the virus will certainly be curtailed and the chain of the disease cycle broken at what is now its strongest link.

4. Viruses though not organisms in the accepted sense of that word are known to exist as "strains" or variants. Cauliflower mosaic affecting turnips is of very recent definition being identified in Canterbury only in 1949. We do not appear to have had this specific disease much before that time. There may be several strains of it but certainly the dominant one is very severe in the pathogenic sense. It produces a more devastating form of disease in the Canterbury turnip crop than it does under English conditions. We can only speculate on this so far. Where did it come from, for instance? It may have been introduced on or within imported plant material but not on dormant seed, for the virus can only survive in actual, living plant cells. Most of our plant diseases would have become established here from some infection on imported material but it was not until 1955 that legislative control was enacted to assist the prevention of these importations in the form of Plant Quarantine regulations. Alternatively the strain now ravaging Brassica crops could be a virulent form derived as a mutation from a mild parental strain of virus. The field evidence, though, suggests that the severity of the disease is more readily accounted for in terms of the insect carriers or aphid vectors that transmit virus-infected sap during the course of their peregrinations. We have climatic conditions in this country so favourable for aphid multiplication. Their density on susceptible Brassicas here surpasses anything of the kind in England and it is reasonable to say that whether or not the primary viruses are an importation or a new severe strain, the severity in the susceptible crop is the resultant of doses that are massive in total, introduced however in minute portions by myriads of individual vectors.

Among predisposing factors, that of Brassica species and varietal susceptibility is important. Trials by the Department of Agriculture, notably those in South Canterbury, show that all the available turnip varieties are equally susceptible to Cauliflower mosaic. There seem to be individual plants within some varieties that resist the disease and these might be the basis of selection work. Among the swedes the position is better and the varieties Doon Spartan, Calder, Sensation are very resistant, while Wilhelmsburger, Wye and Doon Major are resistant. All other swede varieties at present in use are susceptible to mosaic. Chou moellier is evidently the most resistant of the cropping Brassicas but do not let the fact of that crop's imperviousness to symptom damage obscure the realisation in your mind that chou moellier is a reservoir that keeps the virus alive.

It may be sufficient to say the disease has been severe in the past two years because aphid vectors have been abnormally abundant. On the other hand this kind of turnip failure seems to have been increasing in severity. Nitrogen levels in soil may have become a factor influencing the expression of the virus. In English trials it has been shown that severity of Cauliflower mosaic is increased as soil nitrogen increases. In a pot trial I conducted last year levels of nitrogen in a test soil of natural low fertility were adjusted by the use of appropriate rates of sulphate of ammonia, ammonium nitrate, urea. In the turnip plants grown on these we found that after sap inoculation, mosaic developed as follows:

TABLE 2

Mosaic and Nitrogen Levels.

	Height of inoculated plants (inches) Mean of four	Ratio Mosaic/ healthy leaves
Control—No added N	3½	0-7
Ammonium sulphate 5 cwt/acre	6	1-7
10 "	6	5-6
15 "	8	4-7
20 "	8	7-8

Additions of ammonium nitrate and urea acted in the same manner.

Such results from a preliminiary or pilot trial support a hypothesis that with the increased fertility of plains land, arising from improved management and higher production from sheep and grass farming, with attendant heavier depositions of dung, urine and nitrogen of legume origin, so there may be an increased predisposition in the turnip crop to the effects of mosaic virus. It is not clear yet whether the effect is on virus multiplication within the plant tissues more heavily charged with nitrogenous matter, or whether the nitrogen taken up by the plant, leads to a type of leaf growth which proves more favourable for the multiplication of the aphid vectors.

What are the Prospects of Control?

From the evidence I should expect that this disease will be with us so long as we grow susceptible Brassicas. It will ebb and flow in severity depending on the interaction of predisposing factors, some of which have been outlined. Farmers blessed with their characteristic adaptability will have to plan things in order to keep a few steps ahead of trouble. To restrict the losses of turnip mosaic the working plan will have to be dominated by the following propositions: Lessen the dependence on turnips and try suitable alternative feed crops, and encourage the use and general distribution of aphid-resistant rape. Find out whether crop spraying is effective and economic as a preventive of aphid build-up.

Mr Lowe has dealt with spray control. He has also published (Lowe, N.Z. J. Agric. Res. 1, 37-43, 1958) his evidence that Metasystox can completely eradicate the Cabbage aphid when suitably applied. All I wish to add is that although no doubt exists of the efficiency of some spray treatments, there is doubt about the mechanical means of spray application. Proper coverage of the chemical on the host plant is vital and it seems that much room for improvement exists in method of application before chemical control of the virus carriers can be fully effective. Further, it is incumbent on the entomologists to be bold enough to tell the farmer *when* to spray. There are practical possibilities in making disease forecasts based on survey information in such time as to warn farmers of pending outbreaks. Preventive spraying can then be done in the specified interval preceding the attack. I believe the entomologists gave a useful warning this year when the Cabbage aphid began to multiply with the onset of favourable conditions in February.

Dr Smith does not agree with my view that "turnips have just about had it" on some plains land. He can make his own points in discussion but I gather from him that despite mosaic virus, he believes that we can go ahead confidently and grow more and more turnips, taking certain other precautions to restrict the agencies of virus multiplication and spread. He would say, I think, that because the Cabbage aphid does not multiply on the turnip, the severity of attack depends on the size of the turnip population. On this fact it would seem that there could well be less disease if we sow more turnips, that is heavier sowing rates. This may be so but in any event all steps must be taken to limit virus spread from the alternative host plant, rape. This will be achieved by using aphid-resistant rape, by ploughing up depleted rape as soon as feeding is completed, or by spraying the rape before the turnips are sown. Dr Smith's comment to me has been that it may be more effective to spray in order to eradicate aphids on rape near to turnip sowings than to defer treatment until it is too late when the virus carriers have become established on the near-by turnips.

I am going to discuss the approach to the problem of control only through replacement of turnips by alternatives. A helpful contribution to this topic has already been made by Mr M. L. Cameron, Department of Agriculture, Timaru, in his article in the December, 1957, number of the Journal of Agriculture. Emphasis can be given if I now say much the same thing plus some more perhaps in different words, and I should like to acknowledge also the assistance I have had from my colleague, Mr H. E. Garrett, in this commentary on alternatives to turnip crops liable to mosaic.

Later sowings of turnips up to mid-February may avoid the weight of aphid attack. York Globe seems to be the variety best suited for the late sowings and with it, Italian or short-rotation ryegrass can be sown. Difficulties may occur if you get a lot of rain after feeding commences as these late-sown soft turnips can deteriorate and rot very rapidly. This can be contended with by feeding off in small, fenced breaks. Secondly, if grass is included in the mixture you tend to lose something of the cleaning value of the turnip crop in regard to soil preparation for the succeeding sowing of new grass pasture.

The cereal green-feeds are an expensive crop on the basis of food per acre. They have about half the winter-feeding capacity of turnips, but the recovery they give in spring provides a green-feed tonic as lambing approaches. Italian ryegrass is probably a better proposition, if well established after good cultivation, but it still will not produce that measure of winter carrying-capacity of turnips. Much the same goes for autumn-saved grass; whereas turnips winter 25/30 ewes per acre, autumn-saved pasture will be magnificent if it winters ten. If the climate is severe it is difficult to hold as it tends to rot away. Autumn-saved grass, however, can be developed most advantageously where lambs are quickly disposed of and so long as first-class pasture is the source from which the autumn-saved grass is obtained.

Hay and/or silage may fill the gap created by turnip failures and lucerne hay and lucerne-grass mixtures are well to the fore in utterances of the enthusiasts. There has been a difficulty, a temporary one I think, associated with widespread failure or poor growth of lucerne through inoculation failures. In some places this problem has become a lucerne "disease", limiting production from that crop. There seems to be a limit to hay or silage under South Island conditions where we do not get enough good grass growth to provide the desirable balance as between grass pasturage and the hay or silage supplement. You may have to feed too much of the latter and the sheep do not come through the winter like North Island sheep which enjoy better grass on which the hay supplement is fed.

All these possibilities that roots can be dispensed with and sheep wintered on such alternatives as grass pickings and lucerne hay do not carry much support when one has to plan in terms of really-high concentrations of sheep. Those of you with heavy concentrations per acre will find no real substitute for roots. But we have this chronic virus disease and I believe in the meantime it has bested or "worsted" many of the turnip areas. On the evidence, swedes, kale and chou moellier are the best proposition. They do better, certainly, in higher-rainfall districts on a good level of soil fertility but is it not a fact that the once impoverished soils of much plains land are something of a recollection of the past—much less a fact of the present? There is, I understand, a much higher level of fertility on the typical turnip land, the resultant of your improved methods of pasture and sheep husbandry. Indeed I have already suggested in this paper that part of the increased predisposition of our existing varieties of turnips to mosaic, may stem from the enhanced susceptibility through nitrogen levels in these soils. It seems possible to grow swedes now on farms where formerly they did no good at all. A mediocre crop of swedes, unaffected by mosaic should be a better proposition than a crop of soft turnips that started well but which vanished before feeding out on account of mosaic disease.

The mosaic resistant varieties of swedes have been mentioned. They can be sown with a little chou moellier. Even a small portion of turnips can be included on the reasoning that despite the disease, turnips do not fail completely every year. Six ounces of swedes and one pound of chou moellier per acre in half-drill strips is the recommendation. They must be sown early for you cannot treat this slow-growing crop with that same easy flexibility as turnips. Mid-November is the sowing time for coastal Canterbury or late November-early December inland. A difficulty lies in the fact that swedes are hard on sheep's teeth and only the young sheep will relish them. Hence we have the need for that ingredient of chou moellier or the picking of soft turnips.

Finally, as Mr Cameron stated in his article which I mentioned earlier, "It should always be borne in mind that a reduction in the area of the winter Brassica crop or its elimination from the farm programme usually results in a slowing of the rate of pasture renewal, which over a period of years could result in a deterioration of pasture quality. . . . When fertility has been built to a high level and experience has demonstrated the lasting qualities of the pastures, this may not be a serious consideration, but where these factors are doubtful, the question of regular pasture renewal must be considered as a vital policy question."

Consequently, if mosaic is ruining the turnips we must, under a dominantly-grass economy, strive to retain a root or Brassica crop both for its winter-feeding capacity and for the preparation it gives in pasture resowing. Fortunately, the swede-chou moellier mixture is the practical, palliative measure pending something more spectacular in virus prevention that may come in the future from the strivings of "back room" scientists. From the short term viewpoint I think the solution will come from effective spraying of sources of infection, so much so that the aphids' cheerful life of feeding and reproduction, soon will not be worth living.

QUESTIONS ON DR H. C. SMITH'S, MR A. D. LOWE'S AND DR I. D. BLAIR'S PAPERS

Question: What is the incidence of attack of these diseases on fodder beet?

Dr Smith: There is a serious mosaic disease of beet in England which has not got here yet.

Question: What is the relative importance of dry rot between chou moellier seed imported into this country and New Zealand grown?

Dr Smith: The first samples of English seed had quite a lot of dry rot; the New Zealand seed was quite clean. Since then we have had wet harvests and quite a lot of New Zealand chou moellier seed has also been infected.

Mr Lowe: There is very little known about insect pests of fodder beet in New Zealand because fodder beet is so rarely grown in this country. In England the flea beetle is guilty of spreading the disease. I think we have some insects which could carry the disease if it arrived here.

Question: Is there any possibility of crossing silver beet or spinach with brassica to get immunity to white butterfly and other insects?

Dr Smith: It would be quite impossible. There is some resistance in wild turnip to mosaic.

Question: Will tough winters clean up diseases and pests?

Dr Blair: As winter conditions develop many of the insects die out, but the effect of the climatic conditions does not matter very much as far as mosaic is concerned. If only a fraction of the organisms survive until the spring time they will spread very quickly then.

PASTURE-PLANT IMPROVEMENT

L. Corkill, Director, Crop Research Division, D.S.I.R., Lincoln.

I have been invited to speak to you today on the present and future development of pasture plant breeding in this country. Although not now actively engaged in this work I was pleased to accept the invitation, for one does not easily lose interest in a subject with which one has been associated for many years.

Before considering the present work and possible future developments I shall briefly review some results to date.

It was not until the 1920's that the great significance of strain in pasture plants in New Zealand was fully realised. The work of Sir Bruce Levy and his colleagues showed that there are extreme differences between strains of the one species. For instance, what was commonly known as perennial ryegrass in fact consisted of an extremely wide range of different strains which had developed naturally over the years in response to the influence of climate, soil, and farming practices acting on the diverse plant material originating from other countries. These influences, together with the hybridisation which took place between varieties and species, in time gave rise to very distinct ecotypes or strains, some of which came to be known by the name of the region in which they occurred, e.g. Poverty Bay, Hawkes Bay, Sandon and Canterbury ryegrass. The differences between some of these ryegrass strains were large, particularly in characters of prime importance in a pasture plant—productivity, persistency and palatability.

These differences can be readily understood when it is realised that the pastures were subjected for years to very different environments, particularly farming systems. The permanent pasture type of farming practised in the north favoured the evolution of a long-lived persistent type of plant. On the other hand, the arable farming system characteristic of Canterbury favoured a short-lived free-seeding plant described as "false" perennial ryegrass. The development of such short-lived strains was accentuated too by natural crossing between perennial and Italian ryegrass and by the practice of harvesting and sowing maiden seed crops. Although the strains so developed were by no means true perennials, they had one most important character inherited from their Italian ryegrass parents—palatability. I shall refer to this later.

Similar investigations were made on other pasture species and the story was found to follow a like pattern. A persistent, vigorous, leafy strain of cocksfoot was predominant on the Akaroa peninsula. In white clover a vigorous, large-leaved, truly perennial strain described as the "No. 1" strain was confined to restricted areas in the Heretaunga Plains in Hawkes Bay and the Woodend district in Canterbury.

Following Levy's work on the identification and description of the characteristics of these different strains, the certification scheme for pasture plants was introduced and it was these vigorous, true perennial strains which were certified.

The Government Certification Scheme provided a service to the farmer whereby he could be certain that seed complied with a guaranteed standard. It resulted in a very rapid disappearance from the seed trade of a multiplicity of inferior strains, and within a few years the bulk of pasture seed harvested in New Zealand was of certified origin. But some of these certified strains had their faults.

Perhaps the one which was most criticised, particularly by South Island farmers, was the certified strain of perennial ryegrass which was criticised on the score of unpalatability to stock. There was some justification of this criticism, for compared with the "false" perennial ryegrasses it was relatively unpalatable. However, as soil fertility increased through the use of vigorous certified clovers the problem was less acute, for when associated with vigorous clover the ryegrass in the mixture became more thrifty and less unpalatable.

Breeding

The work on strains and the setting up of the Seed Certification Scheme paved the way for an approach to plant breeding aimed at further improvement. The major objectives in the pasture-plant breeding work of the Grasslands Division of the Department of Scientific and Industrial Research have been to breed strains of pasture plants with improved total productivity, seasonal spread of production, and persistency. There are now available to the farmer as certified seed, pedigree strains of pasture plants which, when correctly used, are capable of producing pastures of high and sustained growth throughout the year. The list includes perennial, Italian and short-rotation ryegrass, cocksfoot, timothy, white clover, Montgomery-red clover, and broad-red clover or cowgrass. I think it would be a fair statement that the pedigree strains of each of these species are on the whole better strains than the ones they have replaced. But with each of them there is still plenty of room for further improvement. Breeding and selection do not in practice come to an end with the release of a pedigree strain through the certification scheme. As improvements are brought about, seed of the improved strain is released and in time, as this seed is increased, it replaces the earlier strains.

I do not propose to dwell on the characteristics of those strains already available as certified seed, for they are well known, but will refer to some current work on pasture-plant improvement.

It might be considered that undue emphasis has been placed on the ryegrasses for there are now on the market pedigree strains of three ryegrasses—perennial, short-rotation or H.1, and Italian. Each of these, however, has its particular role. The ryegrass family is a most important one in all grassland areas of moderate climate and good rainfall the world over. Its members have a number of characteristics of importance in a pasture plant—they have the ability to become established rapidly, are high-producing, and within the group there are species or varieties capable of high yield at different times of the year. Considerable work has been carried out at the Grasslands Division on both perennial and Italian ryegrass. Not only have pedigree strains of these two species been produced, but they have also been used in hybridisation programmes to produce new strains with characteristics from each. Short-rotation ryegrass with the high and early production and good palatability of Italian ryegrass, and resistance to leaf rust, together with some of the persistency of perennial ryegrass, is now used extensively, not only in this country but overseas.

The possibilities of developing other strains from hybridisation in the ryegrass group have by no means been exhausted. For some years a breeding programme based on hybrids between perennial and short-rotation ryegrass has been in progress at the Division. This work has now reached an advanced stage and some very promising plant material has been obtained.

The aim of the work has been to breed a perennial ryegrass with good development of some characteristics in which pedigree perennial ryegrass is deficient—with earlier spring production, improved palatability and resistance to leaf rust. An infusion of these characters into a basically-perennial ryegrass has been obtained by selection from hybrids between perennial and short-rotation ryegrass. At the present time third generation progenies, in some of which the desired characteristics are fixed, are being tested under a range of environments at Kaikohe, Palmerston North, Lincoln and Gore. The parents of the best of these progenies will be used to provide a supply of nucleus seed of the new strain for future pasture trials throughout the country. Present indications are that this strain will be a valuable addition to the range of high-producing pasture plants. It is a perennial and will withstand hard and continuous grazing. Its early spring growth is greater than that of pedigree perennial ryegrass, it is much less susceptible to leaf rust and it is more palatable. Should the strain fulfil its present promise, certified seeds will be released when field trials are completed in a few years' time.

The Future

There is still scope for further improvement in those grasses and clovers of which there are already pedigree strains on the market. Further attention to breeding for resistance to diseases would probably be well worth while. The success that has already been obtained by selection for resistance to leaf rust in the ryegrasses has been mentioned. But there are many diseases of pasture plants which have so far received little attention. Virus diseases and *sclerotinia* or root rot of clovers probably cause serious reduction in yield and persistency, whilst many farmers in Canterbury have had first-hand experience this season of the economic loss resulting from blind seed disease of ryegrass.

Other Species

All of the species at present certified—the ryegrasses, cocksfoot, timothy, white clover and red clover—are species adapted to high fertility. But there are many other useful plants, many of which grow well under lower fertility conditions, which have not as yet been included in the breeding programme—such species as browntop, Yorkshire fog, dogstail, *Phalaris and Danthonia*; all of these show wide variability between plants and there is no doubt that higher producing strains could be bred. However, it is problematical whether work on increasing productivity would be warranted. Browntop, for example, is a very useful grass on second-class country as it has the ability to thrive where higher-producing grasses such as ryegrass make but poor growth. But it is likely that a strain with a higher yield-potential would not realise that potential unless it were grown under conditions of higher fertility. With modern methods the fertility of second-class land can be greatly increased, but when this improvement is brought about, conditions are made more favourable for high-producing species such as the ryegrasses. It is a more realistic approach towards increasing pasture production to build fertility and use high-producing pasture plants rather than to attempt, by plant breeding, to increase the productivity of relatively-low producers well adapted to lower fertility conditions.

With improvement in methods of increasing fertility, there will be a wider use of potentially high-producing plants. In recent years our understanding of mineral deficiencies of soils and the development of economic methods of rectifying them has meant that higher-yielding pasture plants can be used in areas where previously only species demanding lower fertility would survive. In much of the foothill country of Canterbury the use of phosphate, molybdenum and sulphur has meant that really high-producing cocksfoot-clover pastures have replaced low-producing pastures.

I do not wish to infer that the species I have mentioned should be entirely neglected in a future plant improvement programme. For instance, Yorkshire fog is a useful pasture plant and would be even more valuable if a strain resistant to leaf rust and with improved palatability were produced. In this species there are wide differences between plants in many characters and there is no doubt that improvement in some of these could be brought about by selection. Prairie grass is an extremely valuable winter grower but does not persist under severe grazing. An investigation of this species and its close relatives and the possibilities from hybridisation between them would probably be rewarding.

Work is at present under way on the improvement of *Lotus* species. *Lotus major* (*L. uliginosus*) is an important legume on the higher rainfall hill country of New Zealand. Improvement is being made in such characters as seedling vigour, productivity and early growth. Unlike *Lotus major* the species *corniculatus* is adapted to relatively dry conditions. Overseas it is considered a useful pasture legume where soil fertility is not quite suitable for lucerne. In the past it has been tried in New Zealand without any great success. However, the wide range of variation within the species would indicate that by selection and breeding a variety suited to our conditions might be produced and the Division now has some promising varieties and progenies under test.

An interesting project at present being undertaken at Grasslands is an investigation into the potentialities of crosses between perennial ryegrass and tall fescue, the ultimate objective being to produce a hybrid plant of predominantly-ryegrass characteristics with the hardiness and adaptability of the fescue. Seed has been obtained from these wide crosses but whether a plant of pasture value will eventually be obtained remains to be seen.

Up to the present the emphasis in pasture plant breeding has been on improvement of quality rather than quality of feed. Improvement has been obtained in both annual and seasonal growth so that pasture production can be more nearly equated to animal requirements. Nevertheless, quality has not been entirely neglected. If improved palatability to stock can be considered a factor of pasture quality then some advance towards increasing quality has certainly been made. Other cases could be quoted of improvement in quality where sufficient is known about the plant constituents which influence this characteristic. For instance, white clover contains a particular glucoside which inhibits the uptake of iodine by the thyroid gland and may cause goitre in stock where the iodine content of the feed is low. Following work on the identification and inheritance of this glucoside a strain of white clover completely free from it has been produced. Whether the use of such a strain would improve stock thrift is a question to be answered by further research. I simply quote this case as an example of how a quality characteristic in a pasture plant can be modified by a plant-breeding approach.

There are a number of animal ailments which are claimed to be directly caused by pasture plants, facial eczema, hogget ill-thrift and bloat, to mention but three. In recent years there has been a marked increase in the research effort of physiologists and biochemists directed towards a better understanding of the influence of pasture on the health of the grazing animal. There is no doubt that in time the quality characteristics of plants which affect animal health and thrift will become more-precisely defined in terms of chemical compounds. It is now well known that under certain conditions pasture plants may have chemical excesses or deficiences which result in ill-thrift in grazing animals. These substances may not normally occur in dangerous amounts in the plant, but may reach a significant level under the influence of climatic or soil factors. It may be that their deleterious effects could be readily overcome or counteracted by manurial treatment or by stock or pasture management. If not, the problem might be overcome by breeding varieties less prone to have harmful effects. It is well known that different plants of one species may normally vary in their content of chemical substances. Wide variation between plants of perennial ryegrass in their iodine content when grown under similar conditions has been shown by Dr Butler of the Plant Chemistry Division and these differences have been shown to be inherited. If it were desirable, a ryegrass strain with increased ability to absorb iodine could be produced by selection and breeding.

When a more complete knowledge of harmful plant compounds is obtained, improvement in quality by breeding may be a well worthwhile approach but success will depend on (1) whether these substances are inseparable from plant growth, (2) whether there are differences between plants in their content of the substances, (3) whether they can be readily determined in individual plants, and (4) whether these differences are inherited. The whole question of breeding for improved quality in pasture plants is dependent upon our obtaining this kind of fundamental information. For this the plant breeder looks to the biochemist, the physiologist and the nutritionist. That the information is gradually being accumulated will be evident from other papers to be read this afternoon.

Question: There are many thousands of acres in the back country which on the average are of pretty poor quality. Is anything being done to try and get plants to increase the carrying capacity of low-fertility country?

Dr Corkill: The work on plant breeding itself has been devoted up to the present to plants of potentially high production for potentially high quality land. It is more realistic to improve the quality of the land and use potentially high producing plants than to improve the productivity of normally low producers.

Question: Is there any analysis done of the different plants for their mineral content?

Dr. Corkill: Chemical tests are made and Grasslands Division is associated with the Plant Chemistry Division which does carry out such tests. There is a lot of work now being carried out on the chemical make-up of pasture plants, on differences between species, and differences between plants of one strain, and the effect of environment, time of year and so on on chemical composition of the plant. For instance we know that plants vary enormously in their ability to absorb iodine from the soil.

Question: Can you tell us anything about rust which I think has a bearing on the health of stock?

Dr Corkill: There are differences between plants in their susceptibility or response to leaf rust which is the only rust we have worked on in ryegrass. Short-rotation ryegrass is much more resistant to leaf rust than is perennial. That is why we wish to incorporate it in the new hybrid perennial ryegrass. Rust-affected grass may be more nutritious to stock but less palatable and palatability is a very important characteristic.

Question: In the plots at the Department of Scientific and Industrial Research at Lincoln, H.1 and Italian show susceptibility to

Argentine stem weevil whereas perennial is virtually unaffected. Is the disease important in Canterbury and is any work being done on it?

Dr Corkill: Some work is being done by Mr Kelsey using material which Grasslands have at Lincoln. I do not know whether this is going to be really important in the persistance of short-rotation pastures in Canterbury. It has affected cereal crops for years. It may be that it is building up.

Question: One of the great drawbacks to our present white clover appears to be the unpalatability of it in the spring when it appears to be very bitter. Some of us have heard a story that you could breed the bitterness out of white clover but were not permitted to because of the picric acid test. Is that so?

Dr Corkill: We have produced white clover without the glucoside (which contains prussic acid) but the certification scheme in New Zealand is based on a high content of prussic acid. We have produced a strain still higher in glucoside than the pedigree strain. We have carried out palatability trials in Palmerston North with sheep and found no difference in palatability. This strain could be certified in New Zealand quite readily. One drawback is that it is particularly palatable to slugs and in the seedling stage the slug damage can be a very important factor in the establishment of white clover in pasture. The introduction of this strain is not warranted at the present stage. If the work being done at present by Dr Butler shows that we should get rid of the glucoside, which affects iodine, we are certainly in a position to do so.

Question: In view of the fact that in Canterbury we are getting a lot of iodine deficiency in lambs is this fact not more important?

Dr Butler: We could say quite definitely that an effect due to this glucoside being in white clover could not produce the disastrous consequences being produced in Canterbury. The worst that we expect would be a trimming back of animal production and also these instances of congenital goitre in lambs. We have a trial to assess the seriousness of that. The first crop of lambs is coming along in August and we are interested to see the incidence of congenital goitre on those lambs particularly when the mother ewes have grazed on short-rotation ryegrass and white clover continuously for 18 months. Until then we cannot assess the economic importance.

PASTURE COMPOSITION AND ITS RELATION TO ANIMAL THRIFT

G. W. Butler, Plant Chemistry Division, Department of Scientific and Industrial Research, Palmerston North.

It is generally agreed that a major barrier to increased animal production from New Zealand's high-producing pastures is the incidence of nutritional upsets in the grazing animal. At Plant Chemistry Division our research programme is aimed at studying the relationship between animal health and the use of the bred strains of grasses and clovers. Today I want to speak about the condition known as "hogget ill-thrift" and about the iodine nutrition of grazing animals. The results I shall quote are largely drawn from a "Ryegrass Strain Trial," which is being jointly carried out by personnel from the Sheep Husbandry Department (Massey College), Plant Chemistry and Grasslands Divisions.

Hoggett Ill-thrift

In the North Island we speak of hogget ill-thrift to describe the condition where hoggets fail to grow in the midst of plentiful pasture growth during the autumn and early winter months, in the absence of any positive cause such as worms or known deficiency of trace elements. Hogget ill-thrift need not necessarily be associated with mortality although it frequently is. Summarising what we know about this condition, as a result of work done in recent years at Ruakura Animal Research Station by Mr Clarke and his co-workers, it has been shown that:

"(1) The onset of hogget ill-thrift is concurrent with the production of fresh growth of pasture, and it occurs in the presence of an apparent abundance of feed during the autumn.

"(2) The condition is not caused by any known parasite or bacterial infection, nor by deficiencies of known minerals or vitamins.

"(3) Infections, including parasitism, manifest themselves when the resistance of the animals has been lowered by 'ill-thrift' and lead to a complex of symptoms.

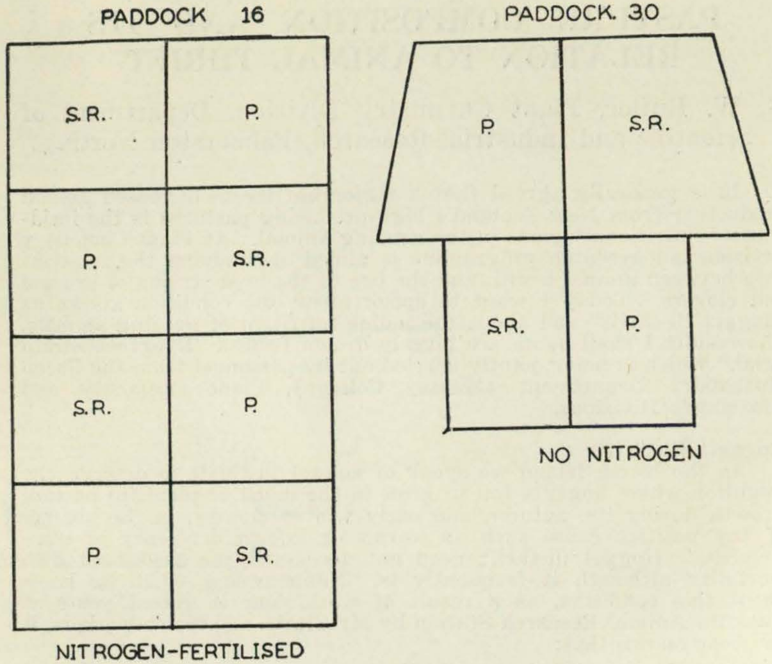
"(4) Its incidence may be reduced by providing hoggets with mature pasture, containing where possible a high proportion of white clover.

"(5) An intake of nutrients lowered to a maintenance or submaintenance level is associated with, if not the actual cause of, the condition.

"(6) Loss of weight on autumn pasture is not confined to the hogget, but occurs in older sheep too."

It will be seen then that the Ruakura workers have shown that "hogget ill-thrift" seems to be associated directly with the ingestion of rapidly-growing autumn grass and our work at Plant Chemistry Division, in collaboration with the Sheep Husbandry Department, Massey College, has been directed at confirming this result and investigating the chemical composition of this type of feed.

To this end, Paddocks 16 and 30 of Massey College Sheep Farm, totalling seventeen acres in all, were sown in early November, 1956, to perennial and short-rotation ryegrass in a balanced layout, as shown in Figure 1. The paddocks had been given a pre-emergent spraying with 2,4-D prior to sowing and pure stands of the two ryegrass strains resulted. White clover was also sown on Paddock 30

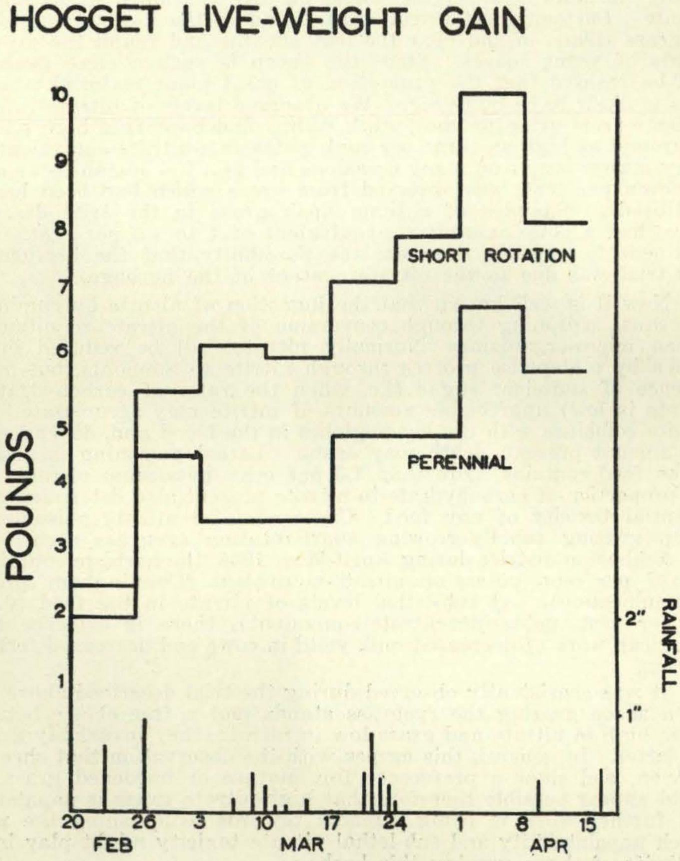


but because of delayed establishment, it was of no significance during the summer and autumn of 1957. The various blocks were fenced off and set-stocked with lambs as from 14 February on Paddock 16 and 7 March on Paddock 30. Sulphate of ammonia was applied to Paddock 16 at the rate of 1 cwt per acre three times during the period November-April, whereas no sulphate of ammonia was applied to Paddock 16. The lambs on each block were weighed at weekly intervals. Herbage samples were taken regularly during the season for chemical analyses.

The average weekly gain in live-weight for the lambs, which were set-stocked on the nitrogen-fertilised perennial and short-rotation ryegrass stands for the period 20 February to 16 April, are given in Figure 2. It will be seen that the weekly fluctuations in weight of the lambs on both short-rotation and perennial ryegrass followed each other rather closely, i.e. over this period of the year there appeared to be no difference between the strains in their ability to fatten the animals. On three weeks only, out of the eight weeks' period shown, was the average rate of live-weight gain at the level which might be considered satisfactory at this time of the year, namely two or more pounds per week. On three separate occasions there was a net loss of weight. The rainfall data are also shown in Figure 2 and it will be seen that it is possible that the commencement of light, autumn rains was associated with the weight losses. Field observations suggested that freshening of the pasture was followed within the week by weight losses and this appears consistent with the findings of Clarke in his studies on hogget ill-thrift. When the flush of growth ceased owing to a lack of moisture and the pasture "hardened," the animals again gained weight.

In Paddock 30, on the other hand—where no fertiliser nitrogen was applied and where little freshening of the pastures occurred following the light rains—the rates of weight gains were in general higher. Over the period which was common to the two grazing trials in Paddock 16 and 30 respectively, from 7 March until 16 April, the average overall gain in live weight for six weeks was 4.9 plus or minus 1.3 lb on Paddock 30, but only 2.5 plus or minus 1.0 lb on Paddock 16, even though both sets of animals appeared to have ample feed. Summing up then, poor thrift of hoggets feeding on ryegrass growing rapidly under conditions of high fertility was confirmed.

Let us now consider some aspects of the chemical composition of this type of herbage which may have a bearing on the problem. Previous work carried out at Rukuhia Soil Research Station and Plant Chemistry Division has shown that the levels of nitrate in the soil under high-fertility pastures in New Zealand can rise in the autumn to levels which in other countries would be regarded as typical of arable soils. The herbage samples taken during the period of autumn-flush growth were therefore screened to determine whether



the high levels of nitrate in the soil give rise to any nitrogenous chemical compounds not present at other times of the year.

The main types of nitrogenous compounds in herbage are, of course, the proteins, which form the basic substance in living tissue. These normally account for 90 per cent. of the total nitrogen present. Dr J. W. Lyttelton, of Plant Chemistry Division, has been studying the proteins of ryegrass herbage, using special techniques, and he has not found any marked variations in the types of proteins present at different times of the year. The remaining ten per cent. of the nitrogen contained in herbage is present in the form of simpler chemical compounds, including nitrate itself and amino-acids. These latter compounds may be regarded as the building blocks from which proteins are formed. It was found that there were no significant differences in the amino-acid content of rapidly and slowly growing ryegrass herbage in the autumn.

With regard to nitrate, it was found that the nitrate content increased as much as tenfold in rapidly-growing ryegrass. Grass growing in urine patches and stock camps and bordering bare patches of ground was more likely to contain herbage high in nitrate, but during the autumn flush the whole pasture contained grass high in nitrate. Further, most nitrate was found in the lower parts of the ryegrass tillers, in and near the leaf sheaths and round the growing points of young leaves. Since the sheep is such a close grazer it will be realised that the proportion of basal plant material which it eats is likely to be quite high. We observed levels of nitrate in grass herbage from urine patches, stock camps and bordering bare patches of ground as high as three per cent. potassium-nitrate-equivalent (on a dry matter basis) on many occasions and in a few instances as much as seven per cent. was observed from areas which had been heavily fertilised. Samples of autumn flush grass in the trial described above had a potassium-nitrate-equivalent of 1 to 1.5 per cent. It is pertinent to consider therefore the possibility that the ill thrift in this trial was due to the nitrate content of the herbage.

Now it is well known that the ingestion of nitrate by ruminants can cause poisoning through conversion of the nitrate to nitrite by rumen micro-organisms. Normally nitrate will be reduced in the rumen by a stepwise process through nitrite to ammonia, but in the absence of sufficient sugar (i.e. when the ratio of carbohydrate to nitrate is low) appreciable amounts of nitrite may accumulate. The nitrate combines with the haemoglobin in the blood and, depending on the amount present, death may ensue. Lethal poisoning is possible if the feed contains more than 1.5 per cent. potassium nitrate, with the proportion of carbohydrate to nitrate present also determining the potential toxicity of any feed. Cases of fatal nitrate poisoning in sheep grazing rapidly-growing short-rotation ryegrass occurred in the Ashburton district during April-May, 1956, the herbage containing 3 to 7 per cent. potassium-nitrate-equivalent (Cunningham, private communication). At sub-lethal levels of nitrate in the feed (0.5 to 1.5 per cent. potassium-nitrate-equivalent), there is evidence from American work of decreased milk yield in cows and decreased fertility in rats.

It was consistently observed during the trial described above that when sheep grazing the ryegrass stands had a free choice between grass high in nitrate and grass low in nitrate, they invariably grazed the latter. In general, this agrees with the observation that sheep do best on, and show a preference for, mature or hardened grass. It would appear possible therefore that high-nitrate grass is unpalatable and further work is being directed towards establishing the parts which unpalatability and sub-lethal nitrate toxicity might play in the ill thrift of sheep grazing this herbage.

In the course of the chemical work, we found some evidence that a fraction of the nitrogen which we analysed as inorganic nitrate was probably in more complex combination in the plant. We are continuing work on this, since any nitrocompounds present might have harmful effects on grazing animals.

It will be seen from what I have said that, if my premises are correct, hogget ill-thrift is particularly likely to occur on the most fertile pastures, where the nitrogen cycle is operating at its highest pitch. It is on such land that soil nitrate will rise to the highest levels during the autumn and the autumn flush of growth will be greatest. There is one other possibility which requires investigation. Nitrate accumulation in herbage is favoured by deficiencies of molybdenum, manganese or sulphur. In the case of molybdenum deficiency, the nitrogen status of pastures will generally be low because of poor clover growth, but Lobb has observed high nitrate in molybdenum-deficient clover herbage. Manganese deficiency is unlikely, but the possibility of high levels of nitrate in herbage due to an autumnal sulphur deficiency in the presence of high soil nitrate levels (accentuated by a slower rate of mineralisation of soil sulphur than soil nitrogen) requires investigation. There is a real possibility that in the autumn, herbage nitrate levels are becoming higher through this cause. Because of the large areas of grassland which now show a response to nitrogen fertilisation, this could be a widespread effect.

Importance of Iodine for Pastures

Until the introduction of iodised salt in New Zealand in the 1930's, goitre (or enlargement of the thyroid gland) was quite a common complaint in the human population, particularly in certain areas. This could generally be related to a low content of iodine in the soils and drinking water of the "goiterous" area.

It is not surprising therefore that goitre is not unknown in our farm animals, particularly on alluvial soils in the South Island.

The most acute symptoms are seen in congenital goitre of newborn lambs, a condition which can sporadically lead to quite serious losses.

There is also the possibility that animal production is being curtailed in some degree by insufficient iodine in the diet, or by insufficient use of the iodine which is there.

Over the past three years, research workers at Wallaceville Animal Research Station, Massey College and Plant Chemistry Division, have been studying the factors which influence the iodine nutrition of farm animals.

In these investigations, the approach has been two-pronged, along the following lines:

(1) A study of the factors of soil, plant and climate which influence the iodine content of herbage.

(2) A study of goitrogens, or in other words, substances in the pasture ingested by the animals which depress the normal uptake of iodine in the thyroid gland.

In the study of factors influencing the iodine content of herbage, it was found that there was a very strong strain and species effect, which was more important than soil or climatic factors in determining the iodine content of the herbage.

The mean annual iodine contents of some of the strains of pasture plants tested, expressed on a relative basis, were as follows (Certified New Zealand abbreviated to C.N.Z.):

C.N.Z. perennial ryegrass	21
C.N.Z. Italian ryegrass	12
C.N.Z. short-rotation ryegrass . . .	4
C.N.Z. cocksfoot	2
C.N.Z. white clover	13
C.N.Z. Tallarook subterranean clover . .	3
C.N.Z. Mount Barker subterranean clover .	3
C.N.Z. broad red clover	4
C.N.Z. Montgomery red clover	7
Browntop	3
Yorkshire fog	1
Poa annua	2
Poa trivialis	2

In the above table, any figure below four is likely to be associated with congenital goitre in lambs.

Analysis of single plants showed that within one strain of any species, there is a wide variation in the iodine content of herbage. Analysis of the progenies from crosses between plants which were high and low respectively in herbage iodine showed that the percentage iodine content of the herbage was a strongly-inherited characteristic.

This is important because it means that it is possible for the plant breeder to improve the iodine content of strains which are low in iodine by selecting from plants which are high in herbage iodine.

In the second phase of the investigation, two species have been investigated on account of suspected goitre-producing properties. These are certified N.Z. white clover and thousand-headed kale. Certified white clover contains cyanide, which is potentially a goitre-producing substance.

Feeding experiments were carried out in which small laboratory animals were fed two strains of white clover—one containing cyanide and the other cyanide-free. The group fed white clover containing cyanide showed signs of goitre, so the experiments were extended to sheep. After grazing sheep for six weeks on pure stands of certified white clover, the thyroid glands were shown to be lower in iodine content than those of a group grazing cyanide-free white clover.

A large-scale field trial of three years' duration has now been initiated, using sheep, to test further the effects of white clover in association with perennial and short-rotation ryegrass

Cattle grazing on pastures containing white clover are probably not affected by its goitre-producing potential. This is because they eliminate, or excrete the toxic material much more rapidly from their bloodstreams than is the case with sheep and thus their thyroid glands are not affected.

A potent goitre-producing substance, as yet unidentified, is known to be present in kale, and the nature of this substance is being investigated by Mr E. Wright at Wallaceville.

All the goitre conditions caused by the above factors can be alleviated by administration of iodine to the animals. Stock licks containing iodate are quite effective for this purpose, although the amounts ingested by different animals vary greatly.

Experiments are at present being carried out with an oil containing iodine, which is injected intramuscularly into the animals once a year. The oil should serve as an "iodine depot" and present indications are that it is quite efficient in this capacity. Animals receiving such an injection should be safe from the effects of any dietary shortage of iodine, or that induced by the presence of goitre-producing substances in the feed.

Question: Would those proportions of iodine vary from district to district, particularly from coastal to inland areas?

Dr Butler: The total iodine content of soils in New Zealand varies widely from alluvial, lowest to volcanic soils, highest. The surprising thing is that pasture species have the capacity to absorb the same amount of iodine fairly independently of the total iodine content of the soil on which they are growing. This is apparently due to the amount of available iodine throughout the soils being very similar. In respect to coastal versus inland areas it could be expected that iodine derived from sea spray would be a significant factor but the amount of iodine which would be deposited on an area of pasture is very little compared with the iodine content of the soils. It is a fairly small factor in the overall situation.

Question: Do harmful effects occur when there is imbalance of carbohydrate and nitrogen in the feed? Do you know of any experimental work whereby carbohydrate level has been artificially raised and did it have any effect in counteracting ill-thrift?

Dr Butler: The proportion of carbohydrate to protein in feed has been the subject of a considerable amount of work over the years both here and overseas. It is widely thought that our high-producing grasses could have a carbohydrate content which is too low for maximum utilisation of the feed. Experiments have been done in which carbohydrate supplements have been fed to advantage. This has been done in the U.S.A. with cows with quite beneficial effects. Only in cases of very severe nitrate poisoning were the workers unable to reverse the process whereby the nitrate in the presence of extra sugar will go through to ammonia which is harmless rather than half to nitrite which is poisonous.

SOILS IN RELATION TO ANIMAL HEALTH

T. W. Walker, Lincoln College.

In most countries soil scientists are satisfied with a definition of soil fertility that is concerned solely with crops. The one I was given at college says, "Soil fertility is the ability of a given soil to grow satisfactorily some or all of those crops permitted to grow by reason of the climate." This is inadequate in a country where virtually all plants grown on a farm are converted by animals into meat, milk or wool. All too often we face a situation where, to all appearances, we have grown a perfect pasture of high productivity, and yet animals will not eat it or if they do they fail to thrive on it. We cannot be satisfied with any definition of soil fertility which excludes the animal. Such a definition might be: "The ability of a given soil to continue to grow crops and pastures that will produce maximum amounts of meat, milk and wool, and at the same time maintain animals and their offspring in perfect health insofar as this is dependent on nutritional factors only." The last qualification is important; when an animal is on a perfect diet it should naturally resist attack by certain pathogenic organisms, but a perfect diet (even if we knew what this was) can give no absolute insurance against worm infestation, foot-rot, foot-and-mouth disease and the like. Soil and plant scientists can no longer be satisfied to produce high quantities of dry matter per acre. There are probably few soils in New Zealand on which the nutritional factors limiting pasture production cannot be diagnosed and corrected, and the emphasis must swing more and more from a study of soil-plant relationships to the more complex sphere of soil-plant-animal relationship.

Nutritional Disorders Produced in Animals by Plants.

Farm animals live on plants (although for at least one essential vitamin—vitamin B.12 which contains cobalt—micro-organisms appear indispensable), plants grow on soil and many farmers are inclined to blame the soil where nutritional disorders arise. Plants may be defective from the point of view of animal health without soil properties having any influence at all. One can think of certain plants which produce harmful compounds due to some genetic character of the plant which is not influenced by soil type at all. Alkaloids, oestrogenic, goitrogenic and photo-sensitizing substances, and others come to mind. Plants attacked by some disease organisms may affect animal health; ergot-infected herbage is a case in point. The production of bloat or facial eczema by certain pastures may be due as much to climate, species and stage of growth as to soil properties, although in the case of bloat say, soil properties may be indirectly responsible for giving rise to occasional clover-dominance. Soils cannot be credited with the sole blame even for a mineral deficiency such as iodine. Butler and his colleagues at Plant Chemistry have shown for instance that even closely-related plants inherit quite different capacities for accumulating iodine, and when grown side-by-side on the same soil H.1 always contains less iodine than perennial and Italian ryegrasses. When we remember that the general syndrome of goitre may be complicated by goitrogenic factors present in some plants, it is obvious that soils are not always to blame for mineral deficiencies.

While the soil may not be directly responsible for all nutritional disorders, soils may be responsible for animal ill-health in two main ways. These are firstly, by a direct effect on the animal of some mineral deficiency or excess produced in the plant by soil conditions, and secondly, by indirect effects of mineral deficiencies or excesses on plant metabolism, so that some compound produced in the plant, or not produced in the plant, adversely affects animal metabolism.

Direct Effects of Mineral Deficiencies and Excesses

Let us examine first the mineral nutrition of plants. We now have a pretty complete picture of those elements which a plant must get from soil or air if it is to grow well. Apart from carbon, hydrogen, oxygen and, in the case of legumes, nitrogen, which plants obtain from the air or water, these essential elements are nitrogen (for non-legumes), phosphorus, sulphur, calcium, magnesium, potassium, and the so-called trace elements, iron, manganese, copper, zinc, boron, molybdenum, chlorine, possibly vanadium, and according to the Russians, cobalt. Plants always contain other elements too, which as far as we know are not essential to their growth; fluorine, sodium and iodine for instance, which are needed by animals, and even poisonous elements such as arsenic and selenium. A deficiency of any one of the essential nutrients listed will limit plant growth, but because plants need more nitrogen than any other nutrient, nitrogen deficiency is, the world over, the most common factor limiting plant growth. The large amounts of nitrogen needed by a productive pasture can be met only by supplementing the natural supplies from the breakdown of soil organic matter with nitrogen fertilisers, or more economically, by the fixation of nitrogen from the air through the medium of legumes and their associated rhizobia. The simple principle underlying high production of dry matter from pastures in New Zealand is to define and correct any nutrient deficiency which is limiting fixation of nitrogen by legumes. Clovers for instance need about one pound of phosphorus and sulphur, three pounds of potassium and 1/2000 oz of molybdenum to fix ten pounds of nitrogen. Because grasses are able to compete with clovers so effectively for most if not all plant foods, the needs of grasses for such minerals as sulphur, phosphorus and potassium, are met automatically, if enough is present to ensure maximum growth and nitrogen fixation by clovers. Indeed, it may be necessary to apply so much of some nutrients to a pasture to get optimum growth of clovers, that grasses take up some of these nutrients in excess (so-called luxury consumption), and this may be responsible for some stock disorders to be mentioned later.

It is of interest that over most of New Zealand it is only necessary to apply superphosphate, which supplies both phosphorus and sulphur; lime, mainly as a corrective of factors associated with acidity rather than correcting deficiencies of calcium; molybdenum; and of increasing importance, potassium, to ensure high pasture production. This means of course that most soils at present are able to supply enough of the other essential nutrients to meet plant requirements, although as our knowledge improves we may find that other elements are needed on some soils to maintain or increase production of dry matter.

Now, two highly fertile soils of different origin may produce plants of markedly different mineral composition. This illustrates a most important principle, namely that the mineral composition of well-grown plants of say ryegrass or white clover, can vary between fairly wide limits. The growth of a plant will suffer if the content of an element drops below a certain critical value; but the content can be several times higher than the critical level without increasing plant growth, and high levels of some nutrients may easily reduce plant growth because of "antagonism." For instance, high levels of potassium may cause magnesium deficiency, high levels of manganese can cause deficiencies of iron or molybdenum. It is important to grasp the point that if the level of any essential plant food falls below a certain critical value, plant growth will be curtailed. This is one reason why, I think, one rarely sees acute deficiencies of phosphorus or sulphur in animals. If a soil is acutely deficient in phosphorus or sulphur, clover growth is inhibited, pasture production and carrying capacity are low, but the phosphorus and sulphur levels although low are usually adequate for the class and numbers of stock that normally graze such areas.

It would be highly convenient if the critical levels of various elements needed by clovers corresponded to the critical levels needed by animals, then whatever elements we applied to improve pasture production would also help to meet animal requirements, which should go far to avoid actual deficiencies in animals. Unfortunately this is not the case. As far as we know plants will grow perfectly well without sodium, fluorine, iodine and possibly cobalt if the Russians are wrong! (An indication that they may be wrong, or that plants may need exceptionally low levels of cobalt is provided by the fact that pastures will grow perfectly well on soils where sheep and cattle will die of cobalt deficiency.) In the case of these elements therefore, plant and animal needs are not synchronised at all. Copper provides a good example of an element needed by both plants and animals, where a deficiency may arise in an animal while the pasture plants are growing perfectly well, although soils can be so deficient in copper that clovers will not grow. Molydenum of course may enter the picture here. Plants can take up much more molybdenum than they actually need without any obvious harmful effect, but these relatively high molybdenum levels may affect the copper nutrition of the animal, and it may be necessary to apply copper, not for the plant, but for the benefit of the animal. Furthermore, the inorganic sulphur (sulphate) content of herbage can be increased markedly from applications of superphosphate, gypsum or sulphur, without any ill-effects on the plant, but this sulphate may enhance the effects of molybdenum toxicity in a copper deficient diet.

These are examples of mineral deficiencies arising in animals, in what may appear, from the point of view of dry matter production, perfect pastures. But there are others, and it is most disconcerting to find that animals will thrive quite well on some unimproved pastures, and yet after pasture improvement stock health may deteriorate. Under the conditions of low production animal requirements for minerals may be met, and growth and fattening rates may be limited more by a deficiency of protein and carbohydrates than by minerals. Now when we improve clover growth and nitrogen fixation by correcting such deficiencies as phosphorus, sulphur, potassium and molybdenum (either by applying molybdenum or lime) we automatically increase the production of proteins and carbohydrates, and carrying capacity increases. While the nitrogen content and the content of any other element we apply will normally increase in the herbage, there is no automatic increase in other minerals. Some may increase and others decrease. Superphosphate or gypsum or muriate of potash may increase the level of such elements as manganese or cobalt particularly on acid soils. Lime may reduce uptake of manganese, cobalt, copper, boron and iron; potash and lime may both lead to lower levels of magnesium in the herbage. In some cases, plant growth may be depressed, in others and more commonly, deficiencies may be induced in the animal without the plant being obviously affected. Where it is known that applications of, say, lime or molybdenum may greatly improve pasture production but induce copper deficiency in stock, a farmer may choose not to improve his pastures and keep a smaller number of healthy animals. More logically he can apply copper as well as lime or molybdenum. The point I want to make here, and I could choose other examples, is that it is quite illogical to limit production by purposely not applying minerals that will increase pasture growth. One might just as well hope for a drought each year so that the low yields of dry matter will contain higher levels of minerals. No, surely the right step is to discover what other mineral deficiencies in the plant and particularly the animal, may be induced by improving pasture growth and correct them. Unfortunately research work in this country has been confined largely to deficiency of cobalt and copper. In other countries the influence of high levels of potassium and nitrogen in the herbage on the incidence of hypermagnesaemia is under examination.

Imbalance of certain nutrients may be the cause of some disorders. Calcium-phosphorus ratios have been implicated in some cases of infertility, and on less certain grounds high calcium-manganese and calcium-iodine ratios are thought to cause trouble, but on grazed pastures these ratios are affected greatly by the clover content of the pasture which of course is only partially dependent on the soil. Lack of fundamental knowledge is at the bottom of the failure to answer many of these problems as yet. The functions of minerals in plants and animals are numerous, varied and complex; it is doubtful if any one of them has a single simple job to perform, and until these functions are known the approach must remain an empirical one.

Possible Effects Due to Faulty Plant Metabolism

Disorders may arise in animals because of faulty plant metabolism, which may or may not be due to mineral deficiencies or excesses. I will illustrate this possibility with some of our own data. In unimproved high-country pastures we have not yet found mixed herbage with a nitrogen-sulphur ratio greater than 15, considered by animal nutritionists to be about the maximum permissible if sulphur deficiency is to be avoided. On applying sulphur, the ratio may drop to four or five with the accumulation of much free sulphate, especially in the grasses, with possible effects on the molybdenum-copper nutrition of the animal. There may be marked differences between grasses and clovers. Where clovers are short of sulphur (they make very little contribution to production of course) they tend to contain high nitrogen-sulphur ratios, greater than 15; they are probably fixing more nitrogen than the plant can convert into protein with the limited amount available of sulphur, which is an important constituent of proteins. Much of this excess nitrogen accumulates as non-protein nitrogen. The same applies to grasses if they get a high level of nitrogen without adequate sulphur. This non-protein nitrogen may or may not be harmful to stock; we are very ignorant about these factors and that is why I believe Dr Butler's work is so important. It is not without interest that many unanswered problems of animal health are associated with flush periods of growth when nitrogen contents of herbage are normally high, and much of it may be present in forms other than protein.

As a plant grows many complicated chemical reactions occur as the plant produces complex proteins, carbohydrates and other components from relatively simple compounds. Proteins are formed from the simpler amino acids, and in plants growing in soils deficient in potassium or magnesium or manganese for example, certain amino acids tend to accumulate as such instead of forming protein. The nutritional significance of these factors is still to be demonstrated.

Pasture Composition, Climate and Management

In some countries such as Britain, compound feeding-stuffs are fed liberally to farm animals. In a recent article by a manufacturer, these compounds were described as complex. "They contain a great variety of ingredients to ensure that all the essential amino-acids are not only present but in balance, and that no single factor likely to influence the growth or production of the animal is missing. The various ingredients are included in correct proportion to ensure a proper balance between protein and the energy-producing carbohydrates, a low fibre-content, a sufficiency of oil, high digestibility and good palatability, and are fortified by the addition of minerals, vitamins, trace elements, antibiotics or medicaments according to specific requirements of the different species of animals. Their production is scientifically controlled. The analysis is guaranteed and their conversion into terms of milk, meat or eggs can be accurately assessed."

Even if we know what minerals to apply to a particular soil to grow herbage with the same qualities of such a product, the problem would by no means be solved. The mineral and organic components of plants vary with age. A young plant is usually rich in minerals and the content drops as the plant matures. Nitrogen may be very high in fresh young grass (six per cent.) and fall to less than one per cent. in mature, stemmy grass. The high level may be too high for health and the low level too low for milk, meat or wool production. Fibre increases with age. We could exercise greater control if we were growing single-plant species and conserving the feed, preferably as dried grass. In a grazed pasture normally containing at least one species of legume and a grass, the situation is much more complex. One or the other may be dominant at certain times and pasture composition may swing from almost pure grass to pure clover. Take calcium; clovers usually contain two to three times more calcium than grasses. Clearly the calcium nutrition of animals will vary widely. Legumes usually contain more cobalt and copper but less manganese than grasses. Different varieties or even strains of grasses and legumes will vary in composition. Weed plants are often rich in minerals. Also when grazed, there will be large variations in herbage composition between urine and non-urine patches. Climate will have major effects on the composition of plants in the same way as management. There may be safety in variety in the present state of knowledge, and disadvantages in special-purpose pastures containing only two or three species. Further, animals may graze selectively. They certainly do not always behave as we expect; palatability and nutrient values do not always go hand in hand. It is doubtful if animals can distinguish between plants on the basis of variations in mineral content, such as cobalt or copper, unless the minerals also bring about some differences in the quantity or quality of plant metabolites. Even when an animal has made its choice the nature of the microflora in the rumen may influence the nutritive value of the food.

Conclusion

If I have done nothing else, I hope I have conveyed to you the enormous complexity of the situation. Gross nutritional disorders such as cobalt or copper deficiency can be readily diagnosed, and analysis of soils, plants and animal organs may all be employed. Areas where such mineral deficiencies are inherited from the parent material of the soil, acquired during the processes of soil formation primarily by leaching, or induced by applications of other nutrients, can be mapped, and the farmer forewarned. Sub-clinical cases must also surely yield to the same approach in time. It will be surprising however if such unsolved problems as facial eczema and some forms of ill-thrift, are shown to be due directly to mineral deficiencies. They occur on such a variety of soils and pasture species, with variable management, climate and other unknowns. Biochemists in particular will be needed to solve these problems, and that will take money, men and time.

What is the farmer to do in the meantime, when faced with a disorder such as ill-thrift? Assuming he has checked up with his advisers that cobalt and copper deficiency are not implicated and that stomach worms are under control, I would suggest that, however unscientific it may appear, he has little option but to resort to the shot-gun methods of trying mineral licks or various trace elements in his top-dressing programme. It would be highly surprising if it achieved anything, but it may be worth a trial on an experimental basis. It is not unknown for scientific progress in agriculture to be originated by the empirical approach of some exasperated or inquisitive farmer.

Question: If we put on, say, 4 lb blue stone and a few ounces of cobalt on pasture, are we assured it is readily available to the animal within a reasonable time?

Prof. Walker: Most experiments certainly show that applications of copper sulphate very soon get taken up by the plants. On some soils certainly there is some loss of copper by fixation but you should get almost immediate effects as far as copper and cobalt are concerned.

Question: Would you advocate cobalt-deficient areas being sprayed as a possible solution, for example, with weed-killers?

Prof. Walker: Certainly, you can spray it on. It is a question of economics, whether it is cheaper to spray on with other materials or whether you buy cobaltised super. I do not know whether the spray would be compatible with the particular spray solution; it might damage the weed-killing properties. Where it is compatible you can certainly spray it on.

Question: Do you think the use of basic slag would replenish some of these possible deficiencies better than superphosphate?

Prof. Walker: Slag is a more complex material than superphosphate and contains higher quantities of molybdenum, manganese, copper, zinc; it contains very little or no sulphur and so is useless where sulphur deficiency occurs. The availability of some trace elements in slag is questionable. Cockle Park experiments have shown that the application of slag actually reduced the trace elements in the pastures. Slag contains lime and liming will lower the trace-element content of many species. Slag contains more trace elements than superphosphate, certainly. My chief objection is its price; it is too dear in relation to its value.

(At this stage the chairman thanked Dr Walker on behalf of New Zealand farmers for his great services to farming in this country and wished him happiness and success in his new position as Professor of Agriculture in the University of Durham.)

RECENT ADVANCES IN ILL-THRIFT

J. W. McLean, Lincoln College.

In discussing "Recent Advances in Ill-thrift," I propose to restrict my remarks to the latest published work and other recent information on the problem of ill-thrift as it occurs in the South Island, and to contrast this with what is known of the condition in the North Island.

Definition of Ill-thrift

The condition known as ill-thrift may be defined as an inability to thrive, grow or put on weight in the midst of apparent plenty, and in the absence of obvious parasitic disease, of trace-element deficiency and of other obvious causes. It occurs in both young and adult stock, but its effects are more obvious and serious in young animals.

I would like to stress that the primary feature is a slowing up in growth rate, which may be followed by an actual loss of weight, the cause of which is a self-imposed reduction in food intake. If this condition is allowed to persist for even a short time, it may progress to a rapid deterioration in the health of the animal with severe loss of condition, coughing, scouring, thirst, dehydration and death.

Post-mortem examination of advanced cases shows a skinny carcase, fatty liver, flabby heart, fragile bones, watery intestinal contents sometimes mixed with large quantities of dirt, inflammation of various parts of the gut, variable numbers of stomach and intestinal worms, pneumonia, pleurisy and injury to the heart sac. This is the typical picture, but many lambs die before reaching this stage, and quite often it is impossible to find the cause of death. Just why lambs that lose weight under these conditions should die while those losing weight under other conditions do not, is I believe, a complete mystery. It is usually attributed to secondary infections of some kind, and here I would stress the phrase "of some kind" because I believe that very often we do not know.

The evidence varies from year to year, season to season, district to district, form to farm and even paddock to paddock; the cause of this variable incidence is another mystery.

It appears to occur on all types of pasture and all types of forage crop, which is a bit of a blow to those who would like to blame it all on to perennial ryegrass.

Ill-thrift in the North Island

Let us now consider the results of research into the condition as it occurs in the North Island, where it has been studied intensively over the last eight years, mainly by Clarke and his team at Ruakura; and then contrast this information with what we find here in the South Island.

In the North Island it occurs in the autumn in weaned lambs from March to the end of May or the beginning of June. Rarely is it seen as early as January. It occurs only on the short young green growing grass that comes away so rapidly with the autumn rains, under weather conditions that are almost invariably warm, humid and overcast. The same pasture when allowed to mature and grow long not only does not produce the disease but brings about recovery in those that have it. "Cow" pasture on dairy farms has long been known to be good autumn feed for hoggets.

It is never seen in unweaned lambs in the spring on the same type of pasture, and after late June, spontaneous recovery occurs on the same pasture that previously caused the animals to fade away and die. The practice has developed therefore of avoiding the condition by pasture management, so that long mature growth is available in the autumn when weather conditions are favourable for development of the disease.

The next important step was the demonstration, in feeding trials, that the failure to make normal gains was due to a reduced feed intake; the lambs just did not eat enough of this special type of pasture to maintain normal growth.

They showed clearly, for the first time, also, that the condition was not caused by the common worm parasites, Ostertagia, Trichostrongylus, etc. Hoggets could be dosed artificially with large numbers of worm parasite larvae, on long pasture, and show no ill effects, and others could be maintained relatively worm-free on "ill-thrift" pasture and yet fail to thrive. Primary parasitic disease can of course be caused by the large stomach worm (*Haemonchus contortus*) under conditions of high summer rainfall.

In the same way, known trace elements deficiencies were eliminated.

The important factor that is not yet clearly understood is why the lambs lose their appetite and fail to eat enough of the "toxic" pasture to make normal growth gains.

One obvious suggestion is that the pasture is unpalatable under these growth conditions; another is that when it is eaten, it upsets the animal which then, being off colour, loses its appetite.

This problem has been tackled by harvesting the two types of pasture, drying it at about 110°C. and feeding as dried grass to hoggets in pens.

When fed ill-thrift pasture, the food-intake which is normal for a start, gradually falls over 10-14 days to 50 per cent.—sometimes less—of what it should be, and fluctuates daily about this level for many weeks. If these sheep are then switched to so-called "non-toxic" dried grass, from long pasture, the food intake returns to normal in 24 hours.

The easiest and perhaps the most obvious answer to this immediate return to normal intake, is of course palatability; the gradual decline may be interpreted in either way.

Mr Clarke, I am sure, would be the first to agree that these pen-fed sheep on a reduced food intake, do not show the supposed classical symptoms of ill-thrift as it occurs naturally in the field; for example, they do not develop pneumonia and die. Under his conditions, however, affected sheep do recover in the majority of cases when they are put on long mature pasture in the field.

In other trials in the Gisborne area, Sinclair, Clarke and Robertson have shown that perennial ryegrass pastures failed to produce normal gains in hoggets in the autumn, while pure white clover pastures, under the same conditions, did so consistently.

We will hear today from Dr Butler of the Plant Chemistry Division, of the work on the changes in the chemical composition of pasture—particularly the N.P.N. fraction—in spring and autumn and its effects on ill-thrift.

Ill-thrift in the South Island

Let us now consider the picture of ill-thrift as it occurs in the South Island, in the light of what we have already discussed.

While it occurs on some farms in some districts every year, it will be generally agreed that the trouble was unusually serious in mid-Canterbury last season. In general it was more common on the light shingly soils, and probably also on farms that had been "improved" by high liming and topdressing with superphosphate. It does occur however on the heavier soils, even on those of the highest fertility. It tends to be associated therefore with relatively high carrying capacity.

Field observations by ourselves here at the College, and a survey conducted by the Economics Section of the Fields Division of the Department of Agriculture late last season brought to light the following salient features.

1. The early outbreaks were observed in unweaned lambs in the spring, even as early as October.

2. Unusually high rainfall led to an exceptional growth of pasture which tended to become long and rank and the weather was mild and overcast, conditions, as we have noted, that are associated with outbreaks in the autumn in the Waikato. Evidence of this exceptional growth is available in grass production figures from the Field Husbandry Department of this College.

3. Serious losses commenced in December and reached a maximum in January and February during which the weather was rather dry.

4. Losses in general ceased with the regrowth of pastures in March following rain in late February.

5. After this, further less extensive outbreaks occurred in flocks not previously affected.

6. Little response was obtained to treatment with worm drenches or supplements of cobalt and other trace-elements.

7. About one-third of the affected flocks first showed signs of ill-thrift on rape.

8. Where pasture was kept controlled at about 1 in. to 3 in. high during the flush period, less trouble was encountered.

9. When affected lambs were shifted to attractive feed in the early stages, they usually recovered quickly.

10. Change to young fresh irrigated pasture consistently gave a good response. Other feeds observed to benefit affected stock were newly-sown pasture, fresh, green lucerne and pure white clover.

11. When the disease had reached an advanced stage, change to alternate feed gave disappointing results, until fresh growth occurred in March, and then interestingly enough, recoveries appeared to take place on any or all kinds of feed. This could be taken as evidence that the disease had run its course in about four months and was about to clear up, in these sheep, in any case. Note that it clears up spontaneously after running a course of similar duration in the autumn in the Waikato.

It must be emphasised that this is the general pattern emerging from a broad general survey of the problem. Obviously, there must have been quite a few cases which did not conform to this pattern.

Field Trials in South Canterbury

Now let us consider the situation this season. While there were again outbreaks of ill-thrift throughout Mid and North Canterbury at least up to the Waipara River, some of which were quite severe, the disease centre appears to have shifted to South Canterbury in the early part of the season, November-December, on the light, stony, sandy silt loams of Glenavy, of a similar soil classification—Lismore stony silt loams—to those districts so badly affected the previous year in the Ashburton County, on similarly "improved" farms, and on the same type of pasture, that is, rank uncontrolled growth with a predominance of clovers.

In the later part of the season, according to Armstrong, areas of the heavier downlands and foothills became affected.

Again, according to Armstrong, the spring outbreaks were associated with evidence of heavy worm infestation, particularly of Osterlagia. This, in itself, is not surprising; in fact, I think it can be regarded as a normal state of affairs in ill-thrift lambs. What is unusual is that, in general, good responses were obtained to drenching with phenothiazine; in particular, apparently, with fine particle size phenothiazine given at somewhat higher than the usually recommended dose rates.

The inference from this must be that the primary cause of the early outbreaks was parasitic infestation, an inference I would be reluctant to concede, particularly in view of the absence of such response to worm drenching in the Ashburton County the previous year.

In this respect it is of interest to note that results from eight years' trials at the Kirwee Experiment Farm in Canterbury, showed that a significant response to worm drenching could be expected about once every four years.

Later in the season, following reports from the Waimate Veterinary Club of the beneficial effects of Co supplements, the Department of Agriculture at Timaru carried out more extensive trials to test the general response to cobalt administration, sometimes with additions of copper and iron.

Armstrong reports that these trials showed cobalt responses in six of the seven trials conducted in the Glenavy, Fairlie and Orton districts. In three, where copper and iron were also used, the results were no better than for cobalt alone. In five of the trials an average gain in weight of 13.5 lb per head was observed for the cobalt-treated group as against 6.8 lb gain for the controls. In one trial where no worm drench was used the cobalt group gained only 3.3 lb while the controls lost 9.4 lb. All trials were conducted over eight weeks.

He summarises these results thus: "(1) The provision of cobalt is necessary on six of the seven farms. (2) The addition of copper and iron to cobalt was of no additional significant value. The results of liver examination from several farms were in agreement with this finding. (3) Worm control measures are essential when climatic conditions favour the development, survival and activity of gastro-intestinal parasites."

I would like to add to this by saying that from our own experience in the field in this area, there was a better-than-usual response to worm drenching and cobalt dosing; although I must admit that we made these recommendations, together with a change of feed, mainly because the farmer had to do something, and we didn't know of anything else he could do.

Trials at Lincoln

In co-operation with Dr Watkins of the Grasslands Section of the Crop Research Division of the Department of Scientific and Industrial Research, at Lincoln, we carried out a small trial this autumn designed to compare the rate of growth of groups of lambs on long and short pastures of mainly ryegrass and white clover. Another group was maintained on pasture consisting of legumes, i.e, lucerne, red and white clover.

Three groups of 15-20 good quality store lambs were rotated daily round some 28 one-twelfth of an acre plots of these three treatments. A cobalt trial was superimposed on this by giving half of each group a cobalt "bullet," kindly supplied by Nicholas Proprietary Ltd. This was not done for the purpose of overcoming a specific cobalt deficiency but in the hope that, if ill-thrift conditions did develop and the pastures became "toxic," adequate cobalt might prevent the condition in the same unknown way that it does in "Phalaris staggers."

The results can be summarised quite briefly by saying that no significant differences could be demonstrated between the treatments, in the gains made over some eight weeks. All of the lambs made good gains from 71 lb to 90 lb live weight.

In association with the grazing of these trial plots, Dr Watkins took the opportunity of developing a promising technique for measuring the density and height of the various pasture species, before and after grazing, for the purpose of assessing objectively what is eaten during the grazing period.

In another small observational trial at the College, we attempted treatment of some 21 "tail-enders" of a stud flock by putting them in sheltered pens and feeding them on lucerne hay and sheep nuts, after dosing with phenothiazine and inoculating them with rumenal contents from healthy sheep on three occasions. Most of the early deaths were due to pneumonia. The others made slow but steady gains over a period of two months.

A feature of these lambs, worthy of note I think, was that 17 out of 21 showed signs of sunburning of the ears and about half of them moderate to severe burning along the back. The photosensitisation of the ears and burning of the skin of the back in shorn lambs is not an uncommon finding in lambs affected with ill-thrift in Canterbury.

Trials of Winchmore Irrigation Research Station

Largely as a consequence of the results of the survey in Ashburton County last season, already mentioned, which indicated that less trouble occurred when pastures were controlled by heavy stocking, the trials at Winchmore were designed to study the effects on stock thrift and health of controlled and uncontrolled grazing under both irrigation and dry land farming.

The trials which were commenced in mid-October covered the following treatments:

1.	Controlled by stocking . .	5 ewes per acre
	Uncontrolled	2½ " " "
2.	Uncontrolled by stocking . .	2 " " "
	Controlled by mowing . .	2 " " "
3.	Controlled by stocking . .	4 " " "
	Controlled by mowing . .	2 " " "
4.	Irrigated pasture	
	Controlled by stocking .	6 " " "
	Uncontrolled . . .	4 " " "

All ewes had single Romney lambs at foot. Superimposed on these trials were various copper and cobalt treatments; the copper being injected as copper glycinate, and the cobalt given as cobalt "bullets."

The data of these extensive trials have not yet been subjected to critical analysis, but by kind permission of Messrs McPherson and Walker of the Winchmore Station, I have been supplied with a copy of the raw data and have discussed the general picture with them. They have graciously allowed me to present this general picture to you today. Obviously it is a little risky to present results before a detailed analysis of the data has been carried out, but with this proviso I am happy to give this short summary.

In general, the growth rate of lambs in all treatments was uniformly high up to weaning on 18th December and no differences of a significant nature were observed between treatments.

After weaning, again no unexplained changes in growth rate were observed in most of the dry land treatments.

On the irrigated plots, however, there was a distinct slowing up of growth which occurred quite suddenly, towards the end of January in the lightly stocked group; practically no increase in live weight took place in the two weeks after the weighing on 22 January. This check, however, did not persist for very long, normal gains being resumed without treatment of any kind. There is a suggestion of a similar but less obvious check occurring at the same time in some of the non-irrigated trials.

Some three weeks later, a marked depression in growth rate was observed in the irrigated, controlled grazing group, and this check persisted for a longer time, and coincident with it and later, deaths occurred in a relatively high proportion of the lambs.

Quite apart from the deaths, I believe that this picture is suspiciously like ill-thrift as it occurs in the field, and is the first occasion, to my knowledge, that it has been observed in controlled experiments in the South Island. It should be mentioned that none of the groups was given worm drenches.

Furthermore, while details of the cause of the deaths occurring have not yet come to hand, it is of interest to note that six out of 35 in the uncontrolled, and seven out of 35 in the controlled grazing groups died from some cause.

More interesting still, perhaps, is the fact that these two trials under irrigation had a cobalt trial superimposed on them, half of each group receiving a cobalt "bullet." Out of 35 lambs that received no cobalt, ten died or were killed, while only three out of the 35 that did get cobalt died; and according to Mr Walker, in two of these, the cobalt "bullet" could not be recovered at post-mortem examination. Such differences would appear to indicate some beneficial effect from cobalt.

There is one further observation that might usefully be made about this trial; under irrigation in the autumn, the uncontrolled pasture became quite long and consisted mainly of red and white clover, and even the controlled paddock, while much shorter, tended to become long compared with normal, heavily stocked pastures.

Discussion

The first essential in the intelligent discussion of any problem is the definition, in reasonably precise terms, of the things to be discussed.

So far as ill-thrift is concerned, we might very well adopt the classical nomenclature of veterinary science in such cases, and call it x disease—x being the unknown—if it were not for the fact that there are already too many of these in veterinary literature.

We do not really know what ill-thrift is, and I very much doubt if a veterinary pathologist could identify it. We must needs have recourse therefore to the method of identifying it by what it isn't or couldn't be, under the circumstances of its occurrence.

Unfortunately we do not know very precisely the conditions under which it makes its appearance. This is well illustrated by a comparison of the circumstances under which the disease occurs in the North Island and in the South.

Superficially at least, it would appear that in the South Island a major portion of the trouble is associated with spring pastures, and if the evidence from last season can be relied upon, much of the trouble cleared up with the freshening of pastures following autumn rains, the very conditions that apparently produce it in the North.

This perhaps is not unexpected, for we all know that the North Island is really different in many respects. By and large it gets Facial Eczema and we do not, while White Muscle disease is becoming increasingly important here, and is practically unheard of in the North. It is true, of course, that we get ill-thrift here also in the autumn, but under somewhat different circumstances.

If we use the definition quoted earlier that ill-thrift is "an inability of stock to thrive in the midst of apparent plenty, and in the absence of obvious parasitic disease, trace element or vitamin deficiency and other known causes," we are still in a quandary. This might apply to the North Island, but if this season's evidence of the beneficial effects of worm drenches and cobalt supplements is reliable, it would seem risky to apply it to the South. Furthermore, while the evidence from controlled experiments in the Waikato shows that the great majority of affected lambs regain their appetite and commence to thrive when put on long mature pasture, field observation in this area indicates that when their appetite is decreased, very often they cannot be induced to eat anything in reasonable quantities; and it is hard to believe that everything is unpalatable. It seems more reasonable, under these circumstances to assume that there is something wrong with the animal rather than with the feed.

Now is it possible to resolve these apparent anomalies, and see some pattern in the multitude of observations and experiments that would suggest that we are in fact dealing with a single entity, called ill-thrift?

It is quite obvious that there are a large number of diseases and conditions that can be primary causes of unsatisfactory gains in young sheep. For example, stomach and intestinal worms, lung worm, cobalt deficiency, white muscle disease, pulpy kidney disease, footrot, external parasites, arthritis, scabby mouth, pink eye, ricketts, coccidiosis, sunburning, pleurisy and pneumonia, lack of feed and bad management.

In any flock of lambs we find a "tail-end" that are suffering from one or more of these conditions, and they are not going to do very well in any case, but usually the cause is identifiable.

The three most likely things, however, to cause a severe check over the whole of the flock are, I believe, cobalt deficiency, heavy worm infestation and bad feeding and management. Omitting the last, because few would admit it anyway, we are left with cobalt deficiency and worm parasites, both of which can be primary causes of failure to thrive. Obviously, therefore, if specific measures are taken to treat these conditions there will be an immediate response.

As far as heavy worm infestation is concerned, in addition to its occasional primary role, it is well known as a secondary complicating factor in cobalt deficiency, and in lambs checked for any other reason. It is rational, therefore, to expect at least a partial response to efficient worm treatment in such cases.

I think it is possible to explain on this basis the response to phenothiazine reported from South Canterbury this season, together with the additional benefit accruing from the change to other feed that almost certainly took place at the same time.

The situation regarding cobalt responses is a little more difficult to explain. It is well known that heavy liming reduces the availability of cobalt and certain other trace elements; so that there may actually be a specific, induced, marginal deficiency of cobalt on such country which shows up clearly only under conditions of vigorous pasture growth and is therefore seasonal in occurrence.

There is, however, one other way, I think, that the beneficial effects of cobalt could be explained, but I must admit that there is no evidence for this hypothesis.

It has been demonstrated that quantities of cobalt, perhaps above those required to prevent a specific cobalt deficiency, protect sheep against the condition known as "Phalaris staggers." In some as yet unknown way, the additional cobalt leads to the destruction of the toxic substance in Phalaris that causes the staggers.

Is it not possible, if ill-thrift is due to some toxic substance in pasture under these peculiar conditions of growth, that a similar detoxicating action could occur in the presence of additional cobalt? This might explain the observed responses to cobalt on pastures that have a cobalt content sufficient to prevent a specific cobalt deficiency.

Whether cobalt supplements operate in this way or in overcoming a specific cobalt deficiency, is not clear; but it is of interest to note that Andrews and his co-workers have shown that symptoms of cobalt deficiency, on cobalt deficient country, are less severe when pastures are close grazed. This they believe to be due to the eating of more soil with the pasture when it is short, and since soil contains more cobalt than pasture, the intake of cobalt is higher.

Furthermore, this hypothesis is in line with the observations reported in the outbreak of ill-thrift in the Ashburton County last season, in that much less trouble was experienced on pastures that were well controlled by heavy stocking.

Apart from a cobalt "deficiency" of some kind, for which I think there is a good deal of evidence, and which I think is responsible for quite a lot of the ill-thrift in Canterbury, I believe it is possible to postulate a primary condition of ill-thrift that fits reasonably well into the picture as it occurs throughout New Zealand.

In general, widespread outbreaks of ill-thrift are almost invariably associated with two things:

1. an unusually rapid growth of pasture, and

2. weather conditions that are damp, overcast and often, but not always, warm; and these two things do not necessarily occur together.

How often does one hear, under such conditions, the expression: "If only we could get a few sunny days to harden off the feed, everything would be all right." We don't know why, but it usually is all right, and we don't know whether or not it is due to the "hardening off" of the feed. Under these conditions pasture, and even forage crops, are either unpalatable so that stock do not eat them or injurious or "toxic" when they do, and the stock are checked.

If the check is continued long enough, for some unknown reason, secondary complications develop in the form of worm infestation, lung and bowel infection, scouring, dehydration, depraved appetite with the eating of dirt and all kinds of rubbish. The food eaten passes through such lambs at such a rate that they cannot utilise it; there is a loss of minerals from the body and an upset in metabolism that leads to death.

As far as minerals and trace elements are concerned, in the South Island, the situation can only be described as chaotic. Clearly something must be done about it soon, if farmers are going to avoid unnecessary expense and, in some cases, perhaps, avoid doing irreparable harm to their soils in well-intended but misguided attempts to solve the problems confronting them themselves. At the moment, ill-thrift is inextricably bound up with trace-element theory.

Theories are not enough in this most important problem. These theories must be tested. They can only be tested by more intensive scientific research. The answer is obvious.

Before closing I would like to acknowledge the generous assistance given by the following people in providing information for the preparation of this paper:

The officers of the Winchmore Irrigation Research Station, the officers of the Economics Section of the Extension Division of the Department of Agriculture in Christchurch, the officers of the Animal Industry Division of the Department of Agriculture, Timaru; many farmers in Canterbury; and the co-operation of the Grasslands section at the Crop Research Division of the Department of Scientific and Industrial Research at Lincoln with the officers of the Veterinary Department of this College in the ill-thrift trials done at Lincoln.

Question: Is ill-thrift in lambs infectious? If not, how would you explain a farmer putting lambs on rape where the lambs were already dying, then as soon as the lambs get there they die?

Dr McLean: I do not think there is any information that ill-thrift is infectious. Probably the same factor which gave rise to ill-thrift in the first mob of lambs caused the ill-thrift in the others.

Question: Is it considered that there is any possibility of connection between South Island ill-thrift and pulpy kidney? There is some evidence that farmers in 1957 inoculated lambs after weaning for pulpy kidney and these lambs did not suffer from ill-thrift.

Dr McLean: From experience in the field there does seem to be an association between early stages of ill-thrift and outbreaks of pulpy kidney disease. In our own stud flock last season we had a check in the growth of stud lambs well before weaning started, about November through to December. In late December we had lambs looking miserable and some died. From Christmas through New Year to mid-January we had a cessation of this sort of loss but had a number of deaths from pulpy kidney disease.

Dr Cunningham: At Wallaceville on looking at stomach contents of lambs with ill-thrift, we found the pulpy kidney organism. We tried to protect against ill-thrift by vaccinating against pulpy kidney but without success.

Question: You touched on the iodine content of most of our grasses and legumes. We are specially interested in lucerne. Have you an analysis on the iodine content of lucerne?

Dr Butler: We have not, mainly because we do not grow it in the North Island. I hope to remedy that shortly.

Mr Slater: In Canterbury farmers need adequate diagnostic facilities here in our midst where we can take ailing animals. It is no good waiting until the animal dies and then carting them up north. We need a local diagnostic centre. We want a diagnostic centre in Canterbury where we can concentrate the effort of all the brains on the problem.

Dr. McLean: It is fairly apparent that there are differences between ill-thrift in the north and south. Are we to infer that a major cause of ill-thrift is cobalt deficiency?

Dr Cunningham: A lot of Canterbury seems to have fairly stony soil; most stony soils are likely to be cobalt deficient. If on Lismore, stony silt, loam and similar soils, lambs do not do well, the first guess is that you might have cobalt deficiency. You should do the experiment mentioned in the paper.

Question If you do a cobalt trial and lambs still are dying, what then?

Dr Cunningham: I cannot tell. If they are dying of ill-thrift I cannot tell you what to do. The practice in the North Island is to put them on long pasture, in the South Island on short pasture.

RECENT KNOWLEDGE OF TRACE ELEMENTS AND ANIMAL HEALTH

I. J. Cunningham, Wallaceville Animal Research Station, Department of Agriculture.

Though I have been asked to deal with the recent advances in our knowledge of trace elements and animal health, I shall not be able to keep to these alone. New knowledge is coming too slowly to give enough material for a whole talk. I have to include some of the older material to give a proper background, and I hope you will forgive me if I repeat things you already know.

I have restricted myself to those trace elements that are of direct concern to farm animals and these are iodine, cobalt and copper with molybdenum associated. Zinc has been touched on briefly also because it has become of importance in pig raising in overseas countries.

Iodine

Iodine deficiency causes goitre, which is a condition familiar to most of us and recognisable by a swelling in the throat region caused by enlargement of the thyroid gland.

In New Zealand, sheep are the most frequently affected, though cattle, horses and pigs are all susceptible. Further, amongst animals it is the newly born which is by far the most susceptible. For practical purposes, therefore, goitre in farm animals in this country can be taken as a disease of newly born lambs.

The swelling in the throat region has already been mentioned as the most characteristic sign of the disease. Some of the affected lambs, especially those in which the thyroid is grossly enlarged, may be dead at birth, or die soon after; others in which the condition is not quite so severe may die up to within about three days of birth; those that survive for three days usually recover.

In a very few cases lambs are born dead with less than the usual covering of wool. This has been taken to indicate abortion, but abortion does not, in fact, occur. On the contrary where accurate records of gestation periods have been taken, as by workers in the United States, and by Sinclair and Andrews (N.Z. Vet. Journal 1954, p. 72) in New Zealand, it has been found that gestation is actually prolonged by several days.

Lambs that live more than about three days after birth will survive and grow satisfactorily. In fact, Sinclair and Andrews have shown that they will grow and fatten as well as lambs in the same flock in which goitre was prevented by dosing iodine to their mothers before the lambs were born. It is because lambs that survive the birth process will do well without treatment, and because adult sheep can have moderately enlarged thyroids without ill effect on wool growth or health, that the disease is stated to be of most significance in the newly born. But this makes it of no less importance economically, as losses in new born lambs can be very heavy indeed.

Regions where Goitre Occurs

Our present information on places where goitre is likely to occur comes from two sources. The first is from records of all the cases of goitre that have been reported by field officers of the Department of Agriculture and by club veterinarians; the second is from analyses of thyroid glands collected from lambs slaughtered at freezing works. This analytical work, summarised by Waters in N.Z. Journal of Agriculture, February, 1939, showed those districts where lamb thyroids are low in iodine content. The results of both these studies have been brought together and placed on a map which appeared in N.Z. Journal of Agriculture for December, 1955. That map shows that goitre has occurred in parts of Southland and Otago, extensively in North and South Canterbury, in Westland, Nelson and Marlborough—all in the South Island, and in the districts of Gisborne, Hawkes Bay and between Palmerston North and Wanganui in the North Island.

Goitre is generally attributed to deficiency of iodine in the feed. There seems to be no doubt that this is one cause, but there can also be another cause. That is the presence in the food of substances that interfere with the use of iodine, either by preventing the thyroid gland from collecting iodine from the blood, or by preventing the change of collected iodine into the thyroid hormone.

Our information on the occurrence of these interfering substances in fodders is yet quite incomplete, but there seems to be no doubt from the work of Wright at Wallaceville and others that Brassica crops contain such substances.

The places where goitre is likely to occur, because of iodine deficiency in the diet, are most likely to be included in the goitre map references. Goitre in lambs could occur almost anywhere that the ewes were wintered on Brassica crop.

Control of Goitre

Goitre is controlled by feeding iodine and, since the new born lamb is the most susceptible, it is essential that iodine be given to the pregnant ewe, so that it can reach the developing lamb before birth. The most effective time is the latter half of pregnancy, as at this period the thyroid of the foetal lamb is forming.

Iodine cannot be supplied economically by topdressing pastures or crops with iodides, and must, therefore, be given directly to the animal. Up to the present the usual method has been in licks, and potassium iodide has been the compound most frequently used. This compound is unstable when exposed to weather and iodine may be lost, so that the lick, as actually consumed by stock, could be supplying no iodine. To overcome this in the past iodide was stabilised, or the amount of potassium iodide was increased. Neither method was fully effective. Potassium iodate is another compound which is a suitable source of iodine for stock, and is, moreover, stable when exposed in licks. The use of this compound is now insisted upon by the Stock Remedies Board, and licks are a much more effective source of iodine.

Licks have other disadvantages besides the possibility of loss of some of the important constituents. Their cost is not inconsiderable and the labour cost of maintaining lick supplies to stock is also an important factor. To avoid this, Sinclair and Andrews have examined the effectiveness of drenching iodine compounds to ewes, as a method of preventing goitre in their lambs. Their experiments were carried out on ewes which were run on kale during some of the latter half of gestation, and in which the occurrence of goitrous lambs was very high when no treatment was given. After a number of trials, they found that two drenches of either potassium iodide or potassium iodate, one administered to the ewe in the fourth, and the other in the fifth month of pregnancy was an effective means of preventing losses in the lambs. Goitre in the lambs was practically eliminated, except for a small degree of enlargement of the thyroid gland in some lambs. This had no ill effect on health or growth. The dose used was 280 mg. of potassium iodide or 360 mg. of potassium iodate. This means that one ounce of potassium iodide would be sufficient to give one dose to each of 100 ewes, and one ounce of potassium iodate would be sufficient for one dose for each of 80 ewes. This method of control can be strongly recommended to replace licks. Labour demand is not high because at least one muster is carried out for crutching or prelambing shearing, so that there is only one extra muster involved. This extra labour, moreover, is not likely to be more than that entailed in providing licks. The important thing is that every sheep is treated with the correct amount of iodine and none are missed, as could happen with licks if some ewes did not eat the licks. Furthermore, the money spent is on the essential element, iodine, and not on the lure or the diluting substance, which forms by far the greater part of the lick.

Goitre is fairly straight-forward. The disease is important for the newly-born lamb, but can be prevented by feeding iodine in licks or by drenching. Preventive treatment must be given to the in-lamb ewe.

Cobalt

Cobalt deficiency of cattle and sheep, in the severe form first known as bushsickness, is no longer a problem. In bushsickness, as many will remember, there was loss of appetite, wasting, and often death within a few months of the animal going on to the deficient area. The condition, in fact, appeared to be chronic starvation, even though there was plenty of feed available. The discovery that cobalt feeding would cure, or prevent, the disease, set off a train of experimental work that quickly turned up effective and cheap methods of control. It was found that cobalt could be mixed with fertilisers and used as a top-dressiing to increase cobalt in the pasture, or that cobalt could be successfully used in licks, or given directly to animals in drenches. The use of these methods, wherever bushsickness occurred, quickly controlled the more easily recognised severe forms.

One of the most important recent advances is the recognition that cobalt deficiency does not occur only in this severe form. There are milder and more insidious forms of deficiency in which the result is not necessarily death, but may merely be unthriftiness or reduced rate of growth. Moreover, the reaction to this milder deficiency differs according to species and age: Cattle are less susceptible than sheep, and adult sheep are less susceptible than lambs. In consequence lambs can be unthrifty through shortage of cobalt on the same farm where adult sheep and cattle are healthy. The effect is most obvious after weaning, and often results in a bigger "tail" of unthrifty lambs, and sometimes some deaths.

Recognition of this form of cobalt deficiency is not easy because the unthriftiness can readily be confused with unthriftiness from other causes, such as lack of feed, parasitism, or hogget unthriftiness of unknown origin. There are some points that can be of help in the diagnosis. If young sheep are healthy while adult sheep or cattle are unthrifty, cobalt deficiency is excluded. On the other hand, if young stock are affected while adult animals are healthy, the possibility of cobalt deficiency exists. Of course, these considerations alone are not enough to establish a diagnosis of cobalt deficiency, and some other aid to diagnosis is necessary.

Analyses of pastures, or of livers of lambs, help in diagnosing cobalt deficiency, but such analyses are costly and slow and may be inconclusive in the case of borderline deficiency, unless a number are carried out. The best diagnostic aid, and the most certain sign of cobalt deficiency, is the response in appetite and growth when cobalt is supplied to deficient animals. Certain precautions have to be observed when dealing with a mild deficiency because the response to dosing is likely to be small. What amounts to a proper experiment must be run, and a suitable test would include two lots of about 20 lambs each, starting shortly after weaning. One lot of lambs should have regular doses of cobalt as a drench, or be given a cobalt bullet (to be described later) at the beginning. Both lots should be weighed at the start and after about 2 months of treatment. If there is an average difference of about 6 lbs. in growth in favour of the treated animals cobalt deficiency is confirmed.

A correct diagnosis of cobalt deficiency carried out by the methods described is necessary before control methods are applied. When a diagnosis is reached, control is effected by supplying cobalt by mouth. No other way of administering it to animals is of any use. The use of drenches, licks and topdressing have already been mentioned, and indeed these are well known in agriculture in New Zealand. Drenches are impracticable for any sustained programme of control; licks containing 4 oz. of cobalt sulphate per ton are satisfactory for cattle or sheep, provided they are available all the year round, though all stock do not eat them; while topdressing at the rate of 5 oz. cobalt sulphate per acre once per year has been found a most effective control measure.

Autumn topdressing is satisfactory where grassland feeding is carried on, but where ewes are held on crops over winter, the effect of cobalt topdressed on to pastures in autumn is gone by late spring, when lambs need the cobalt. If ewes have been wintered on crops, cobalt may need to be applied in spring.

A new prospect for control of cobalt deficiency in sheep is the cobalt bullet mentioned above. This is a hard dense cylindrical mass ½in. long and ½in. in diameter, containing 90 per cent. cobalt oxide baked hard with 10 per cent. clay. The bullet is heavy and in most cases will remain in the paunch of sheep. While it is there minute amounts of cobalt are dissolved each day and are used by the host sheep. The 'bullet' was first thought of and developed in Australia, and has had extensive testing there: it has also been tested in New Zealand by Andrews.

The work on cobalt bullets is in its early stages both in Australia and New Zealand, and a good deal more experience in their use is needed.

The bullet has a special interest in Australia for the control of phalaris staggers—a disease of sheep grazed on phalaris tuberosa. This disease can be controlled by increasing the daily intake of cobalt and this is efficiently done by use of the cobalt bullet. We have had a few cases of this disease in New Zealand, some in this district, and more cases are likely to occur if more phalaris tuberosa is grown.

At present it is known that the bullet is a satisfactory source of cobalt for as long as it remains in the sheep. Just how long it will be effective has still to be learned, but it could be expected to last more than a year. About five per cent. of sheep regurgitate the bullet in this time, and in a similar small percentage there is a deposit formed over the bullet which prevents solution of the cobalt. If bullets are used these small numbers of sheep which lose them, or coat them, will fail to get cobalt, and in this respect the bullet is less effective than supplying cobalt by topdressing. On the other hand, the per cent. of failures with the bullet is probably about the same as when licks are used. Cost is another consideration: the application of

5 oz. of cobalt sulphate per acre costs about 2/6d. in the South Island, and a bullet costs 1/-. Thus, when there are more than three sheep per acre the use of topdressing is the more economic, whereas the bullet will be much more economic on extensively grazed hill country.

For carrying out diagnostic tests such as those mentioned earlier, the bullet obviously has a great value, as the supply of cobalt can be made with one handling of the experimental sheep, and the weekly yarding necessary with drenching is avoided.

There is no information yet of what will happen to the cobalt bullet in cattle, or how good it is for supplying cobalt to these animals. This must be found out because if the bullet replaces topdressing on land severely deficient in cobalt, treatment of cattle as well as sheep will become necessary.

Cobalt deficiency occurs on considerable areas in North Auckland, East Cape, King Country, Hawkes Bay and Wairarapa in the North Island, and in Canterbury, Otago, Southland and Westland in the South Island. More detail of the distribution is given in Bulletin No. 180 issued by the Department of Agriculture, and in an article by Andrews in Journal of Agriculture for March 1956.

Not even this detail is sufficient to show the individual farms on which cobalt deficiency exists. Deficient farms are continually being found both within the areas mentioned and outside them. It is safe to suggest that on every farm where weaned lambs constantly fail to thrive, the possibility of cobalt deficiency should be considered. The cobalt bullet gives a valuable help towards diagnosis in such cases, and correction of the deficiency by one of the means available can give a very welcome improvement in lamb health.

Copper and Molybdenum

Copper deficiency in this country is of two types, the first a straight out deficiency, and the second a lesser degree of deficiency of copper which is aggravated by high molybdenum. The straight deficiency occurs on some peat and sandy soils and the deficiency aggravated by molybdenum occurs on most peat soils, on some of the pumice soils in Wairoa, Taupo and Taumarunui districts, on river silts and on some other soils which are described in Journal of Agriculture February 1955.

When ewes are copper deficient their lambs have thin bones, and in many of these there may be fractures, or else some of the young lambs may develop ataxia, which is a sort of paralysis usually affecting the hind legs. The wool of Merinos or half breds loses its crimp, but this has not yet been observed in New Zealand in British breeds, though it does occur in these breeds in Australia. There is no clear evidence that unthriftiness of hoggets results from copper deficiency.

In cattle copper deficiency causes unthriftiness, anaemia and loss of coat colour. Young cattle are more susceptible than older ones.

A shortage of copper, complicated by extra molybdenum, in cattle produces poorly developed calves, in many of which bone fractures occur; intense spring scouring in calves and older cattle, loss of coat colour, and reduced production. Usually scouring ceases, the cattle improve in condition and production increases in the summer period, when molybdenum content of pasture falls.

The position regarding sheep on pastures containing high levels of molybdenum is not entirely clear. On some such areas sheep do well even though cattle on the same farms may be badly affected. On other areas there is ataxia in some of the lambs, and in still other areas hoggets have fragile bones and are unthrifty. That is, the results on these places are the same as from straight deficiency of copper. Why extra molybdenum should do this on some places and not on others is unknown at present.

At this point some comment might be made on the relation between copper and molybdenum, because this is rather complex. These two substances are antagonistic to one another in animals. Copper is essential for a number of processes inside animals; molybdenum in sufficient amount can tie up the copper so that it cannot carry out these essential functions. If there is enough molybdenum the copper can even be pushed right out of the animal. But molybdenum cannot do this by itself, it must have another compound called sulphate to help it before the copper can be expelled. Sulphate is a compound of sulphur and oxygen and occurs in most foods, including most pastures that have been topdressed with super.

If there is enough copper in the diet of the animal, the effects of molybdenum or of molybdenum plus sulphate are neutralised. In effect there is a state of balance within animals and the result depends on the relative amounts of copper, molybdenum and sulphate. If there is a normal amount of copper in pastures, the grazing animal is normal unless the molybdenum content is very high; if the copper is low, the amount of molybdenum which is harmful is very much smaller. This explains the danger from excess of molybdenum, when this occurs on land that is already deficient in copper. Sulphate can be regarded as present in all of our pastures, except at the times when these are practically pure clover.

These relationships between copper, molybdenum and sulphate seem to work out fairly well in practice with cattle, but the situation is not so clear with sheep. Extra molybdenum and sulphate in the sheep's diet will deplete copper. So far in our experiments at Wallaceville raising molybdenum in the diet has not brought about the disease in lambs or hoggets that has been observed in other districts, even though the dietary molybdenum has been raised to high levels. There must be some other factor at work besides the copper, molybdenum and sulphate. In attempts to find what this is many things have been tried but so far with no success.

The recognition of copper deficiency is made from the symptoms outlined, and can be confirmed when necessary by chemical examination of livers for copper, or of pastures for copper, molybdenum and sulphate. Generally such examinations are unnecessary as the disease symptoms, along with location of the farm, are sufficient to make a diagnosis.

The control of copper deficiency is simply and efficiently achieved in most cases by topdressing the whole farm each year with 5 lbs. bluestone per acre. There are other methods, such as the use of licks or drenches, which can be employed to meet special cases. Such methods are described in J. Agric. for April 1954.

A new method that has certain advantages, the injection of a copper compound subcutaneously into sheep or cattle, is described in N.Z. Journal of Agriculture September 1957. The compound employed is copper glycinate and this is mixed into a paste, sterilised, and put up in small tubes each containing one dose. Such a preparation is convenient, clean and safe. Two dose levels are employed, that for sheep gives 45 mg. of copper, and that for cattle 120 mg. of copper. The cattle dose could be poisonous to a small sheep. For sheep the preparation is designed only for ewes. It is used for prevention of ataxia in their lambs and should be given to the ewe not more than once a year, and at some period at least a couple of months before lambing. For cattle the preparation is suitable for all ages and types and for protection against copper deficiency or such deficiency aggravated by excess of molybdenum. The dose is effective for about 3 months in young animals, and about 6 months in adults.

Over 70 per cent. of the injected copper reaches the liver within 2 or 3 weeks of dosing, and thus the method is highly efficient. There is some local damage at the point of injection which must be taken into account in its use. A swelling persists after subcutaneous injection for several weeks, but eventually subsides in most cases—in a few there is some discharge and this happens more often in sheep than in cattle. There is no permanent damage and any blemishes present when the animal is slaughtered can be trimmed.

The method has value in a few areas, notably some of the volcanic ash showers and some river silts on which the effect of topdressing by copper salts is short lived. It is also suitable as a cheaper method than topdressing when the density of stock needing treatment is low. This occurs on areas where cattle are affected by molybdenum poisoning, but sheep on the same farm are not. The cost of correcting disease in cattle in such circumstances would be very high if topdressing were employed.

Zinc.

My remarks so far have concerned trace elements that are deficient, or occur in excess, in the ordinary foodstuffs that are available to farm animals. Until recently the only comment on zinc in this connection would have dealt with poisoning of pigs when excess zinc was dissolved from zinc lined pipes by skim milk pumped through these pipes to feed the pigs.

Now another interesting disease has been associated with zinc, but this time with not enough zinc. The disease affects pigs and has been observed in a number of parts of Europe, Britain and the United States. It is called para-keratosis and the symptoms are a dermatitis not unlike the result of mange infestation, impaired growth or loss of weight, loss of appetite and sometimes vomiting and diarrhoea. The full range of symptoms does not always occur and the most usual are dermatitis and failure to grow.

The disease occurs in most cases in pigs kept on dry rations under self-feeding conditions, and is prevented if the ration is fed wet. It is aggravated when the content of lime or phosphate in the ration is increased by adding chalk or steamed bone flour.

Addition of zinc to the ration also prevents the disease.

At this stage para-keratosis is not regarded as a simple zinc deficiency, because it will occur on rations that contain 30 to 40 ppm of zinc, and in such cases is not prevented until the additions of zinc raise the level to about 100 ppm in the diet. These quantities are very much above the level on other rations known to maintain pigs in health. It is considered that the lime and phosphate in the ration in some way tie up the zinc and make it unavailable to the animals.

So far we have had no cases of parakeratosis in pigs in New Zealand, and the disease has been mentioned very briefly and as a matter of academic interest only.

Perhaps I could finish off by recapitulating the more important recent advances in our knowledge of trace elements and their relation to animal health.

One new element, zinc, has been added to the list that must be considered in the commercial handling of farm animals. The dry meal self-feeding management most commonly associated with parakeratosis is not practised in New Zealand, so the risk of meeting the disease here is small.

Cobalt deficiency can be mild and cause no more than a slightly reduced rate of growth in lambs. Failure to recognise this might cause appreciable loss in carcase weights. Extra cobalt too has been shown capable of preventing phalaris staggers in sheep.

A most important feature is the accumulation of still further information pointing to the fact that the story of a trace element is not always simple. It is not a question of deficiency, or excess, purely on a quantitative basis, because other substances in the diet can alter the picture completely. For example, interfering substances (goitrogens) in the diet can convert a sufficiency of iodine to a deficiency; extra lime or phosphate can convert a sufficiency of zinc to a deficiency; extra molybdenum and sulphate can induce a copper deficiency. These points have an academic interest and a very practical one also. For they show that feeding of extra trace minerals, or indeed of any minerals, should be undertaken with care and to meet a need, otherwise harm might be done by inducing a deficiency.

In the control of trace element deficiencies attention has been turned to their administration direct to animals. Methods have been devised for iodine, for cobalt and for copper, and each has certain advantages over some of the ways previously used.

Question: Have any recent experiments been done regarding the aerial application of cobalt at 5 oz per acre without a filler?

Dr Cunningham: At Taumarunui we applied 20 oz cobalt per acre dissolved in water to see if the effect would be lasting. It controlled the cobalt deficiency for three years.

Question: What proportion of the ground of any one paddock would it be necessary to cover to save spraying?

Dr Cunningham: At a guess I would say from 50 to 60 per cent. of the area would probably be alright. There have been no experiments based on that point. If you can't get a reasonable spread I would suggest you use a better method.

Question: If you topdressed lucerne with cobalt before cutting for hay could you get sufficient intake of cobalt for stock?

Dr Cunningham: I imagine it could be done. Legumes are normally high in cobalt and if you feed lucerne hay you would probably get enough cobalt. You can increase the cobalt content of most grasses by topdressing but I imagine it is an uneconomical way of doing it. When feeding the hay it would be better to use licks or bullets.

Question: What is the earliest age you could give bullets to lambs?

Dr Cunningham: About two months would be satisfactory. It should be when the rumen is formed. It is not often you get response in lambs as young as that. Cobalt has to be very deficient to need it as young as that.

Question: How long would you wait to get an effect from a bullet before you saw an improvement?

Dr Cunningham: You may not see any effect at all. You would have to weigh them to see the difference. The bullet is effective in 24 hours and after three or four weeks the animals will be well recovered.

VACCINATION OF LAMBS AGAINST INFECTIOUS EPIDIDYMITIS

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The economic importance of infertility in the sheep industry is well appreciated by farmers, veterinarians and research workers. Recent research in New Zealand has shown that infectious diseases contribute significantly to these losses. During recent years, more intensive research has been concentrated on *Brucella ovis* infection of sheep. Infection of sheep with this bacterium, which is closely related to the organism causing brucellosis or contagious abortion in dairy and beef cattle, is widespread in New Zealand, Australia and almost certainly in other major sheep raising countries. The disease has most serious and lasting effects on the fertility of rams, many affected animals being rendered permanently sterile. Infection is excreted in the semen of infected rams following localisation in the genital organs.

A significant percentage of rams infected with this organism show obvious abnormalities of the genital organs. One of the commonest abnormalities, that can be palpated within the scrotum or purse of the ram, is a swelling of the tail of the epididymis, an organ attached to the base of the testicle. Inflamation of this organ is referred to as epididymitis. All abnormalities of the epididymis are not invariably caused by *Br. ovis* infection, but in New Zealand the vast majority of cases are due to this specific disease. Further, all infected rams do not show such abnormalities of the genital organs that can be readily recognised by palpation.

This disease constitutes a major cause of ram wastage. Ewes may also become infected with the disease and deliver dead lambs up to full term, or weakly lambs which may die within a few days of birth.

Infection of sheep with *Br. ovis* may be described as a venereal disease, as infected rams have been shown experimentally to transmit infection to clean ewes at tupping. Tupping also provides the greatest opportunities for spread of infection from infected to clean rams. Clean rams have been shown to readily acquire infection following mating to ewes which have been served recently by infected rams. Also clean rams may acquire infection from diseased rams even in the absence of ewes. The common habit of rams jumping one another is responsible for the dissemination of infective semen and the consequent infection of clean rams through mucus surfaces such as the rectum, sheath, eye, nostril or mouth.

Experimental transmission trials have shown that rams and pregnant ewes may become infected following drenching with *Br. ovis* organisms. In other experiments, where non-infected rams and pregnant ewes were grazed on pastures intentionally heavily contaminated with diseased afterbirths, none of these animals developed infection. However, the possibility is not excluded that individual rams and ewes may become infected by grazing contaminated pastures.

Ram lambs, as young as eight weeks of age, have been shown to be susceptible to experimental infection. On the other hand, active disease did not develop subsequently in an experimental group of ram lambs which were delivered and reared by a number of actively-infected ewes.

Active infection is more persistent in rams than in ewes. In one experiment a group of ewes, all of which had diseased membranes at their first lambing, was observed over subsequent years. Only 16 per cent. of the ewes had diseased membranes at their second lambing, and at their third lambing all ewes had normal membranes. Rams mated to these ewes subsequent to their first lambing, failed to develop active infection.

Some attention has been directed at the treatment of affected rams. In view of the encouraging results using aureomycin, particularly when combined with streptomycin, in human Brucella infections, this form of treatment was tested on a small group of experimentally-infected rams at Wallaceville. Two other simpler and less-expensive forms of treatment were applied to other groups. Aureomycin plus streptomycin was the only procedure which eliminated infection in all the treated rams. Treatment of individual animals of special value would have greater appeal if more economical and convenient forms of treatment were available which, in addition to eliminating infection, resulted in the animal regaining unimpaired fertility.

What methods of control are available in the light of our knowledge of the disease? We know that a significant proportion of infected rams can be detected by palpation of the scrotum. These rams are of doubtful fertility and serve as reservoirs of infection for clean rams and ewes. Obviously these rams are better culled from the flock. Unfortunately, a number of infected rams do not exhibit obvious abnormalities of the genital organs in spite of being capable of transmitting infection in the semen. It is possible for these rams to be identified by laboratory examinations conducted on semen samples collected by electrical stimulation. For very practical reasons it is not possible to apply this supplementary method of diagnosis on a very extensive scale. However, by the institution of annual, or even more frequent, veterinary examinations of the ram flock, and culling of the rams with obvious genital abnormalities, the incidence and spread of the disease has been substantially reduced on many properties in New Zealand.

Spread of infection may also be controlled by rigid isolation of the younger, clean rams from the older rams. Infection can develop in ram hoggets and virgin 2-tooth rams following contact with older, infected rams and every effort should be made to avoid such contact. Also, young rams have been protected from contact with heavy infection during the tupping season by ensuring their segregation from the older rams, or by confining their mating to ewes of their own age.

As soon as the infective nature of the disease was established, research was undertaken at Wallaceville to develop methods of conferring immunity or resistance on sheep against the disease. A reliable method of vaccination would greatly facilitate control of this widespread disease.

In experiments extending over four years, attention was first directed at the development of vaccination procedures which would confer a high degree of immunity against controlled experimental infection. In preliminary trials, rams and ewes were inoculated with a variety of vaccines, either singly or in various combinations. Vaccinated and non-vaccinated animals in the various groups were later exposed to severe infection by the intravenous inoculation of virulent *Br. ovis* organisms. The procedure which consistently conferred the most effective protection was the simultaneous inoculation of *Brucella abortus* Strain 19 and a special vaccine prepared from killed *Br. ovis* organisms. Strain 19 is the vaccine used for the protection of cattle against contagious abortion and is a suspension of living but non-virulent organisms. This vaccine was shown to be incapable of causing active disease in rams or ewes. The special *Br. ovis* vaccine contains chemically-treated and killed organisms in an emulsion prepared from mineral oil. This method of preparation of the vaccine greatly improves its efficiency, so consequently this type of product has been called an "adjuvant vaccine."

Field trials to determine the efficiency of vaccination procedures for disease control were initiated in 1955. Following successful preliminary field trials, two large-scale experiments were conducted in 1957. The more intensive trial was conducted in the Rotorua district through the collaboration of the Lands & Survey Department. Flocks were selected for inclusion in the experiment on the basis of high incidence of epididymitis in the rams. Ten weeks prior to the commencement of tupping the recently-purchased 2-tooth rams in each flock were divided into three groups of approximately equal numbers and treated as follows:

1. Adjuvant vaccine plus Strain 19.
2. Adjuvant vaccine alone.
3. Left unvaccinated as controls.

To ensure that the 2-tooth rams were exposed to intensive infection during their first tupping season, the infected older rams were intentionally retained in the flocks, and rams of all ages were run together during tupping. Prior to commencement of tupping, the incidence of clinical epididymitis in the older rams in the various flocks visited varied from 13 to 36 per cent., the average incidence being 18.6 per cent (113/606).

Twelve weeks from the commencement of tupping, clinical examinations were conducted on all 2-tooth rams, and, in addition, semen samples were collected for bacteriological examination from the rams by electrical stimulation in three of the four flocks.

The incidences of clinical epididymitis in the 2-tooth rams in the three groups were:

1. Double vaccination	1.0 per cent.	(2/208)
2. Single vaccination	7.2 per cent.	(14/193)
3. Non-vaccinated	21.3 per cent.	(50/235)

Both vaccination treatments afforded significant protection on rams against exposure to heavy infection, but the double vaccination provided a significantly-higher degree of immunity. Similar results were observed when comparisons were made of the numbers of rams in the three groups which were secreting infection in the semen. The percentages of infected rams in the three groups were:

1. Double vaccination	5.5 per cent.	(8/146)
2. Single vaccination	16.0 per cent.	(21/131)
3. Non-vaccinated	43.2 per cent.	(76/176)

A more extensive trial was run concurrently with the collaboration of local veterinary surgeons in a number of privately-owned flocks showing high incidences of epididymitis. In this trial approxmately half of the 2-tooth rams were immunized with the adjuvant vaccine alone and the others left untreated. Older rams showing clinical epididymitis were culled from the flocks prior to the commencement of tupping. Arrangements were made for the 2-tooth rams to be run together with the older rams during and subsequent to tupping to ensure adequate exposure to infection. Four weeks after the conclusion of the tupping season, clinical examinations for epididymitis were conducted on the vaccinated and non-vaccinated rams by the co-operating veterinary surgeons. The incidences of epididymitis in the various groups of rams post tupping were.

2-tooth rams		
1. Adjuvant vaccine alone	6.7 per cent.	(44/659)
2. Non-vaccinated	16.0 per cent.	(126/788)
Non-vaccinated older rams	17.7 per cent.	(435/2453)

The field trials thus provided conclusive evidence that either the simultaneous inoculation of adjuvant vaccine and Strain 19, or the adjuvant vaccine used alone, confers substantial protection on rams against intensive infection presented during the tupping season. The superior efficiency of the double-inoculation procedure as compared to the adjuvant vaccine used alone was also clearly established in these trials. Consequently the double-inoculation procedure is now being used exclusively.

Vaccination studies have been primarily concentrated on rams in view of the importance of the male as regards susceptibility and transmission in this disease. Whilst an accurate assessment of the economic loss from *Br. ovis* infection of ewes in New Zealand is not possible, individual flocks have been shown to experience substantial losses in lambs from this disease. However, as it appears that infection in ewes originates almost exclusively from the use of infected rams, lamb losses through infection of ewes might be most conveniently and economically controlled by confining vaccination to rams. Studies are still in progress on the control of lamb mortalities from *Br. ovis* infection by vaccination under field conditions.

The vaccines are now readily available to veterinary surgeons from a laboratory producing commercial vaccine. The Department of Agriculture is strongly recommending ram vaccination to sheep farmers, as it is felt that the wide adoption of the procedure will contribute greatly to more effective control of the disease. Further, the cost of vaccination is insignificant in relation to the benefit derived.

To conclude, we might summarise the official recommendations for ram vaccination in New Zealand flocks.

1. Ram lambs after weaning must be kept in strict isolation from older sheep.
2. Young rams may be vaccinated at any age from four months until two months before the commencement of their first tupping season. Vaccination as yearlings rather than at an earlier age will result in the development of better protection and should therefore be left as late as possible.
3. Older rams should be examined by a veterinary surgeon, and rams with clinical lesions of the disease culled from the flock. The remainder of the rams may be vaccinated either immediately or subsequently at any time until two months prior to the commencement of the next tupping season.

The enthusiastic acceptance of ram vaccination by sheep farmers during the past twelve months augurs well for accelerated progress in the control and eventual eradication of this insidious and costly disease.

Dr McLean: I think on occasions during conferences at Lincoln we have heard of work concerned with epididymitis in rams. This paper can be regarded as the successful conclusion of effective research conducted by the Wallaceville people, and by others in the North Island, in the control of this particular disease. Most of the evidence at the present time indicates that this quite serious disease can now be controlled and this is due I think entirely to the work of scientists of which Dr Buddle was a leader. I think they should be congratulated on the work they have done.

Question: In those cases mentioned in the paper where the ram shows no signs of lesions but still is infected what would be the result of the vaccine on the affected ram?

Dr Buddle: Those rams would not be affected by the vaccine, they would still remain infected. The best thing therefore would be to concentrate on the young rams.

Question: What system of marking vaccinated rams is used? What about rams for sale?

Dr. Buddle: At a meeting at Ruakura it was suggested that the Department should be responsible for the marking of vaccinated rams. The Department feels this should be a problem left to the farmers to develop a system. If a farmer sells a ram and claims it is vaccinated and it turns out not to be, he is liable at common law.

Question: You mentioned that ram lambs can be done at four months old but that it was more effective two months prior to tupping. What is the advisability of revaccinating rams that have been done at four months old?

Dr Buddle: Under the best conditions where your young rams can be kept in isolation from all the older rams a double shot in October is satisfactory. But if it should not be possible and you cannot depend on keeping the young rams from mature rams on the farm, then give them a shot at weaning and a booster shot as yearlings. If you get cases amongst virgin rams look at this possibility even though it does double the cost. There is an infection which causes similar clinical appearances in virgin rams but is not *Brucella ovis*. This will not be affected by vaccination.

Question: What is the right place to inject the ram for epididymitis? I have had it done in the brisket with damaging results.

Dr Buddle: The right place is where the local veterinary surgeon does it. I personally prefer on either side of the shoulder.

Question: Is there any setback after the injection in the health of the ram?

Dr Buddle: The vaccine was tested for a number of years before we released it. We followed vaccinated rams carefully but noticed very little reaction at all. Sometimes there was a swelling the size of a marble or a golf ball which indicated that an infection had been introduced with the vaccine. It should be done preferably two months before tupping to get the maximum immunity and it may cause a slight fever in the ram. I don't think you would detect any effect under field conditions.

Question: What is the approximate cost of the injection per head?

Dr Buddle: The minimum charges suggested by the Veterinary Association are:—

First 25 rams 7/- per ram.
25 - 50 rams 6/6 per ram.
50 - 75 rams 6/- per ram.
More than 75 rams 5/6 per ram.

Question: Does that include the cost of the vaccine?

Dr Buddle: Yes, the cost of the vaccine runs to approximately 3/- per ram.