Seaweed in the Falkland Islands and its potential role in agriculture

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There are huge reserves of seaweed (mainly the giant kelp, Macrocystis pyrifera) in the waters around the Falkland Islands and it is widely known that seaweed can have a manurial value.

A programme was initiated and funded by the UK Falkland Islands Trust to investigate the prospects for biological husbandry in the Falkland Islands and particularly on the role and effect of seaweed on grassland. From a series of field experiments a response to liquid seaweed extract was found, though the quantities required were large.

The results are sufficiently encouraging that a further development programme involving a number of sites across the islands is planned. A continuation of the biological husbandry research programme by investigating techniques of improving tree survival and establishment is also proposed.

In the Falkland Islands, seaweed is referred to locally as 'kelp' which covers several species of brown seaweed found growing in different zones just below the water line. The main species of interest and also the most abundant is Macrocystis pyrifera which tends to be found in the deeper waters of the sub-littoral zone, and which forms vast beds commonly extending to many ha. Also included under the name 'kelp' are species of Lessonia (mainly L. flavicans but also L. nigrescens and L. frutescens) (Patterson, 1986).

In this article the word 'kelp' refers to Macrocystis pyrifera.

History

In 1904, Governor Allardyce requested to be "furnished with information relative to the possibility of putting seaweed to commercial use". One year later a report was prepared by the Imperial Institute which concluded that there was no merit in the commercial extraction of iodine in the Falkland Islands.

In relation to its use in agriculture, William Davies, the second agriculturalist to report on the state and improvement of the sheep farming industry, suggested that "measures be taken to haul kelp for manurial purposes". However, Gwyer (1984) stated in his report that "the use of kelp does not seem attractive because of its bulk in relation to its nutrient content" yet in another section recommends that "desk studies should be carried out on the technical and economical feasibility of producing a concentrated liquid fertiliser from kelp".

Seaweed resources

All the information available on the abundance and annual sustainable yield is published in the Shackleton Report (1976) and in the report of a survey made by the Kelco Company of San Diego in 1973 when a commercial evaluation was made of the Falkland Islands macrocystis resource (Connor, 1973).

Lord Shackleton has estimated that the total sustainable yield of the Falkland resource is one million tonnes of wet weed per year – yielding 80,000 tons of dried milled weed.

The Kelco estimate of a standing crop in excess of 120,000 tonnes was based on a detailed survey by sea and air of approximately 1/6 of the total Falkland Islands coastline. It was anticipated that three harvests per year could be sustained giving approximately 360,000 tonnes of wet weed or 28,000 tonnes of dried weed.

This represents one of the largest areas of sustainable kelp resource in the world at present.

TABLE 1
Analysis of Kelp (Macrocystis pyrifera) collected in the Falkland Islands (Keppel Island), January 1987.

Element	Level
Carbon(%)	62.1
Nitrogen (%)	1.79
C:N ratio	34.7
Potassium (%)	3.3
Phosperous (%)	1.5
Magnesium (%)	0.4
Chlorine (%)	3.1
Calcium (%)	1.4
Cobalt ppm	<3.0
Copper ppm	7.9
Iodine ppm	1000.0
Vanadium ppm	7.0

Value of Seaweed

Seaweed contains a wide range of major and trace plant nutrients, vitamins and several plant hormones. Although different seaweeds vary in their trace element and hormone contents, typically N, P and K contents are 1.5-2.0, 0.2 and 3.5 percent of the dry matter respectively.

There have been few chemical analyses of the seaweed found in the waters around the Falkland Islands. Davies (1939) on the basis of three samples, reports moisture, crude protein, phosphate, lime and the potash values as 7.4, 10.3, 0.6, 1.2 and 6.6 per cent of the DM respectively. An analysis of Macrocystis pyrifera sampled during this project is presented in Table 1. Therefore, although the levels of macronutrients are not high, the principal value of seaweed may either be as some form of soil condition improver or in the

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trace element and plant hormones it contains.

Uses

It is clear that the Falklands have a huge and potentially valuable seaweed source. Commercial companies have shown interest in the past. Alginate Industries had a pilot plant operating until the early 1970s but ceased production due to a worldwide slump in the alginate trade.

Just prior to the Argentine invasion in 1982 an American company (Ocean Labs Ltd) expressed great interest in establishing a seaweed drying and milling plant with a view to export.

In the past the possible utilization of kelp in agriculture and horticulture in the Falkland Islands has been seen to be along 2 main lines (McAdam, J.H. – paper to H.E. The Governor of the Falkland Islands, 1977):–

(a) dried, ground and fed as meal to breeding sheep or used to check trace element deficiencies.

(b) in making the cost effectiveness of a commercial horticulture scheme more attractive in its usage as an adequate natural substitute for artificial fertiliser.

However, since the recent expansion programme of subdivision and the need to increase output from sheep farming, the use of seaweed as a grassland fertiliser is seen as of highest priority.

Research Programme

The UK Falkland Islands Trust's research progamme into the potential for and application of biological husbandry can be separated into four phases.

- To determine the potential for biological husbandry by soil analysis and soil response.
- An assessment of the value of seaweed as fertiliser.
- The processing and utilisation of indigenous seaweed resources.
- The successful establishment of trees using a range of soil improvement and preliminary shelter techniques.

To date, phase one has been completed, phase two is partially complete and phase three and four are being planned with a view to commence in 1989.

Soil analysis and response to fertiliser – (Phase 1)

Soil analyses

TABLE 2
Soil chemical analyses for a range of Falkland Islands soil types.

Soil Type	pH	P	K	Mg	Mineral N	% Total N
		(mg l^{-1})			(mg kg^{-1})	
Cultivated/ fertilised	4.2	72	272	398	459	0.64
Cultivated/non-fertilised	4.2	30	139	215	73	0.36
Garden soil	4.7	140	434	385	118	0.41
'Poor' Camp	4.2	18	319	455	78	0.74
'Good' Camp	4.5	376	184	387	58	0.60

TABLE 3
The mean increase over control in mineral -N (kg ha^{-1}) content of two soil types treated with an organic and an imported nitrogen source.

Soil Type	Liquid Seaweed Extract	Inorganic Nitrogen
'Good'	147	195
'Poor'	26	26

Samples were collected from pits dug at a range of sites and a summary of the pH and major elements content of these is presented in table 2, and the trace elements in table 3.

The levels of phosphate and magnesium can be considered adequate with potash high and pH low. Levels of total N were high with available N (in the top 20 cm) in the order of 75 kg N ha^{-1}.

Rates of mineralisation were extremely low at ambient pH and temperature and although there were adequate general decomposer bacteria, no nitrogen fixing bacteria were detached. Mycorrhizal fungi were present in all the soil samples tested. It was concluded that the general level of microbial activity in Falkland Islands soils was low and that the nitrogen and lime would have to be applied to improve soil fertility.

Soil Response

A range of organic (in the form of proprietary seaweed extract) and inorganic (in the form of ICI Nitrochalk) nitrogen sources were added to small plots at four sites. The liquid seaweed extract ('Marinure') was applied at a rate equivalent to 50 l ha^{-1} and the nitrogen at 80 kg ha^{-1}. The mean increase (over control) in mineral -N (kg ha^{-1}) over a 6 month period (Table 4) was approximately six times greater from the 'good' soil than the 'poor' soil. The application of inorganic N stimulated soil activity to the extent that a flush of mineral N was released, this release persisting over the season. To a lesser extent the same type of response was found with

the application of liquid seaweed extract. In relation to the relative proportions of N in the two materials the response to seaweed extract per kg of N applied was substantially greater than to inorganic N.

Conclusions

It was concluded that macronutrient levels in Falkland Island soils – particularly the drier soils – were acceptable, and that moderate amounts of mineral -N had accumulated in the soil. However, possibly due to a combination of low temperatures, low rainfall and factors inherent within the plants, this N uptake was low. Levels of soil biological activity were extremely low but adequate numbers of bacteria were present and, provided some form of substrate were added, the soil response was encouraging. In this respect, the response of the soil to an organic N source in the form of a liquid seaweed extract, while not as high as the response to inorganic-N, was sufficiently encouraging to merit further research.

The effect of Seaweed on Grassland (Phase 2)

Introduction

In order to assess the potential which seaweed may have as fertiliser in the Falkland Islands it was decided to test a range of commercial seaweed-based products manufactured in the UK. It was felt that much time would be wasted in preparing such products locally, as the facilities are not available for liquidising or grinding seaweed.

Two commercially processed seaweed products in the liquid extract form (to be applied as foliar spray) – 'marinure' and 'kelp', one finely ground dried seaweed product 'algit' and a calcified seaweed product 'Cornish Calcified Seaweed' were used.

Trials were also carried out using chopped (locally collected) seaweed and fishmeal. In addition, two other proprietary soil improvement products – Landspeed and Wormcasts were incorporated into the trial. Conventional inorganic nitrogen fertiliser (ICI Nitrochalk) was included in the trial for comparative purposes and there were control plots (with no additive).

Cornish Calcified Seaweed was one of the products used in the trials

Trial sites

Seven trial sites were established, three on Keppel Island, two at Fitzroy and one each at Port Howard and Sealion Island. Treatments were applied to plots protected from grazing (generally three replicates per treatment) in September/October and the response measured by standard tissue turnover techniques or by clipping to measure yield.

Results

Most of these trials are ongoing and final results are not yet available. The summer immediately following sowing was very dry and seedling establishment was poor.

From experiment one it was concluded that, of the organic products used, foliar-applied liquid-seaweed extract gave the best response though, as would be expected, the response to inorganic 'Nitrochalk' was greatest.

There was no significant difference between foliar applied seaweed, but as the analysis of 'Manurine' most closely resembled that of Falkland Islands' seaweeds, it was used in subsequent trials. Although soil pH was not appreciably altered by the addition of 'Cornish →

Treatments were apllied to plots - protected from grazing - in September and October.

Calcified Seaweed' the germination of grass and clover seedlings was better where calcified seaweed had been applied than where it had not.

From experiment two it was found that reseed establishment was not improved by adding either 'Nitrochalk' or 'Marinure'. This confirmed other work that, following cultivation, a flush of available N is released from the soil and until this is depleted by uptake and leaching, a response to treatments is unlikely.

However, one year after sowing, growth of individual cocksfoot plants was greater following treatment application than where no fertiliser was applied and the response to 'Nitrochalk' was greater than the response to 'Marinure'. The 'Marinure' response was only detected at a level of application of 50 l ha^{-1} (five times the normal recommended strength).

The establishment and growth of tussock grass was unaffected by either chopped, raw seaweed at Port Howard or fishmeal at Sealion Island. On both sites no response to any fertiliser, inorganic or organic was detected.

On Keppel Island (Experiment three) although the tussock grass plants grew very little during the first year, plants grew taller following application of seaweed extract than where either 'Nitrochalk' had been applied. During the second year all plants grew rapidly and mean tiller number increased from two to 21 over the year. Although plants treated with seaweed extract grew taller than those receiving any other treatment, the effect was not significant anfd tillering (and hence basal circumference) were unaffected by treatment.

TABLE 4

The effect of seaweed extract (50 l ha^{-1} equivalent) and Nitrochalk (50 kg N ha^{-1} equivalent) applied in November on the growth of the cocksfoot tillers (mg $tiller^{-1}$ day^{-1}) in the following January.

	Growth (mg $tiller^{-1}$ day^{-1})
Control	7
Seaweed Extract	17
Nitrochalk	21
L.S.D.	9.6
Significance	**

TABLE 5

The effect of seaweed extract applied at 50 litres ha^{-1} (1.2 kg N ha^{-1} equivalent) and inorganic nitrogen applied as ICI Nitrochalk at 60 kg N ha^{-1} equivalent) on grass production between October and January.

	Control	Nitro Chalk	Seaweed	S.E. Extract
Total grass yield (kg DM ha^{-1})	1980	5531	2430	148
Stubble height following 2 weeks regrowth (cm)	2.7	3.4	5.1	0.28

In terms of herbage production (measured in Experiment 6 – Fitzroy Bridge) the response per unit of nitrogen applied was greater from seaweed extract than from nitrogen fertiliser at the levels applied. The response was only achieved when extract was applied at a rate equivalent to 50 l ha^{-1}.

From subsidary experiments it was found that whole kelp plants reached a constant dry matter level of 20 percent witihin 16 hours of spreading on the ground on a dry windy day. The same species could radily composted if a carbon substrate (such as dried peat) and a proprietry 'inoculant' were added.

It is clear from the experiments carried out that in a liquid extract form, seaweed has some fertiliser value and the response it evokes in grassland and plant growth must be more than just to the nitrogen content of the material.

Other major elements (P and

Subsidiary experiments showed that whole kelp plants reached a constant dry matter level of 20% within 16 hours of spreading on the ground on a dry windy day.

K), trace elements and plant hormones may be involved though this would require further verification. Although the material can be composted, dried or chopped the response obtained was not as good as to the foliar applied liquid extract.

It can be concluded that reseeds and tussock grass in the Falklands will respond to seaweed extract though the quantities of extract involved will be large if a reasonable response is to be expected and if the site is sufficiently infertile initially.

As quantity of material is unlikely to be limiting, the results are sufficiently encouraging to proceed with a further research and development programme.

Further Research and Development Work

Having determined that a response can be found to seaweed extract, albeit that the amounts involved will be large, an evaluation of the processing of indigenous seaweed into a usable form is seen as the next phase of the project. Initial studies in the UK on a low-cost prototype digestion plant are in process.

A large-scale development project on 6-8 sites in the Islands is also proposed to demonstrate on a more widespread basis the potential of seaweed extract as a fertiliser. In view of the recent interest in tree planting in the Falklands, the problems encountered with establishing trees and the role seaweed-based products could play in this stituation, the United Kingdom Falkland Islands' Trust has proposed a research project into the effect of seawed and composted products on aspects of tree establishment.

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