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thirds of a cow to the acre he means the application in most areas of more phosphate to bring the land into high production. The same with sheep. Take the 4, 3, and 2 sheep per acre - that allows for topdressing where it fits in reasonably with the economics of the farm.

Dr W.M. Hamilton: In making estimates of this sort, taking the question of the percentage utilisation of land, there will be areas like the Manawatu where practically one hundred per cent. of the land can be used for farming. You will all know of areas, such as the Waikato, where there are steep valleys which cannot be utilised. There are areas in North Auckland where the percentage of utilisable land will be considerably lower than one hundred percent. In making an estimate of this sort Mr Taylor is faced with some difficulty in deciding just what percentage of the grass area covered on the map is utilisable for farming. You can get some measure for that by taking the survey of 19,000 farms carried out by the Government Statistician in 1937. He found that the average area of farms was 169 acres and of that, 29 acres was not used for farming; that means that 20% of the average farm is not utilisable. You have to make allowance for that in the average carrying capacity on which you assess the basis of this table.

Reply: That is so. Also it has to be remembered that the tables must be taken as concerning units. Mr Taylor is not dealing with the proportion of cows in relation to fat lambs which should be carried on this easy country, or saying that certain areas should carry more dairy cows and less sheep, and vice versa. The best utilisation at any particular time is an involved problem.

Professor W. Riddet, on behalf of the members of the Society, expressed thanks to Mr Taylor for his valuable contribution, and complimented Dr Grange and his co-workers on the outstanding soil survey work they are doing in New Zealand.

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"PLANTS AND FOOD"

by

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Introduction:

A paper written in 1944 and dealing with plants and food will have as its background a world where hunger for man and beast exists throughout vast populations in Europe and Asia, accentuated by conditions of war, memories of a not far distant past when large quantities of foodstuffs were accumulated and were destroyed because of man's inability to distribute these to many who were undernourished, and a world where science is showing the potentialities of proper diets as a means towards health and better development both mentally and physically. Against such a background the role of the plant in food supply stands out prominently.

From plant materials alone man may derive all his nourishment as vegetarians actually do in practice, while the main food producing animals of the world, cattle, sheep and pigs and poultry, are almost entirely (pigs and poultry excepted) dependent upon plants as their feed. It is through them that plant material is concentrated into forms of food more suitable to the human needs. Hence the quotation "All flesh is grass".

From the vast numbers of plant varieties, comparatively few function as direct providers of food for human beings, but animals make use of a much wider range of plants in their feed and render available in the forms of milk, flesh and eggs much potential food which otherwise could not be drawn upon.

The plant constitutes itself the intermediary factory which, bringing together comparatively simple elements from air and soil, converts them into complex compounds of carbohydrates (starches, sugars and oils) and proteins. In plant tissues also are stored minerals and vitamins which constitute an all important bodybuilding and health maintenance property.

Plants in New Zealand Contributing to Food Supplies:

Crops grown in New Zealand for human food or stock food in the year 1942-43 were as follows:-

	<u>Acres</u>	<u>Yields.</u>	<u>Av.Yields</u>
Wheat for grain	286,998	9,819,342 bus.	34.21 bus.
Wheat for fodder	3,150		
Oats for grain	56,291	2,808,774 bus.	49.90 bus.
Oats for fodder	196,060		
Barley for grain	28,657	1,057,608 bus.	36.91 bus.
Barley for fodder	6,600		
Maize for grain	7,291	370,875 bus.	50.87 bus.
Maize for fodder	5,244		
Ryecorn	328	5,455 bus.	
Peas	33,006	889,224 bus.	26.94 bus.
Beans	267	6,857 bus.	25.68 bus.
Linseed	354		
Potatoes	23,860	139,044 tons	5.83
Onions	962	10,401	
Rape	160,765		
Kale	64,427		
Swedes	128,178		
Turnips	198,880		
Turnips, Rape & Other Crops	47,800		
Mangolds	6,126		
Pumpkins & Marrows	1,389		
Carrots & Parsnips	652		
Artichokes	217		
Kumaras	215		
Sugar Beet	202		
Pastures	17,876,302		
Orchards	19,190		
Market Gardens (vegetables)	11,299		

Cereals:

Pre-eminent among plant groups which provide food direct to man are the cereals - wheat, oats, maize, barley, ryecorn, and rice. Of these, wheat is of first important to European peoples providing as it does, bread, which occupies a very large portion of their diet, and offals in the form of bran and pollard which are used extensively as stock feeds for pigs and poultry.

The areas devoted to cereals in New Zealand and the average yields secured from each are as follows for the year 1942-43

<u>Cereal</u>	<u>Acres</u>	<u>G R A I N</u>		<u>Acres</u>	<u>F O D D E R</u>	
		<u>Bushels</u>	<u>Av.Yields</u>		<u>Yield</u>	<u>Av.Yield</u>
Wheat	287,000	9,800,000	34.2	1,165	2,376	2.04 ton
Oats	56,000	2,800,000	49.9	121,435	214,884	1.77
Barley	28,657	1,507,000	36.91	596	1,350	2.27
Maize	7,291	371,000	50.87	91	426	5.08

Wheat: Some 6.7 million bushels of wheat are converted to flour and 2 million bushels used for stock feed. Unfortunately the quantity of wheat produced locally has in recent years been insufficient to meet local requirements and this has reconstituted imports of up to 3½ million bushels in these years.

A survey made in 1930 indicated that the average consumption of bread in New Zealand is of the order of $\frac{1}{2}$ lb. daily. The rest of the wheat and its offals is utilised for pigs and poultry feed and is estimated to absorb over 2,000,000 bushels annually. The average yield of 34 bushels per acre places New Zealand almost first in the world on this score, but limitations of suitable soils and competition with other crops is likely to prevent a stage being reached when New Zealand will again be an exporter of wheat. It is obvious that shortage of wheat and its offals prevents ready local expansion in the pig and poultry industries.

Oats: Of the 2,800,000 bushels of oats produced each year in New Zealand, only 20 per cent are used directly as human food in oatmeal and other oaten products and the average consumption per head of the Dominion is estimated to amount to some 9 lbs. per annum, a figure which appears unduly low considering the importance of oatmeal as a breakfast product. Some 55 per cent of the oats grown are white oats suitable for milling purposes, the remainder being almost exclusively used for stock feed. In addition and distinct from wheat, 214,000 acres are devoted to green feed, hay or ensilage oat crops as compared with 1,100 acres of wheat. Oats provide most useful green feed in winter and spring months to provide a better balanced stock diet at a season of the year when much reliance has to be placed on hay ensilage or root crops. From the same crop, fed off in situ, a further crop suitable for hay or chaff may often be taken. This versatility of oats, the fact that it is not an exacting crop insofar as soil conditions are concerned, renders it a crop whose acreage could readily be extended if such were desired.

Barley: Barley is the least important of New Zealand cereal crops, insofar as a human foodstuff is concerned, but it ranks high as a beverage-producing grain. The acreage grown in 1942-43 is lower than the average of recent years when usually some 34,000 acres were devoted to this crop, approximately 75 per cent of which is used for grain production and 25 per cent fed off as grain feed. The New Zealand acreage yield of 36.9 bushels is higher, but the total yield is often insufficient to meet local needs, and in some seasons up to 500,000 bushels of malting and feed barley have had to be imported from Australia. Soil and climatic conditions are very favourable to heavy yields of barley in many parts of New Zealand and if the monetary returns from this crop were comparable with those from the other avenues of farming it would be expanded considerably and would help materially in the development of pig and poultry industries.

Maize: Maize grown in New Zealand is entirely used as stock feed and forms a valuable addition to the diet of poultry and pigs. It is the smallest in acreage of New Zealand's cereal crops, only 7,300 acres being devoted to it in the warmer districts of Auckland and Hawkes Bay. As a stock feed, used in both the grain and the green stage, it is capable of marked expansion. Because of its ill balance as a stock feed, being too rich in starch and poor in protein fibre and ash, it is not readily favourable except in feed mixtures where some adjustment of balance has been made.

Peas: In 1942-43 33,000 acres were devoted to peas, and with an average of 26.9 bushels per acre a total yield of 889,000 bushels was secured. The pea crop in New Zealand provides:

1. Peas for direct consumption as split peas, boiling peas, etc.
2. Peas for stock feed - maples.
3. Garden peas for resowing to produce green peas.

The crop is one which can readily be expanded and has great potentialities as a crop likely to assist distressed nations in post-war years owing to its high protein content being valuable during a period of protein scarcity. The composition of peas varies a great deal, but the following analysis gives an average set of percentages. The composition of wheat is also given for comparison purposes:-

	<u>Peas</u>	<u>Wheat</u>
Moisture	14%	13.0%
Albriminoids	22.5 - 86% digestible	12.5
Oil	1.5 - 65	1.7
Crude Fibre	5.5 - 70	2.5
Ash	3.0	1.8
Soluble Carbohydrates	53.5 - 93	68.5
	<u>100.0</u>	<u>100.0</u>

Peas are characterised by their richness in protein which is very readily digestible and therein lies their great value as a foodstuff both for man and animals. Peas have almost double the protein content of any of the cereal crops and when used as green peas their protein figure of 6.7 is second only to soya beans, which contain 8.5%. The body building and energy value of dry peas is approximately 4 times that of green peas. Closely associated with peas are the other legume crops, of which soya, butter and haricot beans and lentils rank highest in quality. Our climatic conditions do not appear to favour the growth of these on a large scale and their considerable contribution to the world's food supply must come from countries possessed of a more continental type of climate than ours.

Pastures: Forty-one per cent of the total area of land in occupation in New Zealand, or 17,622,000 acres are in sown grass pastures. These pastures, with the partial assistance of some 1,270,000 acres of grain and fodder crops, maintain a livestock population totalling 4,448,000 cattle, 605,000 pigs, 33,000,000 sheep, and 249 horses. These figures readily show that the plants, grasses and clovers and weeds, which form our pastures, contribute far more by way of feed to stock and ultimately food to human beings than does any other group of plant. The widest variation of course occurs in the productivity of these pastures, and it would be assuming too much to consider that the area topdressed (now 3,470,000 acres) constituted first class pastures. It has been shown in experimental trials at Palmerston North on rich alluvial soils that annual yields of from 9,000 to 15,000 lbs. per acre of dry matter may be obtained from pasture swards comprised of good species and managed carefully under a sheep grazing management. Pasture so managed would have a crude protein content of some 20 to 30 percent and would therefore yield from $\frac{3}{4}$ to 1 ton protein annually per acre. It is unlikely that any considerable area of New Zealand's grasslands is at present yielding anything approaching this production, nor will such ever be attainable on much of the area devoted at present to pasture. Nevertheless, such high figures indicate a goal to be aimed at comparable with "a cow to the acre all the year round on grass".

There is no group of plants which possesses greater potentialities than pastures for increasing the food production of New Zealand. It would appear that in all regions of mild climate with a rainfall of between 20 and 90 inches a year, provided fertilisers are available for topdressing, reasonable pastures can be maintained almost irrespective of the quality of the underlying soil as it is characteristic at present that very extensive areas of New Zealand soils have only the thinnest veneer of a fertile surface layer.

No matter how high yielding a pasture may be a difficulty is always experienced in obtaining a high percentage of utilisation owing to lack of correlation between sward growth and stock demands throughout the various seasons of the year. All pasture species go through periods of quality variation. Chemical analyses and grazing trials show that the percentage of digestible protein and carbohydrates reaches its maximum when the plants are under six inches high and then falls rather rapidly as the plant develops towards the seeding stage. Hence the increasing adoption of close grazing and rotational grazing in farm practice, a method that has been greatly assisted by the improved strains of ryegrass and white clover developed by the Grasslands Division. These strains owe much of their value to the fact that ryegrass is, among grass species

suitable for fertile soils, pre-eminent in its capacity to recover rapidly after grazing or mowing and possessed of a capacity to produce for a longer period each year than does any other grass on the same type of soil. The same remarks apply to the certified strains of white clover now in use. With pastures comprised of these species it is possible to smooth out the feed production over a greater period of the year by following a practice of rotation grazing which enables the pasture to be used moreover at a stage when its feed value approximates to its maximum.

Nevertheless the use of good strains of ryegrass and clover carefully managed, do not even in the most favoured districts of New Zealand suffice to provide for the need of the dairy cow which is, on the authority of Halnan, the most efficient animal for converting plant material into human food. At a Grasslands Conference some years ago it almost seemed that some skilled farmers using nitrogenous fertilisers in a scheme of highly skilled pasture management, were about to reach a stage when supplementing feed could be dispensed with, but subsequent experience has shown that such has not yet been attained.

In general, sixty percent of the total production of pasture occurs in the spring and early summer period, September; 30% between January and April, and 10% in the period May to August. This represents the order of seasonal variation in good pastures. On poor types the total dry matter not only is less, but its variations are much greater and hence the stocking problem is much worse. These fluctuations in grass production seasonally, because of their bad correlation with stock feed demands, of necessity involve wastage of valuable feed material unless, of course, there is extreme elasticity possible in the number of grazing animals. Once grass gets past its short stage its optimum value as a food deteriorates through the formation of indigestible matter and reduction in the amount of soluble protein and carbohydrates. Conservation of grass in the form of hay or ensilage involves, under the best of conditions, losses of the order of 30% to 50% in food value. Artificial drying of grass reduces this loss to some 10% and no information is available as to the losses arising through the common practice of allowing grass to go into the rough feed stage for winter grazing. It does seem that at the present time vast losses are occurring in the complete utilisation of the grass feed grown on any farm, and it would be interesting to have some information as to the percentage actually occurring through defective grazing, conservation as hay, silage, or rough grazing on a selected field or farm. In view of the close relationship existing between the amount of hay or ensilage made and butterfat production of the subsequent season, as revealed in W.M. Hamilton's "Survey of the Dairy Industry", and the losses revealed in the Silage Survey of the Dairy Institute, and the losses revealed in the silage surveys and experiments of the Grasslands Division, it is evident that the utilisation of New Zealand's pastures would merit study and that knowledge gathered on this point would rapidly help food production in the way of meat and dairy produce.

Supplementary Feed Crops:

The deficiency arising from pastures is made up by recourse to supplementary fodder crops of which some 700,000 acres are at present grown in the Dominion, the great bulk of which is comprised of various brassica crops and green feed oats and lupins. This group of crops is selected because their period of maximum production coincides with dry summer periods, e.g. rape; or with winter period, e.g. turnips and lupins when feed shortages for stock occur; or again because of their capacity to store in roots feed which will be available over a longer period and therefore available when unforeseen shortages occur. It is in these districts where climatic conditions are more extreme, either through alternate dry and wet periods or through cold conditions, that the need for supplementary fodders becomes more real. Nevertheless, every farmer in New Zealand is confronted with the problem of whether to supply his supplementary feed through intensification of his grass utilisation or by resort to special fodder crops. An outstanding

problem of today is whether the supplementary fodder crop, drawing upon accumulated stores of plant food in the soil and giving a good yield in consequence, should not be utilised in many farms to replace existing swards with certified pasture grasses and clovers to enable their production to be increased. More extended use of the plough and of supplementary fodders might reasonably be expected to give both immediate and long distance increased yields of stock feed.

Potatoes:

Potatoes rank high as a food producing crop of all temperate countries, though they do not enter largely into the export trade of many countries. The New Zealand crop at present extends to approximately 24,000 acres and, with an average yield of 5.83 tons, provide a total tonnage of 139,000 tons, by far the greater amount of which is used for human consumption, only low grade tubers being used as pig feed. In common with wheat, the potatoe crop requires a soil of deep fertility, and though for special reasons it could be extended considerably, it would not be possible to retain permanently such an area. As food, potatoes owe their value to their high content of 22% of readily digestible starch. The protein content is of the order of 2%, over half of which is readily digesible. New potatoes have a high vitamin C. content value ranging from 3 to 16, while they also contain traces of vitamins A and B. Vitamin C. values are quite low in old potatoes. This crop figures largely in the dehydration programme, and though exceptionally difficult to dry satisfactorily, it does make a very satisfactory food product containing some 75% of soluble carbohydrates and 7 to 8 percent of protein. In this form potatoes could be readily made available to the Northern Hemisphere and tropical countries where it would not now be possible to ship them in the fresh state.

Vegetables and Fruits:

Unless they are capable of being preserved by canning, drying or refrigeration, vegetables and fruits are limited almost to local consumption only.

At present potatoes, carrots, cabbage, cauliflower and onions are being dehydrated for use overseas mostly by the services. In the dried form very little of the food value is lost and their content of vitamins is maintained. They therefore retain their values as "protective" foods, and if required overseas the quantity of these crops produced could be readily and rapidly increased.

Fruits are of value as food largely on account of their vitamin content and their percentage of readily digestible sugars. All citrus fruit is a rich source of vitamin C., as also are tomatoes and blackcurrants. Similarly, investigations carried out recently by the Cawthron Institute indicate that the sturmer variety of apple is also quite rich in this vitamin.

New Zealand pre-war was estimated to produce some 3,000,000 cases of apples and pears, and of these 1,000,000 cases were regularly exported. In war years consumption has increased locally to a very marked extent, but it is hoped in post-war years exports will be resumed.

Plants in the Feeding of Post-war Europe:

Sir John Russell, reviewing the European food situation early in 1943, drew attention to the fact that the need would be most pressing for crops giving a high return in food calories per acre. This group was represented by cereals, potatoes, peas and beans. It was hoped that 90% of the seed required to get these crops established again could be secured in Europe itself, but probably more than 10% would require to be imported. In addition, a very large amount of each of these foodstuffs would be required for immediate consumption as no doubt war conditions would leave no considerable stocks of food on hand in most of the areas liberated. Sir John also drew attention to an important European

dietary problem concerning what should be the aims of post-war European countries. Should they aim at a high standard of nutrition using a varied diet, such as was the case in pre-war Europe when 2 acres were required to provide sufficient per person; or should a maximum degree of self-sufficiency be aimed at, as was the case in pre-war Germany where a very simple diet, high in potatoes and requiring only 1 acre to produce, was the general standard.

A review of New Zealand's potentialities to help post-war Europe and other countries where food shortages exist, leads one to the conclusion that the Dominion can afford no help by export of any of its cereals which are all required for local needs. Peas are a distinct possibility as their production can be expanded considerably if necessary and without detriment to soil fertility. On account of their high protein content they will be one of the most valuable foodstuffs, while, with their low moisture content, their preservation and transport is relatively easy. Potatoes cannot be transported and distributed readily from New Zealand to Europe, but in dehydrated form they can be readily handled. The acreage is capable of considerable expansion locally and the likeliest limiting factor in the quantity exported would be the capacity of the drying plants. Similar remarks apply to carrots and onions, both of which constitute valuable foods and are readily handled when transported. By far the largest food export must be accounted for by foods of animal origin: meats, butter, cheese and dried milk. Hence, chief reliance will of necessity have to be placed on the Dominion's resources as represented by its pastures and supplementary fodder crops. In this direction soil and climatic conditions are conducive to readier expansion than in any other direction. Therefore, no matter what call arises insofar as New Zealand is concerned, it seems clear that plants will make their contribution to the world supply of food, not directly, but indirectly through animal foodstuffs, the products of the grazing animal.

DISCUSSION

Dr P.R. McMahon: Is it really possible that appreciable amounts of our grasslands might be converted direct into human food instead of via the animal?

Reply: That is a thing which might happen. Up to the present time various experimental attempts have been made to use grass direct as human food - the material is reported as being highly unpalatable.

Professor W. Riddet: You very rightly pointed out the fact that New Zealand, probably more than any other country, is able to produce a high yield of dry matter from her pastures. Considering the question of total food production, have you any information on the dry matter per acre that could be produced from other crops under these identical conditions? Until we have that definite information on the physical capacity of the soil our ability to consider fully the needs of the world for food will be incomplete. Conversely, could you tell us what quantity of dry matter per acre could be produced in those grass growing areas of the South Island where meanwhile we produce our wheat and barley, which could be considerably cheaper produced and imported from other parts of the world?

Reply: I could not give to this conference a useful relationship of the dry matter contributed by crops in competition with grass. This will always remain a rather vexed question. With grass, as distinct from most other crops, there is more or less continuous production. With all these arable crops, with perhaps the exception of lucerne, use of the plough and renewal are necessary.