Seaweed in Agriculture and Horticulture

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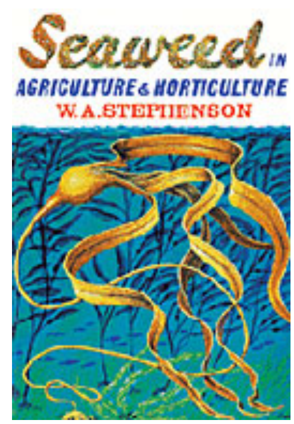
Chapter 7
Seaweed and Plant Growth



Seaweed contains all major and minor plant nutrients, and all trace elements; alginic acid; vitamins; auxins; at least two gibberellins; and antibiotics.

Of the seaweed contents listed after nutrients and trace elements, the first, alginic acid, is a soil conditioner; the remainder, if the word may be forgiven in this context, are plant conditioners. All are found in fresh seaweed, dried seaweed meal and liquid seaweed extract -- with the one exception of vitamins: these, while present in both fresh seaweed and dried seaweed meal, are absent from the extract.

We will deal first with alginic acid as a soil conditioner. It is a matter of common experience that seaweed, and seaweed products, improve the water-holding characteristics of soil and help the formation of crumb structure. They do this because the alginic acid in the seaweed combines with metallic radicals in the soil to form a polymer with greatly increased molecular weight, of the type known as cross-linked. One might describe the process more simply, if less accurately, by saying that the salts formed by alginic acid with soil metals swell when wet and retain moisture tenaciously, so helping the soil to form a crumb structure.

These brief notes cover two examples: one of the way in which seaweed helps to produce a crumb structure in the soil, another of the way in which it helps soil to retain moisture.

We have a market gardener customer at Sittingbourne in Kent who tells us that before he used seaweed meal, heavy rain used to run down his sloping plots and carry all his seedlings and fertilizers into the ditch. Since his introduction of seaweed, the structure of his silty, sandy soil has so improved that soil, seedlings and nutrients are no longer of being washed away, even in the heaviest rain.

As to water-retaining characteristics, Miss Constance MacFarlane of the Nova Scotia Research Foundation told members of the Fourth Seaweed Symposium at Biarritz, in 1961: 'In the spring of 1956 I was greatly impressed with fields in the island of Jersey. This was not in any way a scientific experiment, but the results were most obvious. The year 1955 had been exceedingly dry. The only fields suitable for a second crop of hay were those which had been fertilized with seaweed. All the others had dried out, and had to be ploughed up for other crops.'

Research confirms this observation: two workers at the Agricultural Research Council's unit of soil metabolism (now disbanded) reported in 1947 that 0.1 of a gram of sodium alginate added to 100 grams of soil increased its water-holding power by 11 per cent. This is the first way in which seaweed and seaweed products condition the soil: by increasing its water-holding capacity, and encouraging its crumb structure. This in turn leads to better aeration and capillary action, and these stimulate the root systems of plants to further growth, and so stimulate the soil bacteria to greater activity.

As far as soil-conditioning is concerned -- and that is all we are to consider for the moment -- bacterial activity in the presence of seaweed has two results: first the secretion of substances which further help to condition the soil; and second, an effect on the nitrogen content of the soil. We will deal with these in turn.

The substances secreted by soil bacteria in the presence of seaweed include organic chemicals known as polyuronides. Polyuronides are chemically similar to the soil conditioner alginic acid, whose direct effect on the soil we have already noticed, and themselves have soil-stabilizing properties. This means that to the soil-conditioning agent which the soil derives from undecomposed seaweed -- alginic acid -- other conditioning agents are later added: the polyuronides, which result from the decomposition of seaweed.

The second effect of adding seaweed, or seaweed meal, to a soil well populated with bacteria, has already been mentioned briefly. It is a more complex matter, and requires consideration in some detail. Basically, the addition of seaweed leads to a temporary diminution of nitrogen available for crops, then a considerable augmentation of the nitrogen total.

When seaweed, or indeed any undecomposed organic matter, is put into the soil, it is attacked by bacteria which break the material down into simpler units -- in a word, decompose it. To do this effectively the bacteria need nitrogen, and this they take from the first available source, the soil. This means that after seaweed has been added to the soil, there is a period during which the amount of soil nitrogen available to plants is reduced. During this period seed germination, and the feeding and growth of plants, can be inhibited to greater or lesser degree. This temporary nitrogen deficiency is brought about when any undecomposed vegetable matter is added to the soil. In the case of straw, for example, which is ploughed in after harvest, bacteria use up soil nitrogen in breaking down its cellulose, so that a 'latent' period follows. Farmers burn stubble after harvest to avoid this latent period, and the short-term loss of available nitrogen which causes it. But such stubble-burning is done at the cost of soil structure, soil fertility, and long-term supplies of nitrogen which ultimately would have been released from the decomposed straw.

It has been said by one authority that the latent period following the application of seaweed to the soil is one of fifteen weeks. But during this period, while there is a temporary shortage of available nitrogen, total nitrogen in the soil is being increased. This increase makes itself felt after the seaweed is completely broken down. Total nitrogen then becomes available to the plant, and there is a corresponding upsurge in plant growth.

It is therefore clear that while seaweed, in common with all organic matter, is beneficial to soil and plant, it has to be broken down, or decomposed, before its benefits are available. (I have already pointed out, but repeat it here, that liquid seaweed extract is not subject to this latent period. The nutrients and other substances it contains are available to the plant at once.)

This period of decomposition -- or composting, as gardeners know it -- usually extends over months. It can, however, be reduced by the use of dried blood and loam according to the technique invented by Mr. L. C. Chilcott, Brent Parks Manager. Only fourteen days of heating up are required before the mixture is used, and no latent period follows. This technique is described in detail on page 182.

So much for the soil conditioning effects of seaweed. Now a word about what I have called its plant-conditioning contents, beginning with vitamins.

Brown seaweeds, which are the ones used in agriculture and horticulture, not only contain vitamins common to land plants, but also vitamins which may owe their origin to bacteria which attach themselves to sea plants, in particular vitamin B12. There is still some doubt about this -- B12 may be contained in the seaweed, although in some cases it is in associated bacteria. Vitamins known to be present in the brown seaweeds include vitamin C (ascorbic acid), which appears in as high a proportion as in lucerne. Vitamin A is not present, but its precursor, beta-carotene, is, as well as fucoxanthin, which may also be the precursor of Vitamin A. B group vitamins present are B1 (thiamine), B2 (riboflavin), B12, as well as pantothenic acid, folic acid and folinic acid. Also found in brown seaweeds are vitamin E (tocopherol), vitamin K, and other growth-promoting substances. The unusual nature of the vitamin E in seaweed should be stressed. It has valuable characteristics (put technically, a complete set of isomers) found only in such seed oils as wheat germ oil.

Auxins in seaweed include indolyl-acetic acid, discovered in seaweed in 1933 for the first time. Two new auxins, as yet unidentified, but unlike any of the known indolyl-acetic acid types, were also discovered in 1958 in the *Laminaria* and *Ascophyllum* seaweeds used for processing into dried seaweed meal and liquid extract. These auxins have been found to encourage the growth of more cells -- in which they differ from more familiar types of auxin which simply enlarge the cells without increasing their number. One of the auxins also stimulates growth in both stems and roots of plants, and in this differs from indolyl-acetic acid and its derivatives, which cause cells to elongate but not to divide. The balanced action of this seaweed auxin has not been found in any other auxin.

It has been proved at the Marine Laboratory at Aberdeen that indolyl-acetic acid and the other newly discovered seaweed auxins are extracted in increased quantities by the process of alkaline hydrolysis. We believe that much of the value of our hydrolized seaweed extract is due to this auxin content; but since the amount of auxin in the extract is scarcely enough to promote the increased growth which follows its use as a foliar spray, we think plants so treated are themselves stimulated to produce more vitamins and growth hormones than would otherwise be the case.

At least two gibberellins (hormones which simply encourage growth, and have not, like auxins, growth-controlling properties too) have been identified in seaweed. They behave like those gibberellins which research workers have numbered A3 and A7 -- although they may in fact be vitamins A1 and A4.

We now come to trace elements, some of the most important and most complex of all seaweed constituents. Two things must be said at once. The first is, that the more one studies the effect of trace elements on plants and animals, the more difficult and involved the subject becomes. Even those who devote their whole working life to the subject are far from having a complete grasp of it. The second point to make here is that while one can hope, at first, to treat trace elements separately for plants and animals, there comes a time when the two become hopelessly mixed. I shall try, in this chapter, to deal with the effect of trace elements on plants only; but some mention of their effect on animals will be inevitable, if only because animals eat plants and the trace elements they contain.

We have seen that seaweed contains all known trace elements. This is important. But it is also important that these elements are present in a form acceptable to plants. We have seen that trace elements can be made available to plants by chelating -- that is, by combining the mineral atom with organic molecules. This overcomes the difficulty that many trace elements, and iron in particular, cannot be absorbed by plants and animals in their commonest forms. This is because they are thrown out of solution by the calcium carbonate in limy soils, so that fruit trees growing in these soils can suffer from a form of iron deficiency known as chlorosis. It is for this reason that plants such as rhododendrons and azaleas, which are particularly sensitive to iron deficiency, can grow only in acid soils. In these soils, iron does not combine with other elements to form insoluble salts which the plant cannot absorb, and it is therefore more freely available.

It is true that an iron salt such as iron sulphate can be dissolved in water and the solution poured on the soil, injected into an animal, or put into its feed. But iron has such a tendency to become bound up with other elements that it is not available to plants or animals when introduced in this way. If, on the other hand, iron in the form of iron oxide is dissolved in an organic compound, there will be no fusion with other chemicals in the soil, and it will be available to the plants which need it. This is the technique of chelating which makes possible the absorption of iron by living matter.

Such chelating properties are possessed by the starches, sugars and carbohydrates in seaweed and seaweed products. As a result, these constituents are in natural combination with the iron, cobalt, copper, manganese, zinc and other trace elements found naturally in seaweed. That is why these trace elements in seaweed and seaweed products do not settle out, even in alkaline soils, but remain available to plants which need them.

Hydrolized seaweed extract also 'carries' trace elements in this way, in spite of the fact that the liquid is alkaline, having a pH of nine -- in the ordinary way so alkaline a solution would automatically precipitate trace elements. This precipitation does not take place in seaweed extract because the trace elements already form part of stronger, organic, associations.

With liquid extract, this ability to chelate can be taken a stage further than happens naturally with seaweed and seaweed meal. Chelation can also be used, artificially, to cause extract to carry more trace elements than are found in fresh seaweed, in seaweed meal, or in ordinary hydrolized extract.

We have ourselves exploited these chelating properties of liquid seaweed extract by manufacturing three special types, one containing added iron, one added magnesium, and one containing the three trace elements of iron, magnesium and manganese. We have also made experimental batches with copper and boron. Most metals could be chelated in this way.

It will be remembered that liquid seaweed extract differs from seaweed meal in that it can be used directly on the plant in the form of a spray. We know that the minerals in seaweed spray are absorbed through the skin of the leaf into the sap of the plant -- and not only minerals, but the other plant nutrients, auxins and so on, listed earlier. Experience further suggests that plants' needs for trace elements can be satisfied at lower concentrations if those elements are offered to the leaves in the form of a spray, rather than being offered through the soil to the roots.

It is also possible that seaweed sprays stimulate metabolic processes in the leaf and so help the plant to exploit leaf-locked nutrients -- for it is known that trace elements won from the soil, and delivered by the plant to the leaf tissue, can become immobilized there. And if, as has been suggested by E. I. Rabinowitch in a standard work on photosynthesis, a 'considerable proportion' of photosynthesis is carried out by bacteria at the leaf surface, spraying with seaweed extract at this point may feed and stimulate them, and thus increase the rate of photosynthesis.

We now come to the debatable matter of antibiotics in seaweed -- debatable, not because there is any doubt that seaweed contains therapeutic substances, but because the precise nature of those substances is unknown. We call them antibiotics for convenience.

It is known that plants treated with seaweed products develop a resistance to pests and diseases, not only to sap-seeking insects such as red spider mite and aphides, but also to scab, mildew and fungi. Such a possibility may seem novel, but it is in keeping with the results of research in related fields. The control of plant disease by compounds which reduce or nullify the effect of a pathogen after it has entered the plant is an accepted technique. It is in this way that streptomycin given as a foliar spray combats fireblight in apples and pears, and antimycin and malonic acid combat mosaic virus in tobacco. The subject of controlling plant disease by introducing substances into the plant itself is known as chemotherapy, and is dealt with in a useful round-up article in the *Annual Review of Plant Physiology*, 1959, by A. E. Dimond and James G. Horsfall of the Connecticut Agricultural Experiment Station, New Haven, United States.

As far as chemotherapy through seaweed is concerned, the annual report for 1963 of the Institute of Seaweed Research stated that trials in which soil-borne diseases of plants were reduced by adding seaweed products to the soil were the first recorded instance of the control of disease by organic manure. 'Hitherto', the report ran, 'the majority of agricultural scientists believed that the value of organic manures was restricted to their nitrogen-phosphorus-potassium content, with perhaps some additional value as soil conditioner. This new discovery challenges this over-simplified view of the value of organic manures, and has initiated a new appraisal of this very complex problem.'

The reason why seaweed and seaweed products should exert some form of biological control over a number of common plant diseases is unknown. Soil fungi and bacteria are known to produce natural antibiotics which hold down the population of plant pathogens, and when these antibiotics are produced in sufficient quantities they enter the plant and help it to resist disease. The production of such antibiotics is increased in soil high in organic matter, and it may be that seaweed still further encourages this process.

I am aware that the claims made here, and elsewhere in this book, for the control of diseases by seaweed products, are supported more by the practical experience of growers than by the result of trials at research institutions. We have reported such trials as have taken place, but they are few in number. I cannot accept that the testimony of hard-headed farmers and horticulturists is any less reliable than that of academic researchers. But the reader might think that my attitude has been coloured by my interest, and for this reason I would say a word or two about the evidence on which these statements are based.

I have said elsewhere in this book that the evidence of the disease-controlling qualities of seaweed came to us as a complete surprise. It was those who used seaweed extract as a foliar nutrient, or seaweed meal as fertilizer, who first discovered these characteristics, and described them to us. We make no other claims than these, only record what users say, and it would be a poor service to truth to censor this evidence of the value of seaweed because it has not been confirmed in all respects by trials at research stations. Where these trials have taken place they are later reported. Trials in this country [UK] have been few, for a variety of reasons which need not concern us. We might regret that state-supported stations noted for a high standard of scientific integrity are also conservative in outlook, and little disposed to test that which is unusual. It is not for us to criticize their choice of subjects for research, but our own information is so striking that we should wholeheartedly welcome testing of seaweed and seaweed products by those with complete facilities for doing so. The evidence we have collected would then be respectably 'scientific' -- and we do not doubt that the findings would corroborate our claims to the full.