Nutritious leafy plants: also valuable for soil health

Introduction: Factsheets 1-12 have demonstrated that a range of nutritious perennial leafy vegetables can be found and successfully grown on Pacific atolls. However atoll soils, being almost entirely derived from coral, are low in many nutrients particularly potassium, iron, manganese and copper. Availability of nutrients is further exacerbated by the high soil pH. Being sandy in nature, these soils also have a low ability to hold both water and nutrients. This, combined with commonly high levels of salt, creates a tough growing environment for plants. It is important that these constraints are overcome to provide optimal conditions for growing nutritious leafy vegetables.

Inorganic fertilisers are banned on many atolls and traditionally soil fertility for growing crops such as Giant swamp taro has been improved with the addition of compost. In addition to providing and holding necessary plant nutrients, compost also buffers against drought, salinity and high soil pH constraints.

Acanthophora seaweed from Bonriki, Tarawa, Kiribati

Current compost making uses varying proportions of brown and green leaves with addition of animal manure to provide a lot of the necessary nutrients. However on many atolls there are limited numbers of pigs and chickens and manure is not readily available. In addition, unless housed in a pen with a floor, the manure is mixed and diluted with soil. For many atolls alternative compost ingredients are required instead of animal manure.

A new approach to making compost: Following on from preliminary work on Taveuni island, Fiji one of the aims of the current ACIAR atoll soil health project is to improve the science behind making compost. In conjunction with the evaluation of plant leaves for human consumption the project is also assessing the comparative nutritive value of leaves as ingredients in compost.

Results from soil tests highlight likely nutrient deficiencies and to fix these issues, suitable leaves and other inputs are added to improve the composition of the compost. Thus, rather than just making compost with whatever material is available, a more targeted approach is being taken. For example, low iron in soil typically shows as yellowing between the veins of leaves (interveinal chlorosis) in susceptible plants. Mineral analyses of yellow beach pea (te kitoko/saketa sega; Factsheet 7) and chaya (te tiaia; Factsheet 3) have consistently demonstrated high levels of iron in their leaves and so both plants are good accumulators of this nutrient. When soil iron levels are low, leaves from these species can thus be targeted when making compost. We are therefore terming this ***targeted composting***.

What should I be adding to my compost?

When making compost, alternating layers of "brown" and "green" materials are added. For further details on how to get started in making compost see the ACIAR/SPC factsheet, "*Making compost for healthy atoll soils*".

The "brown" component of compost is frequently the fallen leaves of breadfruit (*Artocarpus spp*; te mai/mei) with premna (*Premna serratifolia*; te ango/valovalo) and guettarda (*Guettarda;* te uri/pua) leaves also commonly used, depending on what is most readily available. Mineral nutrient levels in brown breadfruit leaves are presented in the table below. Premna and guettarda leaves are similarly low in most nutrients.

The "green" leaf component used most regularly in compost is beach cabbage (*Scaevola taccada;* te mao/gasu). As with the commonly used brown leaves, mineral tests show only low to moderate levels of nearly all nutrients. The existing use of beach cabbage in compost therefore appears to be based on advantages of abundance and ease of harvest rather than targeted mineral composition. To enhance mineral levels of compost other inputs of higher nutritive value, in addition to the standard brown and green leaf components, are thus required.

Potassium is generally the most limiting macro-nutrient in atoll soils. While green leaves of purslane (te boi/katuli; Factsheet 12) and to a lesser degree, pisonia (*Pisonia grandis;* te buka/pukavai –see table below) and chaya (Factsheet 3) contain reasonably high levels of potassium, this is insufficient to compensate for the generally low soil levels. This deficiency however can be largely overcome through the addition of ash which has very high levels of potassium. This is not surprising as ash is the concentrated by-product of large quantities of plant material. Of the different ashes tested to date, that from burning coconut husks and shells contains by far the highest amounts of potassium. Fortunately this is a very common fuel source for cooking fires. If available, other excellent sources of potassium are the seaweeds (te tiwiita/limu) *Acanthophora spp* and *Sargassum polycystum.* The samples in the table below were collected from Tarawa and Funafuti respectively. In contrast, seagrass (*Thallasia hemprichii*; te keang/mouku ote tai) is much lower in potassium.

Nitrogen is best provided in marine and animal by-products such as fish waste and animal manure. Data in the below table for fishmeal are from the after-processing by-products of fish heads, guts, scales and bones sourced from Levuka, Fiji. Local fish waste should be similar in mineral composition. From preliminary overseas data it also appears that the nutrient content of dried sea cucumber (lollyfish; *Holothuria atra*) is comparable with fishmeal. In the absence of these inputs the best plant sources of nitrogen are chaya (Factsheet 3), drumstick (Factsheet 4), yellow beach pea (Factsheet 7), purslane (Factsheet 12) and pisonia (table below).

Iron deficiency is very common in plants growing in atoll soils. Fishmeal, ash and seaweed all have high iron levels (table below) and there are also moderately high amounts in purslane, yellow beach pea and chaya (see relevant factsheets). It is also likely that soil iron levels can be increased with addition of small amounts of ground-up rusted iron (e.g. 2 mm). While iron oxide is commonly recognised as being unavailable to plants there is anecdotal evidence from trials in Kiribati that addition of rusted iron particles will increase the level of available iron and thus assist in alleviating iron deficiency. Trials are evaluating whether this effect can be further enhanced by adding rusted iron at the beginning of compost making.

Beach cabbage being prepared for compost -Tanaea, Tarawa, Kiribati

Manganese and **copper** deficiency are probably underestimated in their prevalence in atoll soils. Both minerals are present in relatively high levels in ash and to a lesser degree in the leaves of pisonia. Of note, pisonia is often used as a compost ingredient in Tuvalu. Yellow beach pea will also provide useful amounts of manganese.

Phosphorus and **zinc** have been shown to be often present in adequate to high levels in soil tests conducted to date. Given the expected high tie up of both elements in alkaline soils, this result has been surprising and additional tests using different soil P testing methodologies are being undertaken. Phosphorus and zinc are both present in ash and fish meal in relatively high levels. Of note, yellow ilima (*Sida fallax;* te kaura/akata), which is commonly added to babai/pulaka compost, is a good source of both nutrients (see table below).

Sulphur and **boron** are not commonly deficient in atoll soils. Drumstick leaves are recognised as being exceptionally high in sulphur content (Factsheet 4), however the level in seaweed, particularly *Acanthophora* is higher still. Ash, seaweed and seagrass are also rich sources of boron (see table below). The highest levels of boron in terrestrial plants are found in the brown leaves of breadfruit, guettarda and premna and so all compost made using these brown leaves should contain sufficient boron.

Pisonia from Utiroa Tab North, Kiribati

Pisonia from MELAD nursery, Abemama, Kiribati

Note - It is evident that ash from cooking fires, particularly from burning coconut husk and shells, can provide good levels of most plant nutrients. However large amounts of ash added to compost may cause nutrient imbalances due to the additionally high levels of chloride, sodium and magnesium (more of something isn't always good). As part of this ACIAR project we are conducting trials to evaluate the optimal levels of ash that can be safely added to compost. Until these trials are completed, addition of ash should be limited to 2 shovels (4-5 kg) sprinkled in a cubic meter compost heap. In the meantime to help overcome any possible nutrient inadequacies, try to source a small quantity of pig manure to boost mineral levels. Soil tests have also shown that the soil from around tethered pigs is comparatively high in available potassium and nitrogen and this can be added to compost. It may even be useful adding a layer of chopped brown leaves in the pig run to help soak up urine.

Also note that not all of these suggested plants will be readily available. Seaweed for example is seasonal when washed ashore. Some plants such as purslane and yellow ilima may be present but, being herbaceous, are only available in smaller quantities. Inability to supply one or more inputs should not be a problem if other listed options can be substituted.

The data (next page) provide an indication of the most useful ingredients when making compost. The final proof will be through comparative testing of composts made from different ingredients and this is currently being undertaken in pot and field trials conducted by ACIAR. Different vegetables will also have different nutrient requirements; with further trials we will be able to provide variants to compost formulation for different crops.

The table below presents the mineral content in leaves of plants and other materials not listed in previous ACIAR factsheets and currently used or showing potential for making compost. Each data point is the average nutrient content of between 2 and 11 samples collected from Kiribati and Tuvalu between 2014 and 2018. Data for calcium, magnesium and sodium are not presented as these minerals are in ample supply in the soil. (Concentration in mg/kg dry weight, except N: % dry weight).

	N %	P	K	S	B	Cu	Zn	Mn	Fe
Breadfruit	1.1	1930	1535	1750	74	3	12	11	38
Beach cabbage	1.9	2525	8425	3338	41	3	33	10	25
Pisonia	3.7	2883	18883	3617	45	18	19	32	53
Yellow ilima	3.0	5050	11833	1990	30	4	61	19	38
Acanthophora	1.6	967	47200	42333	410	2	10	5	129
Sargassum	1.2	1350	57200	15500	235	1	28	27	95
Seagrass	2.7	2450	22500	6800	512	4	7	7	62
Fish meal/waste	8.3	10800	6900	na	na	5	102	25	836
Ash -coconut husk	0.1	14688	84994	2352	337	99	131	86	235

N: nitrogen; P: phosphorus; K: potassium; S: sulphur; B: boron; Cu: copper; Zn: zinc;
Mn: manganese; Fe: iron; na: not available
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