PART II

STUDIES ON

SEAWEED MANURE
the supply would still fall short of the demand, especially in
the tropical countries. Therefore it follows that any new
source of organic manure would be a welcome addition to the meagre:
resources. The seaweeds are a promising source which should be
exploited.

6:1 Seaweed resources of India

Seaweeds are preferentially used as a raw material for the
manufacture of important chemicals like agar agar, alginic acid,
laminarin, mannitol etc., However only certain species of seaweeds
which are rich in these constituents can be used for this purpose;
while the rest are available for use as organic manure. Estimates
about the availability of seaweeds along the entire coast of India,
are not available. But certain localities have been surveyed for
seaweeds availability. For example, Chacko and Pillay (179)
have estimated that about 66,000 tonnes of wet, red and brown algae
are available in an year, from the area between Point Calimere to
Cape Comorin. Desai (180) has estimated that about 10,000 tonnes
of dry harvestable algae are available along the coast of Saurashtra
and Kutch region of the Gujarat State. Krishnamurthy, Venugopal,
Thiagaraj and Shah (181) have estimated that about 61.45 and about
16.75 tonnes of drift seaweeds (fresh weight) are available near
Idinthkarai and Pamban areas of Tamilnadu State. From the above
figures, it is obvious that the availability of seaweeds is
limited; but as already pointed out, any new source of organic
manure, howsoever small the quantity may be, is to be welcomed.
6:2 Composition of seaweeds

The composition of seaweeds depends upon the species. Generally, the seaweeds are classified into three broad groups: 1) the green seaweeds - chlorophyceae, 2) the brown seaweeds - phaeophyceae, and 3) the red seaweeds - rhodophyceae. The nitrogen content of the green seaweeds is generally higher than that of either brown or red seaweeds, which in turn are rich in alginic acid and agar agar respectively. Garner (182) has reported the average composition of fresh seaweeds to be 0.5 per cent nitrogen, 0.09 per cent P$_2$O$_5$ and 1.2 per cent K$_2$O. Dave and Lewis (183) have found out that the average nitrogen content of green, brown and red algae found along the sea coast of Saurashtra is 2.27, 2.00 and 2.21 per cent (oven dry basis) respectively. Krishnamurthy (184) has reported the average nitrogen content of the drift seaweeds, which consists mainly of brown algae, along the coast of Tamilnadu State, to be 1.43 per cent. Pillai (185, 186) has found that the total organic nitrogen content in seaweeds shows wide variations, reaching maximum values in the months of October to December. He has reported that the usual variation in the total organic nitrogen content is between 0.5 to 1.5 per cent of the dry matter. He has also reported that the potassium content varies between 0.18 to 4.04 per cent of the dry matter in Gracilaria lichenoides. It will thus be seen that the nitrogen content of the seaweeds is generally higher than that of farm yard manure, the nitrogen content of which is about 1.00 per cent. The nitrogen content of seaweeds is comparable with the nitrogen content of green manures, which is about 1.2 to 3.5 per cent. The P$_2$O$_5$ content
of seaweeds is very low; viz., 0.10 to 0.50 percent (dry basis) while its K₂O content is appreciably higher than that of farm yard manure or green manure. It ranges between 1.2 to 3.0 percent as against 0.8 to 2.0 percent range of farm yard manure or green manure. In addition to these major nutrients, seaweeds have been shown to contain all the trace elements, viz., copper, zinc, iron, boron, cobalt, manganese and molybdenum (187 to 191). Black and Michel (192) have correlated the trace element content of the surrounding seawater with that of seaweeds and have established that the trace elements accumulate to a very great extent in seaweeds. Black and Woodward (193) have stated that the trace element content of seaweeds is higher than that of farm yard manure. Pillai (loc cit.) has proved the presence of all the trace elements viz., iron, copper, manganese, boron, molybdenum and zinc, in the seaweeds found along the coast of Tamilnadu State. He has observed that the iron content of chlorophyceae is comparatively lower than that of phaeophyceae or rhodophyceae; the pheophyceae contains the maximum. The highest value found is 504 mg/kg dry weight. The boron content of the brown seaweeds is comparatively greater than that of either green or red seaweeds. The highest value is found to be 12.8 mg/kg dry weight. The maximum content of copper and manganese has been shown to be 12 and 550 mg/kg dry weight respectively. The average range of molybdenum and zinc content is reported to be 0.05 to 0.1 and 10 to 80 mg/kg dry weight respectively. Rao and Tipnis (194) have reported the micro-nutrient status of the green and brown algae of the Saurashtra coast to be as mentioned below:
It is suggested by many workers that the trace elements are more effectively supplied by organic manures than by inorganic salts. For example, DeKock (195) has reported that 2 pounds of zinc in manure is as efficient as 16 pounds of zinc supplied as zinc sulphate.

Booth (196) has reviewed the subject of the manural value of seaweeds. He has brought out the following favourable effects resulting from the use of seaweed manure: 1) The trace elements in the seaweeds influence some enzymatic activities in plants. 2) The presence of plant growth hormones viz., gibberelline and indol compounds; and the effect of algal carbohydrates on plant pathogens, confers a degree of immunity to certain common soil borne diseases. 3) The uptake of nutrients is enhanced by the use of seaweeds. 4) Seaweeds when used in conjunction with inorganic fertilizers give optimum yields. (197). 5) A large number of nitrogen fixing organisms have been recorded from the heaps of rotting seaweeds. Thus the decomposition of seaweeds may modify the pattern of soil micro-organisms. 6) The alginic acid and related compounds present in seaweeds, especially the brown seaweeds.

<table>
<thead>
<tr>
<th>Element</th>
<th>Green algae</th>
<th>Brown algae</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>mg/100 g dry algae</td>
<td></td>
</tr>
<tr>
<td>Boron</td>
<td>1.1 to 23.5</td>
<td>0.2 to 4.0</td>
</tr>
<tr>
<td>Cobalt</td>
<td>0.03 to 0.11</td>
<td>0.01 to 0.17</td>
</tr>
<tr>
<td>Copper</td>
<td>0.50 to 4.66</td>
<td>0.02 to 1.95</td>
</tr>
<tr>
<td>Iron</td>
<td>0.40 to 468.5</td>
<td>30.00 to 250.0</td>
</tr>
<tr>
<td>Manganese</td>
<td>2.3 to 38.4</td>
<td>0.04 to 24.7</td>
</tr>
<tr>
<td>Zinc</td>
<td>0.74 to 1.86</td>
<td>0.13 to 3.46</td>
</tr>
</tbody>
</table>
in which these compounds constitute about 25 per cent of the total solids act as soil conditioners. The laminarin constituent of a certain class of seaweeds reduces the incidence of root rot in beans. This is attributed to the vigorous growth of a plant pathogen, caused by laminarin, which destroys the fungus, Fusarium solani f. phaseoli, which causes the root rot. It will thus be seen that in addition to the major plant nutrients, the seaweeds contain several other constituents which favourably affect the plant growth as well as quality attributes.

6:3 Role of organic manure in crop production

It is now universally accepted that neither chemical fertilizers nor organic manures by themselves are adequate for optimum crop yields. It is only by the combination of both that the best results are obtained. The carbonaceous matter added to the soil in the form of organic manures, forms the primary food supply of the soil micro-organisms and consequently undergoes a series of decompositions and synthesis. The carbon of the organic matter is lost mainly in the form of carbon dioxide diffusing into the atmosphere or leaching out as carbonic acid or bicarbonates. The nitrogen of the organic matter is transformed into nitrates, by the activity of the soil micro-organisms. These nitrates are taken up by the plants or are lost in leaching. The proportion of organic carbon or nitrogen in the soil, or its loss from the soil, depends upon the soil conditions viz., aeration, moisture status, drainage, temperature etc., as well as the source and composition of the organic matter.
6:3.1 Sources of organic matter and their composition

The conventional sources of organic matter in arable farming are: 1) the residues of crops, 2) farm yard manure, 3) town compost, 4) sewage sludge and 5) green manures. The growing crop always leaves behind much of its root system as well as stubble and dead leaves. But, except in the case of some grasses and leguminous leys, the quantity of the organic matter added to the soil by this source is very small. Usually the farm yard manure and the town compost manure form the major sources of organic matter. The system of green manuring is restricted to the areas having irrigation facilities.

The average composition of these conventional sources of organic manures is given in table 6.1

Table 6.1 Manural value of conventional organic manures

<table>
<thead>
<tr>
<th>Material</th>
<th>Nitrogen %</th>
<th>Phosphoric acid %</th>
<th>Potash K₂O %</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Farm yard manure</td>
<td>0.7 - 1.5</td>
<td>0.5 - 0.95</td>
<td>0.8 - 2.0</td>
<td>(198)</td>
</tr>
<tr>
<td>Town compost</td>
<td>0.7 - 1.5</td>
<td>0.8 - 2.50</td>
<td>nil</td>
<td>(199)</td>
</tr>
<tr>
<td>Green manures</td>
<td>1.2 - 3.5</td>
<td>0.2 - 0.70</td>
<td>0.3 - 1.80</td>
<td>(198)</td>
</tr>
<tr>
<td>Sewage activated sludge</td>
<td>4.12</td>
<td>2.24</td>
<td>0.95</td>
<td>(200)</td>
</tr>
<tr>
<td>Seaweeds</td>
<td>0.7 - 4.0</td>
<td>0.1 - 0.50</td>
<td>1.2 - 3.0</td>
<td>(196)</td>
</tr>
</tbody>
</table>

It will thus be seen that the seaweeds are richer in their potash content, poorer in their P₂O₅ content and slightly better in their nitrogen content, as compared to the conventional sources of organic manures.

6:3.2 Composting of organic matter

If the organic matter as such is added to the soil, it
may have depressing effect on the crop growth because of its wider C:N ratio which reduces the availability of soil nitrogen. It is therefore customary to reduce this C:N ratio by composting the organic matter, before adding to the soil. The composting of organic matter decreases the time taken for its complete decomposition and increases its manural value by converting the nutrients in unavailable organic form into available inorganic form. The composting is done by one of the following two methods:

1) Open heap process of Haward and Wad (201) and 2) Hot fermentation process of Acharya (202). In the open heap process, the decomposition is partly aerobic and partly anaerobic. The anaerobic decomposition takes a little more time, but the loss of organic carbon is much less than by the open heap process. There is almost complete recovery of nitrogen provided the C:N ratio is not allowed to fall below the level of 30:1. The loss of nitrogen increases with decreasing C:N ratio. In both the cases, for proper decomposition, the material must have 50 to 55 per cent moisture. A moisture level below 40 per cent reduces the rate of humification while excess moisture above 55 per cent leads to fermentation of the liquid sludge.

6:3.3 Influence of organic manure on physico-chemical properties of soil

The lignin constituent of the organic matter, together with other products of microbial synthesis, influences the important physico-chemical properties of soils. Myers (203) has shown that the organic colloids dry irreversibly and thereby improve the soil aggregation. This aggregating effect depends on the nature of carbonaceous matter (204). The more readily decomposable
material has better aggregating effect than strongly resistant material. McGeorge (205) has estimated that the cation exchange capacity of the organic colloidal complex is about 159 milliequivalents per 100 grams of organic matter. This is greater than the maximum cation exchange capacity of 150 me/100 g exhibited by montmorillonite or vermiculite clay minerals. Thus, more the organic carbon content of the soil, more will be its cation exchange capacity. Marshall and Patnaik (206) have indicated that the humic fraction of the organic matter holds the cations less firmly than the clay minerals, thereby releasing them more easily for the use of plants. The order in which various cations are held by organic colloids is Na>K>Ca. It is well known that the availability of soil nitrogen and to some extent also of P₂O₅, depends on the C:N ratio; Acharya (207) has proved that the availability of nitrogen is maximum when C:N ratio is close to 12:1; wider ratios have depressing effect on crop growth.

It is thus clear that organic matter plays an important role in crop growth. It stimulates the growth of soil microorganisms which are responsible for many chemical processes that take place in soil. It also improves the soil structure and enhances the uptake of nutrients applied in inorganic form. But the organic matter can not be applied as such to the soil because of its wider C:N ratio. It has to be composted during which the nutrients in organic form are mineralised, thereby making them available to plants.

6.4 The suitability of organic waste as manure

Although it is true that the continuous application of heavy
doses of organic manures, even for a number of years, does not ultimately raise the carbon and nitrogen status of the soil, their application does play an important role in the maintenance of soil fertility, especially in tropical countries. This is attributed to the fact that during the growing period of crop, the added organic matter, stimulates the microbial activity of the soil, which brings about in its turn, other beneficial effects like improvement in soil structure, conversion of the reserve nitrogen, phosphoric acid and potassium in the soil, into available forms etc. By the time the growing crops reach the stage of harvest, the beneficial action of organic matter comes to an end, due to the high temperatures prevailing in the tropics. The suitability of any organic waste material for use as a manure, depends upon its ease of decomposition, which in turn, is dependant upon its composition. The process of matter decomposition of the added organic includes the synthesis of microbial protoplasm and the products of microbial metabolism. When any organic matter is added to the soil, it undergoes, during the process of decomposition, many changes, some of which have been claimed to be taking place without the participation of the soil micro-organisms. However it is now established that complete humification of added organic matter can not occur without the activity of soil micro-organisms. The microbial activities can not thrive in presence of any substance which is toxic for plant growth. Misra, Sen and Vyas (208) have reported that the nitrification of the organic nitrogen of the mahua cake did not take place because of the presence
of a toxic substance. On the removal of this substance by extraction with alcohol, the nitrification proceeded in the normal way. Therefore the vigorousness of the microbial activity can be considered to be a good index of the ease of decomposability as well as the non-toxic nature of the added organic matter. The nitrification of the organic nitrogen is the result of the activities of nitrifying bacteria present in the soil. Moreover, the rate of decomposition of the organic matter and the nitrification of the organic nitrogen go hand in hand. Therefore the rate and the total extent of nitrification of the added organic nitrogen is a good index of the usefulness of the organic matter as a manure.

In this part 2 of the thesis, results of the studies on the nitrification of the seaweed nitrogen are reported. In addition, the effect of seaweed manure on the yield and quality attributes of two cereal crops viz., wheat and bajara; and one oil seed crop viz., groundnut, has been investigated by conducting pot culture as well as field manural experiments. The results of these experiments are also reported here.
Figure 8.3 Nitrification of seaweed nitrogen in silty-clay soil
Nitrogen level: 45 mg/kg soil (mixed)

LEGEND
ULVACLACTA + F.Y.M.
DRIFT SEAWEED + F.Y.M.
Figure 8.7 Nitrification of seaweed nitrogen in silty-clay soil

Nitrogen level: 45 mg/Kg. soil

LEGEND

- ULVALACTUCA
- DRIFT SEAWEED
- F.Y M

TIME IN DAYS
Figure 8.6 Nitrification of seaweed nitrogen in silty-clay soil
Nitrogen level: 50 mg/Kg. soil (mixed)
Figure 8.5 Nitrification of seaweed nitrogen in silty-clay soil

Nitrogen level: 30 mg/Kg. soil

LEGEND
- ○ ○ ULVALACTUCA
- □ □ DRIFT SEAWEED
- △ △ F.Y.M.

TIME IN DAYS
Figure 8.4 Nitrification of seaweed nitrogen in sandy soil

Nitrogen level: 45 mg N/ Kg soil (mixed)

LEGEND
- - - - - - ULVA LACTUCA + F.Y M.
- - - - - - DRIFT SEAWEED + F.Y M.
- - - - - - F.Y M.
Figure 8.3 Nitrification of seaweed nitrogen in sandy soil
Nitrogen level: 45 mg/Kg. soil

LEGEND

- ULVALACTUCA
- DRIFT SEAWEED
- F.Y.M.

TIME IN DAYS
Figure 8.2 Nitrification of seaweed nitrogen in sandy soil

Nitrogen level : 30 mg/Kg soil (mixed)
Figure S.1 Nitrification of seaweed nitrogen in sandy soil
Nitrogen level: 30 mg/Kg soil