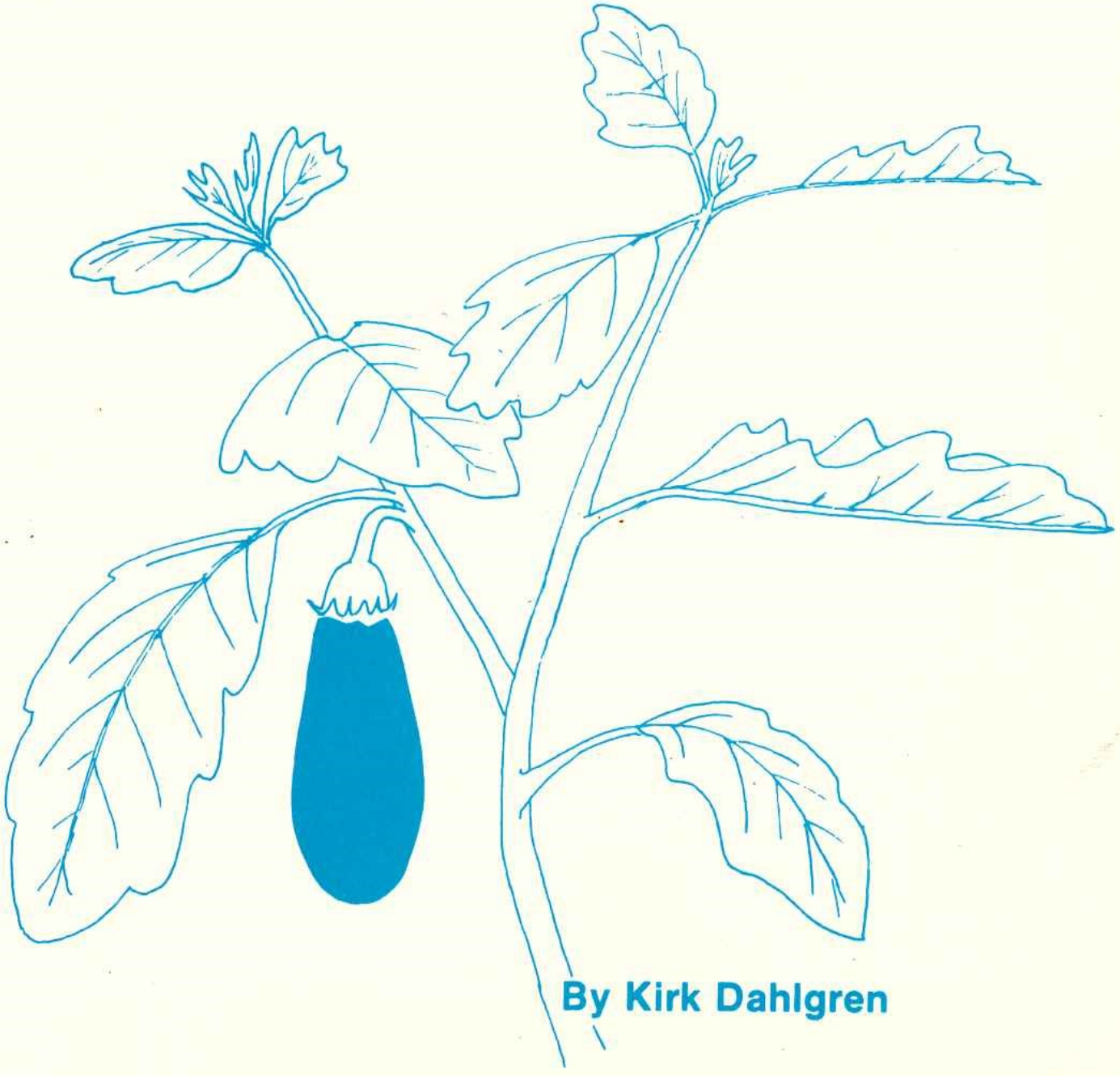
GROWING VEGETABLES IN FIJI



By Kirk Dahlgren

PREFACE TO THE ECHO REPRINT

ECHO receives letters every month from individuals who did not grow up in the tropics, but who now find themselves called upon to do vegetable gardening under tropical conditions. Some may not even have had previous gardening experience in any climate. Now they may even be expected to teach the subject.

We have found this book so helpful in both teaching basic gardening techniques and bridging the gap between temperate experience and tropical realities that we asked its author for permission to reprint it.

I came across this formerly obscure book in the Peace Corps library in Washington. Kirk Dahlgren had written it while working as a Peace Corps director in Fiji. We are glad to be able to make it available again.

I believe that many books could have been written with much fewer pages. One thing I appreciate about Kirk's approach is that he distills out the most important things you need to know, and says them in the least amount of space possible. Thus you will find this small book to be a great introduction to gardening in general as well as tropical gardening in particular. It is required reading for all ECHO interns.

He discusses vegetables with which people from temperate climates may not be familiar, but which are very well adapted to the tropics. But he also discusses techniques for growing temperate vegetables for which there may be considerable demand (and potential profit). Though it may not be possible to grow a particular temperate vegetable in your location, Kirk's comments will help you give it the best chance of success.

We find people making two opposite mistakes. One is to assume that in the tropics they will easily be able to grow the kind of vegetables they knew from temperate climates. The other is to assume too quickly that it cannot be done. To be sure, many temperate vegetables will not grow in most tropical locations. But every so often we find someone succeeding with a vegetable we might have urged them not even to try. Experiments in your garden will cost little!

HOW TO ORDER: Copies of Growing Vegetables in Fiji may be purchased for $5.00 plus postage from ECHO, 17430 Durrance Rd., North Fort Myers, FL 33917 USA. Overseas orders add $5.00 for airmail, $2.00 for surface mail. U. S. orders add $1.00 for postage (and 30 cents sales tax in Florida).

ECHO (Educational Concerns for Hunger Organization) is a Christian, non-profit organization which assists people working with other non-profit organizations in their efforts to help small farmers in the Third World to grow food under difficult conditions. Write us for further information on our free services and an application to become a member of the ECHO network.

Network members receive our quarterly networking newsletter, ECHO DEVELOPMENT NOTES. It is sent to over 90 countries, at no charge, to persons working with small farmers in Third World countries. Others may subscribe for $10.00 per year. Back issues are available in a binder. Write for prices.

Martin L. Price, Executive Director,
January 1989

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By Kirk Dahlgren

Illustrated by Kirk Dahlgren and Valerie Townley
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CONTENTS

INTRODUCTION

Why grow vegetables? Most of us correctly consider vegetables an important food group providing vitamins and minerals important for healthy bodies. Yet this alone is not sufficient reason for growing introduced crops such as tomatoes, cabbage, and carrots (which form the majority of the crops discussed in this book), for studies have shown local garden crops such as bele, saijan, and Amaranthus, and even sweet potato, taro, and cassava leaves, to be far more nutritious than the majority of the introduced vegetables.

While nutritional awareness may account for why people grow vegetables, another reason is the contribution to the variety and palatibility they provide in the diet, and this is the key to the popularity of introduced vegetable crops. Few would deny that a tomato is irreplaceable in a chutney, that there is something special about Chinese cabbage "vaka lolo", and that salad is not a salad without lettuce.

Vegetable consumption is on the increase and many growers, whether farmers in rural areas or backyard gardeners in urban areas, have taken advantage of the expanding market. Unfortunately, local growers have not kept up with demand, for imports of vegetables are on the increase.

Perhaps the two key reasons for the failure to match demand are the climate (in particular, Fiji's tropical wet season) and farmer's unfamiliarity with crop cultural practises, especially with "new" vegetables required by the growing hotel and restaurant trade. While this guide will not change the weather, it is hoped to be a step towards alleviating the misunderstanding that prevents Fiji from becoming not only self-sufficient in vegetable production, but from someday becoming a vegetable exporting country.

I have not mentioned a final reason I feel many people grow vegetables, that is, for the pure joy of gardening. While a vegetable garden has none of the lasting aesthetic value of a piece of sculpture or a painting, the good gardener is nevertheless an artist and architect of nature, constantly redesigning and continually enjoying. While there may be frustrating moments with weeds and weather, the magic of a garden at dusk is always the lasting impression.

Whatever your reasons for growing vegetables, I would wish you success.

chapter one

The Fiji Vegetable Crop Environment

Vegetable crops, as all plants, are products of the environment in which they evolve. Most vegetables have been introduced to Fiji from regions with widely differing environmental conditions. Understanding the nature of these crops and their interaction with the Fiji plant environment is the first step to successful vegetable growing.

THE SIGNIFICANCE OF VEGETABLES IN FIJI

Most of the vegetables that are presently grown in Fiji have been brought here in the last 150 years. Prior to the arrival of the first Christian missionaries in 1839, indigenous Fijians cultivated a limited number of crops with root crops serving as the dietary staple. Today Fijians continue to cultivate root crops and other traditional food plants but have diversified into vegetables and other crops that are today consumed in Fiji.

The introduction of new crops into the Fijian community has affected changes in dietary patterns, nutrition, and potential income. Less obvious, but significant in the agricultural perspective, is that the culture of many of these new food crops required the learning of a totally foreign propagation method

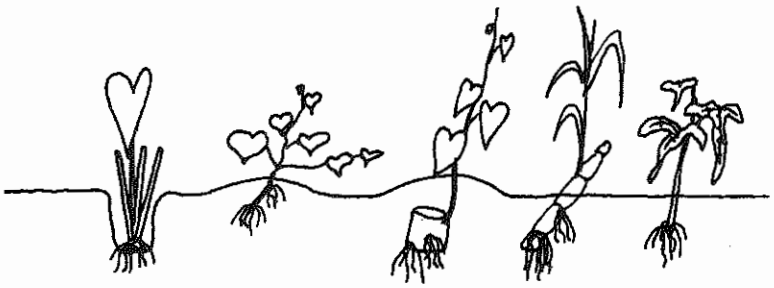


Figure 1. Traditional island crops are propagated vegetatively.

- the use of seeds to grow crops.

SEEDS: A NEW PROPAGATION METHOD

The unifying factor in the list of traditional Fijian crops (table below) is that they are all propagated "vegetatively", that is, a piece of the plant other than a true seed is used to produce new plants. For instance, with taro, "suckers" (or "side shoots") or the top of the taro plant with a bit of the root (or "corm") is planted to produce new plants. Yams are propagated by cutting up pieces of the tuber and planting them. With sweet potatoes, bele, and sugarcane, pieces of stem are planted to produce new plants.

Though native Fijians were undoubtedly aware of the reproductive role of seeds by seeing the phenomena with other local plants, they did not practise the sowing of seeds as part of their agriculture system. Thus when both Europeans and Indian girmits arrived in the nineteenth century, the Fijians were first exposed to the practise of sowing and saving seeds. Needless

Fijian (before 1839)	European (after 1839)	Indian (after 1879)
taro (dalo)	European vegetables	rice
sweet potato (kumala)	pineapple (from Americas)	pulses
yam (uvi)	guava (from Americas)	spices/herbs
sugar cane (dovu)	mango (from Asia)	
bele	cassava (from Americas)	
	papaya (from Americas)	

Table 1. Origins of crops cultivated in Fiji today.

to say this was a two-way exchange, the Europeans and Indians being relatively unaccustomed to the vegetative propagation system of the islanders, a system the "vulagi" must certainly have initially depended on for food.

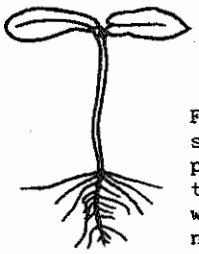


Figure 2. Propagation by seed was the agricultural practice of the "vulagi", the Europeans and Indians who came to Fiji in the nineteenth century.

PLANTS AS A PRODUCT OF THEIR ENVIRONMENT

Why are the reproductive systems of these crops so different? Basically, the ability of plants to form reproductive seeds, grow roots from their stems, or to produce side shoots are all adaptations to the plant environment - the conditions of life and growth. The vegetable crops the missionaries first brought to Fiji evolved in the temperate zones of the northern hemisphere - regions where plants needed to produce resistant bodies, that is, seeds, to survive the harsh winters. The crops that the Indians brought to Fiji also formed seeds, though the natural function of these seeds was to survive the dry months of arid India until the next rainy season.

In Fiji and many other tropical lands it is never cold or dry; in the plant perspective things are "just right", it is warm and wet enough for year-around growth. Thus it is often advantageous for tropical plants to reproduce through means other than seeds. A taro plant, for example, grows and from the sides of the corm grow side shoots that themselves will grow into taro plants. The bele plant grows tall perhaps until the first cyclone comes along. However, special plant adaptations allow the fallen bele stem to root in the moist soil at the leaf nodes and produce new plants. And sweet potato stems grow in all directions from the tuber, efficiently utilising sunlight. The foraging pig cannot destroy the plant by uprooting the tuber, for the stems have rooted into the soil wherever contact was made, in effect, forming new plants.

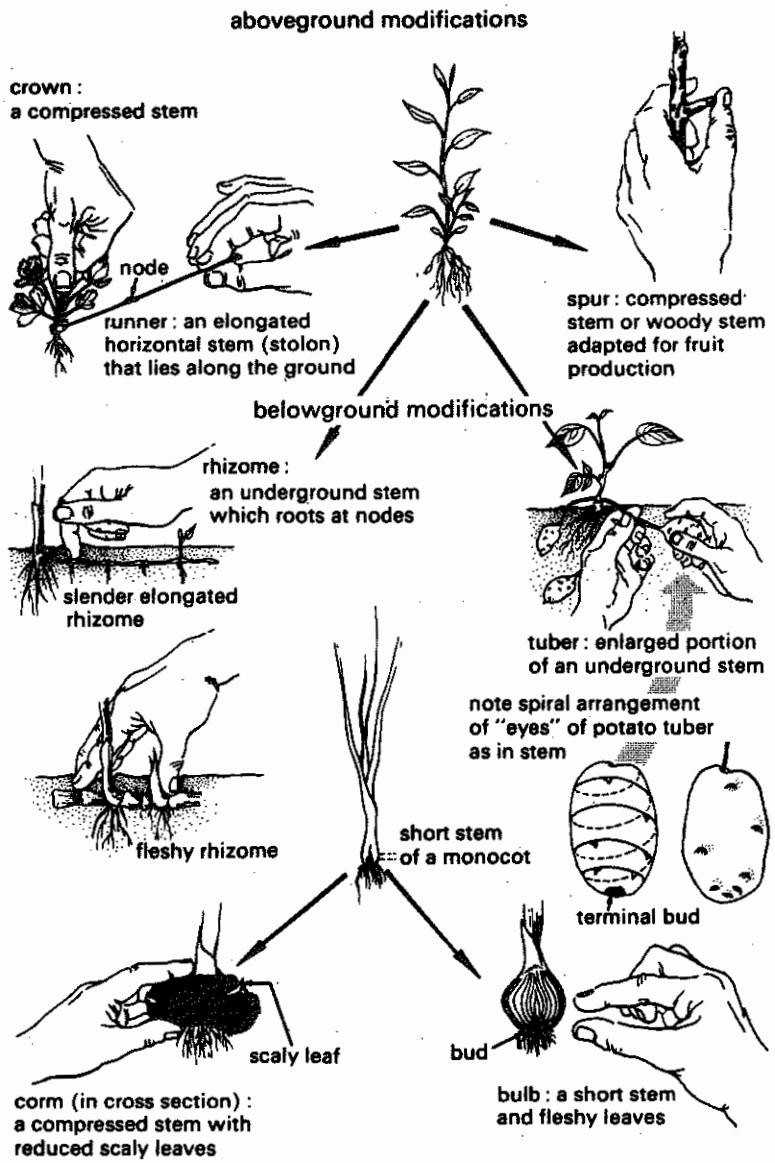


Figure 3. Plant modifications are adaptations to the environment in which the plants evolve. The environment includes all the factors that affect the plants-climate, soil, daylength, and other competing plants.[1]

Plants, no matter where they originate, have made special adaptations to their native environment. It is partly for this reason that the cultivation of vegetable crops in Fiji is less than straightforward. Most of these crops are the products of natural selection in a specific environment - including climate, pests, disease, and other competing plants - plus selection by man since the dawn of agriculture 7,000 - 10,000 years ago. Removing these "programmed" products to a tropical situ means exposing them to an environment with which they often cannot cope.

TWO IMPORTANT FACTORS: CLIMATE AND DAYLENGTH

The most dynamic difference between the temperate zone and the tropics is, of course, the climate. It is generally said that vegetable crops perform best in temperatures between 24°C and 30°C. As can be seen by the graph of average monthly maximum temperatures in Fiji, these temperatures are often exceeded, especially in the summer months. The temperate zone is also relatively dry compared to Fiji. Yearly rainfall in northern Asia, Europe, and America rarely exceeds 1000 mm. whereas the rainfall in Fiji's dry zone is almost twice as high. The combination of high temperature and high rainfall adversely affects vegetable crop biological processes and produces an environment suitable for plant disease organisms.

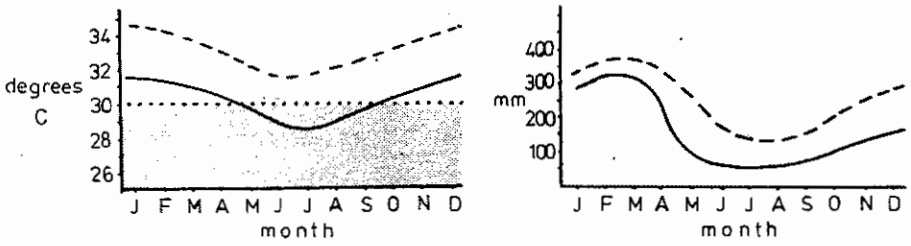


Figure 4. Left: Average daily maximum temperatures (solid line) and average monthly maximum temperatures (broken line) in Nadi. Temperatures between 24 and 30 degrees (shaded area) are considered best for most vegetable crops. Right: Average monthly rainfall for Nadi (solid line) and Suva (broken line).[2]

CROP	LONG DAY RESPONSE	SHORT DAY RESPONSE
onion	bulb formation	vegetative growth, no bulbing
winged bean	vegetative growth	flower, seed formation
rice	flower, seed formation	vegetative growth
tobacco	vegetative growth	flower, seed formation
lettuce	flower, seed formation	vegetative growth
potato	flower, seed formation	vegetative growth
pinto bean	dwarf, bush stature	climbing, pole stature
pigeon pea	vegetative growth	flower, seed formation

Table 2. Plant response to photoperiod (daylength)

Another difference between Fiji and the lands further north or south of the equator is daylength. Fiji, being about 18°from the equator, experiences very little change in daylight hours between June 22 and December 22, the winter and summer solstices. In temperate areas such as Christchurch, New Zealand at 43° south or Paris, France at 48° north, there is a vast difference in daylength between summer and winter.

Daylength serves as a guide to the biological "clocks" of plants. Many temperate plants grow vegetatively during the long days of summer. As the days shorten, the plants redirect their resources into flower and seed production "knowing" that with short days comes the cold winter. Other plants require long days to flower. Many plants of the tropics where daylength is always about twelve hours, are day-neutral and flower regardless of season. Plant response to daylength is known as "photoperiodism". Probably the most dynamic response to photoperiod is by members of the legume family. Understanding photoperiod response is extremely helpful in cultivating crops such as

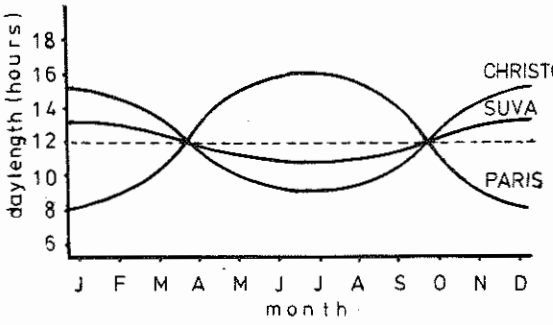


Figure 5. Seasonal variations in daylength vary according to distance from the equator (latitude). Suva (18° south) experiences little change in daylength compared to Christchurch, N.Z. (43° south) and Paris, France (48° north).

winged beans and pigeon peas that only flower in Fiji's short days.

Figure 6. The Maryland Mammoth tobacco plant flowers in short days (left) and remains leafy in long days (right).[3]

THE ROLE OF RESEARCH

That vegetable crops can be grown in Fiji today is largely the result of concerted research. In selection centers around the world, single plants are systematically selected from thousands because they show adaptations to environment including resistance to pests and disease. From these few plants rise the "cultivars" or "varieties" that are sown by farmers and gardeners.

Fiji is today participating in this process of finding suitable vegetable lines for domestic production. At the Sigatoka and Koronivia Research Stations, trials are carried out on an annual basis to find high-yielding vegetable varieties. While many of these lines are commercially available cultivars, the Agriculture Department has also been involved in selection and seed bulking. A good example is selection of tomatoes for high yield and resistant to bacterial wilt, perhaps the single worst economic vegetable disease in Fiji (see chapter 4). From dozens of varieties obtained from other tropical research centers, two varieties, subsequently named "Alton" and "Vuavina", were selected and bulked-up. Their utilization offers an alternative to imports of off-season tomatoes.

The demand for fresh vegetables will continue to increase in Fiji. Whether local growers can match the demand - something they today cannot do - depends on continued and expanded research, better extension efforts, and education of the local grower. The following chapters discuss more of the

intricacies of the Fiji plant environment, the "character" of vegetable crops, and some answers to the problems that inevitably rise in growing vegetable crops in Fiji.

chapter two

Building and Maintaining Soils

The soil, upon which we depend for food production, is a fragile and expendable resource. Careful management is of the utmost importance - especially in high rainfall areas such as Fiji. As farmers strive to produce more or less land, they must concern themselves not only in maintaining soil fertility, but in protecting the finite resource of soil.

SOIL: VALUABLE BUT FRAGILE RESOURCE

The primary resource in agriculture is, of course, the soil. Soil is a layer, varying in depth, of weathered rock particles and organic matter deposited as a result of wind, water, ice, and gravity. The common conception of soil is that of a stable entity formed over hundreds and thousands of years, immune to much change in lifetimes to come. The truth, and indeed a tragic fact, is that the soil upon which the world's population depends for food, is a fragile substance often lost in a few decades through careless agricultural practices.

The significance of this fact has been borne out time and again throughout the history of the human race. Though much of civilisation's rise and fall depended on political and social factors, the savage competition for productive soils

cannot be overlooked. In the years 1938-9, a soil scientist, Dr. W.C. Lowdermilk, travelled throughout Western Europe, North Africa, and the Middle East at the request of a United States congressional committee His purpose was to examine the soils and topography of these lands and record the changes that have evolved due to the activities of man throughout history.

His first stop was the fertile Mesopotamian crescent formed by the Tigris and Euphrates Rivers. According to archeologists, 21,000 of the 35,000 square miles of the rich alluvial flats were once irrigated by canals built by the rulers of biblical Babylon. Yet food needs of the expanding population, six to seven times that of the same area in 1938, forced cultivation of marginal sloping soils that surround the valley. Resulting runoff and erosion increasingly filled the canals with silt and without irrigation water, the millions were eventually forced out by starvation and strife.

The tragic tale of soil misuse was evident everywhere Lowdermilk travelled. The Sinai Peninsula, once covered with a thick crust of brown soil, had been reduced through the centuries to a maze of gullies due to overgrazing by nomadic tribesman. Petra, where failure by Nabotean farmers to maintain hillside terraces resulted in total loss of sloping soils. The French Alps, where improper cultivation of slopes resulted in landslides burying fields, orchards, and villages. Ancient Tyre, where the famed forests of Lebanon once covered 2,000 square miles, but were cleared and cultivated due to population pressures. Today not only have the forests entirely disappeared but the slopes are devoid of a soil that could support crops or trees.

The significance of these sad tales is that they all, with the exception of the French Alps, occured in arid lands with little rainfall. In Fiji, these same foolish agricultural practices are being carried out, but the consequences are being felt not in centuries, but in decades due to pounding tropical downpours. A good example is the soil in parts of

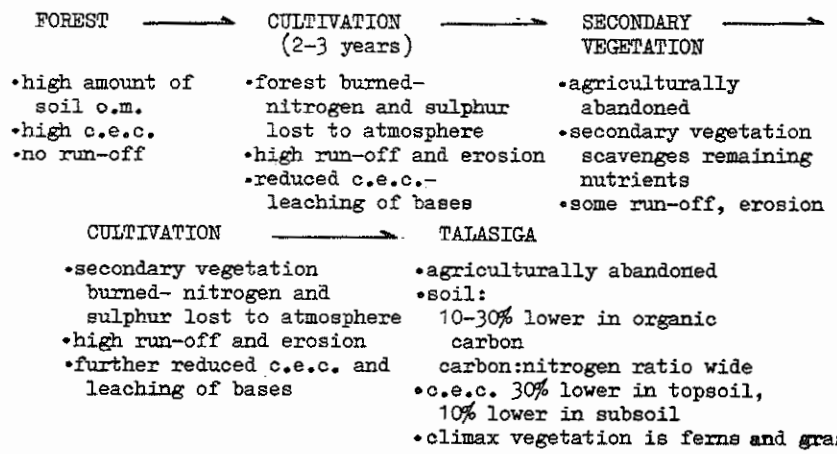


Figure 7. Primary burning and cultivation of forest land leads to fertility decline, erosion, and runoff. This trend is reversible after the plot is abandoned, however, unless secondary vegetation is again burned and cultivated. Secondary cultivation leads to talasiga soils.[5]

the Suva - Nasinu area that overlaps the parent marl, or soapstone, material. These agriculturally-marginal sloping soils are increasingly being cultivated, especially for the production of market vegetables and root crops. However, poor utilization practices, including burning of cover vegetation and organic litter, over-cultivation destroying structure, and digging of drains up and down instead of across slopes have led in some cases to the complete loss of these soils within this century.

FIJI'S FOREST OF LEBANON

Fiji once had its own "forest of Lebanon". Scientists report that the western sides of Viti and Vanua Levu were once entirely forested.[6] However, the arrival of the first Fijians spelt doom for the forests due to the "slash and burn" agriculture practise of these people and burning of forests for defense. It is felt that the strong dry season in the western side aided uncontrolled fires into gradually consuming all forests, whereas the year-around rainfall in other parts of Fiji saved the vegetation we know today. Many tropical forests are tender ecosystems, the roots of large trees recycling nutrients that have degraded from the litter

of dead trees and leaves before the nutrients are lost to the water table. Burning these areas brings on a sequence resulting not only in the permanent destruction of the forest, but in the subsequent creation of "talasiga" ("sun burnt") soils unsuitable for crops and characterised by the climax vegetation of mission grass and ferns. The fragile forest ecosystem was created over thousands of years, was destroyed in a few hundred, and may take thousands of years to recover- if given the chance.

Traditional agriculture is dependant on the exploitation of virgin soils which are fertile upon clearing but lose their fertility rapidly. The rate of fertility loss is well-known to all agriculturists and has been documented in many research trials, the most famous being the Rothhamstead plots in England. In order to insure fertility, traditional agriculturists chose to shift their fields or gardens every three years or so. In high rainfall areas such as Fiji, it was necessary to cut and burn vegetation to expose new soils. The underlying soil was rich in organic matter and available nutrients and was supplemented by the minerals in the wood ash.

This practice in itself does not necessarily permanently destroy forests and the underlying soils. If the burned areas are surrounded by forest and the secondary vegetation that later grows is not burned a second time, the forest will slowly close the gap. However, with the population pressures

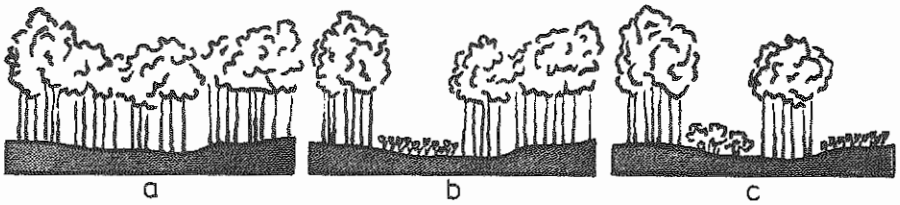


Figure 8. Traditional slash and burn agriculture involves the cutting of natural forest (a) and burning of litter to increase soil fertility. The plot is cultivated (b) for 2 - 3 years or more until the soil is no longer productive. The plot is then abandoned and cultivation is shifted to a new area (c).

of pre-colonial Fiji and the growing demand for land today, reckless practices including repeated burnings have increasingly denuded larger and larger areas of the Fiji islands.

The trend has been away from "shifting" agriculture and towards cultivation of set blocks of land. For this reason it is important that farmers learn soil conservation, soil building, and fertiliser practises.

SOIL IN THE PLANT PERSPECTIVE

Hilgard, a soil scientist, once defined soil as "the more or less loose and friable material in which, by means of their roots, plants may or do find a foothold and nourishment, as well as other conditions of growth".[7] In the case of Fiji, these soils are weathered from rock formed during the volcanic upheaval that resulted in these islands in the Pacific. Soil and plant development have gone hand in hand, the prehistoric soils supporting only simple life forms but becoming more complex, as did the vegetation,

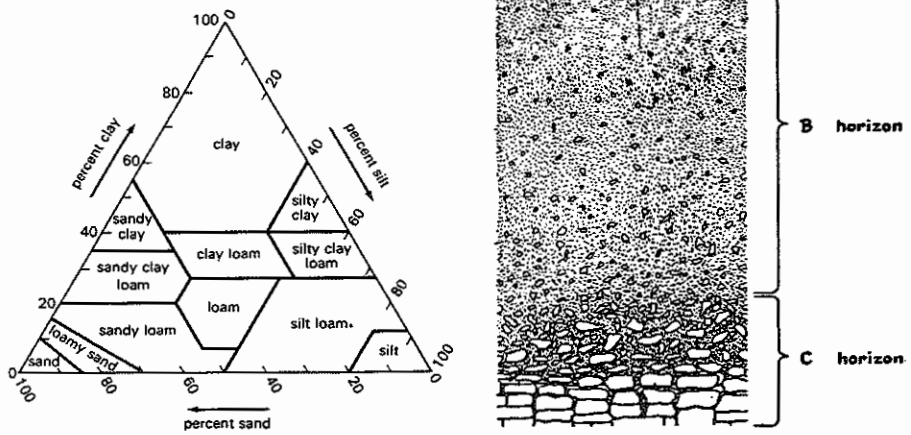


Figure 9. Left: the texture triangle defines soil types by the varying proportions of clay, sand, and silt. Right: a soil profile reveals the layers, or horizons, of soil from the fertile A horizon to the weathered parent material in the C horizon.[8,9]

with the buildup of organic matter.

From the origin of soil as weathered rock in the highlands, gravity, wind, and rain have deposited the material in slumps, depressions, and on the sides of streams and rivers. Today lush vegetation indicates the places where soils have been deposited the deepest. The richest soils are of alluvial origin, those deposited by water on flood plains such as in the Sigatoka, Ba, and Rewa River valleys.

As soil is deposited and subject to leaching by rainfall, distinct layers form and can be seen anytime a cross-section, or "profile", of the soil is visible, such as on a roadcut. Hilgard gave these layers, or "horizons", designations. The top layer, usually fairly thin, especially in the tropics, is the O or organic horizon and is made up of decomposing matter and its by-products. It is this horizon that farmers till into the soil below to insure a rich planting strata. Below this is the A horizon, a layer of soil fairly leached of solutes (the positively-and negatively-charged particles and acids that plants feed on). Underlying that is the B horizon, an accumulated soil layer, quite often clay and if red, then high in iron, saturated in bases and acids but many chemically bound up in compounds not available to plants. The C horizon, underlying the soil above, is the zone directly weathered from the underlying rock, or parent material.

Depending on the parent materials the soil was formed from, the soil has a resulting "texture", a balance of sand, silt, and clay particles. Sandy soils are, of course, well-draining but dry out rather easily. Clay soils are composed of fine minerals and are heavy. Water penetration is slow, drainage is equally slow, and cultivation difficult. Loam soils are the correct balance of sand, clay, and intermediate-sized silt particles and are ideal for cultivation and crop culture.

As soil accumulates over the years it is subject to leaching by

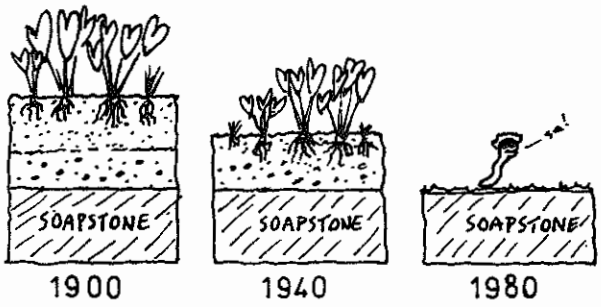


Figure 10. Overcultivation coupled with poor conservation practices has led to the complete loss of soil in a few decades.

rainfall and shrinking and swelling due to changes in moisture content and temperature extremes. The result is development of soil "structure", the architecture of the soil. This is defined by cracks that facilitate drainage, expansion, and contraction and is orderly enough to have recognized structural shapes - prisms, columns, plates, cubes, etc. It is over-cultivation by man that destroys this time-formed structural porosity causing runoff and erosion.

13 ELEMENTS FOR PLANT GROWTH

The presence of plants growing on any soil indicates that elements necessary for plant growth are available in that soil. All plants have the same basic requirements - that is, they need 13 soil elements to grow. Some plants, however, need less of the nutrients to survive on soils that other plants would not grow on, such as the ferns and mission grass on the talasiga soils laid barren by man's activity. Vegetables have the highest requirements - though the same 13 elements - of all crops. Thus in appraising untouched land, land-use planners designate only the best soils for market garden potential.

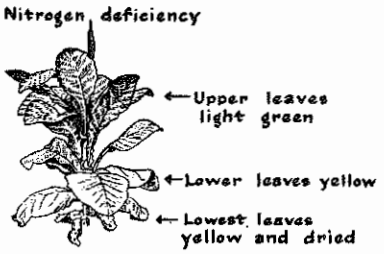
Figure 11. Cousin Momen's endorsement is simply an easy way to remember the symbols for the 16 elements needed by plants: C, H, O, P, K, N, S, Ca, Fe, Mg, Cl, B, Cu, Zn, Mo, Mn (carbon, hydrogen, oxygen, phosphorus, potassium, nitrogen, sulphur, calcium, iron, magnesium, chlorine, boron, copper, zinc, molybdenum, manganese). 13 elements are from the soil and three, C, H, and O, are from air and water.

The local farmer recognizes a good soil by the lay of the land and the vegetation growing on it. Thick para grass or healthy guava trees at the base of a hill or heavy undergrowth and trees at the side of a stream or river are signs of a deep, rich soil suitable for vegetable crops. A soil covered with only light vegetation may be easier to cultivate, but its barrenness indicates the unsuitability of the soil beneath.

However, as mentioned before, even a rich soil is soon depleted of its "power". Maintaining soil fertility depends on returning nutrients to the soil as fast as they are removed by the crop and by leaching. This then, is the basis of fertiliser practise.

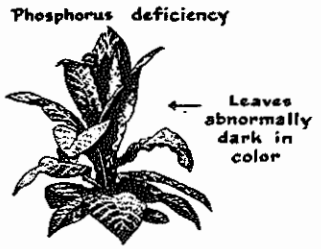
SIX PROBLEM NUTRIENTS

Though plants need 13 soil elements, most soils in Fiji contain sufficient amounts of six of the more minor nutrients (micro-nutrients) and sulphur (a macronutrient). Five macronutrients and one micronutrient are often lacking due primarily to leaching by heavy rains. These elements are nitrogen, phosphorus, potassium, calcium, magnesium, and boron and are discussed individually[10]:

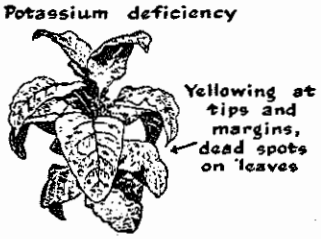


NITROGEN (N): The most dynamic plant nutrient due to its effect on plant growth and mobility in the soil and plant. In almost all soils it is the most limiting nutrient in crop production. Its role in the cycles of plant and animal growth and the fact that legumes are so successful due to the ability of symbiotic bacteria in their roots to trap soil nitrogen further indicate its importance. N is important for vegetative growth in plants. Nitrogen is very soluble in water (as nitrate) so is easily leached. To correct deficiencies in soil N, animal manures, urine, or chemicals such as urea or ammonia sulphate are added to the soil. Nitrogen deficiency symptoms in plants include

pale green or yellow lower leaves, slow stunted growth, and reduced size of fruits, roots, or stems.



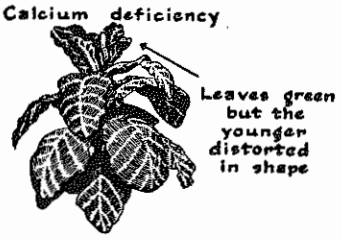
PHOSPHORUS (P) : Though plants require relatively small amounts of phosphorus, it must be added in large amount to the soil due to the quick tying-up of phosphorus with other soil minerals such as aluminium and iron. Phosphorus availability is determined to a great extent by soil pH (page 20), being most available at neutral pH's. Since phosphorus is relatively immobile in the soil, it is usually applied in the soil close to the seed or transplants. Soils deficient in phosphorus are amended with manures (low in available P), bone meal (which releases P slowly), or chemical superphosphate (P in a much more available form). Phosphorus deficiency symptoms in plants include reddish - purple colour on underside of leaves and on stems, slow growth, slender fibrous stems, and delayed maturity.



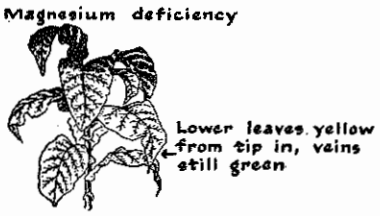
POTASSIUM (K) : Potassium is required in fairly large amount by plants. Potassium is slow-moving in soil but is well-utilized by plants. Potassium is essential in making plant stems rigid and is important in fruit, vegetable, and root crops. Though not easily leached in the soil, in plants it always occurs as a free ion so is readily leached from plant leaves by rain. Potassium is usually added to the soil as potassium chloride, but is also found in wood ash and to a small extent in manures. Potassium deficiency symptoms include curling, drying, and bronzing of leaf margins (the outer edge), especially lower leaves, slow growth, uneven ripening, and tomato fruits not solid inside.

CALCIUM (Ca) : The most common alkaline earth metal, calcium

is involved in proper cell growth and formation of the growing tip of plants. Calcium is lost from the soil by leaching, so many of Fiji's soils are deficient due to high rainfall. Calcium is added to the soil by using lime or dolomite. These two substances not only provide calcium for plants, but since they are added in such high amounts, they change the acid-alkaline balance, or "pH", of the soil (see page 20) making other nutrients more or less available. Calcium deficiency symptoms include yellowing and necrotic (dead) spots on upper portion of plant, tips of leaves curling backwards, leaf margins sometimes wavy and irregular, weak stems, and blossom-end rot of tomato and blackheart of celery (see chapter 4).

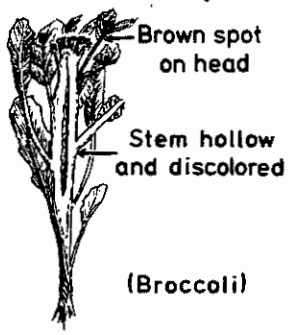


MAGNESIUM (Mg) : Closely related to calcium in its chemical form, it is needed by all plants, though members of the Brassica plant genus (see page 58-9) have a high need. Magnesium, like calcium, is lost through leaching and is replaced by dolomite, which is rarely available in Fiji, or magnesium sulphate (Epsom salts), which is only available in small quantities. The answer to acute deficiency is applying Epsom salts as a foliar spray (see page 34-5). Magnesium deficiency symptoms include mottled yellowing of entire leaves, especially older leaves, brown spots on margins and tips, small and brittle stems, and delayed maturity.



BORON (B) : Boron is a micronutrient easily leached by rain and removed by vegetable crops. Certain vegetable crops have high boron requirements (see page 58-9) and supplemental applications of sodium tetraborate (Borax) are necessary. Being a micronutrient, the usual application rate is only one to two grams per square meter. Too much borax can be

toxic to plants. Boron deficiency symptoms include occasional yellowing or browning of leaf margins, curling of young leaves, and mottling of rootcrop leaves, reduction in plant size, death of growing tip, corky spots in beet roots, water-soaked brown areas in turnip roots, browning of cauliflower and broccoli curds (flowers), and hollow, discoloured stems, and petioles (stems) of celery have dead tissue inside (see chapter 4, crops susceptible to cabbage moths).



Though vegetables require other soil nutrients, deficiencies of nutrients other than those listed above are rare, especially when attention is shown to maintaining high levels of organic matter. The fertiliser recommendations in chapter 3 are designed with these considerations in mind.

UNDERSTANDING SOIL pH

All soils have a chemical reaction, either acid, neutral, or alkaline. Highly leached soils - soils subject to high rainfall - such as are found in Fiji, are acid due to the absence of bases, or "cations" (positively - charged particles such as calcium, potassium, magnesium, and sodium). Soils in arid lands or soils where ocean water has intruded are most often alkaline, high in cations such as the ocean salt, sodium. The significance of the soil's reaction, or "pH", is that plants only do well in fairly neutral or slightly acid soils. In very acid or very alkaline soils different plant nutrients become chemically unavailable (see diagram next page).

The most economic method of raising the pH of a soil (making a soil less acid or more alkaline) is by adding lime or dolomite. Lime is a compound containing calcium, while dolomite contains both calcium and magnesium. While it would be ideal to use dolomite since magnesium is lacking in most

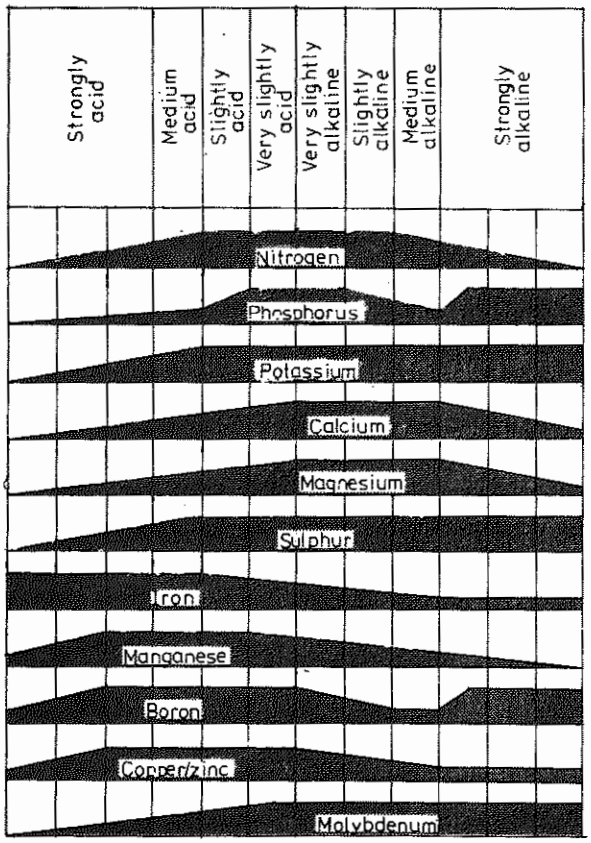


Figure 11. Soil nutrients required by plants are available relative to pH, the thickest horizontal portion of the bands indicating maximum solubility and availability. As the chart indicates, some nutrients, such as molybdenum, are available at a neutral or alkaline pH, while others, such as iron, are most available at a neutral or acid pH. The best overall balance occurs in a neutral or slightly acid soil.[11]

Fiji soils, it is rarely available here. Agricultural lime, however, is available at garden outlets. While liming may prove too expensive for certain field crops such as cereals, pulses, or cane, it often pays off with high income vegetable crops.

Chapter 3 discusses rates of lime application (page 33). While many vegetable crops grown on acid soils will perform better when lime is added to the soil, it is sometimes easier to wait for deficiency symptoms that indicate overly acid soil. Chapter 4 discusses calcium and molybdenum deficiency symptoms (note from the diagram, page 20, that molybdenum is unavailable at low pH's). Blackheart of celery, blossom-end rot of tomatoes, and cavity spot of carrots are all signs of calcium deficiency (see also page 17 for deficiency symptoms). Molybdenum deficiency is indicated by whiptail disease of cauliflower and cabbage. As can be noticed by the rates of lime application table on page 33 , sandy soils require less lime to raise the pH than do heavy clay soils. This is due to the high surface area and absorptive qualities of the small clay particles as opposed to the smaller surface area of the same volume of the larger sand particles. This absorptive quality of a soil is measurable and is known as its "cation exchange capacity" (CEC). The higher the CEC, the greater the ability of a soil to hold on to cations (bases), positively-charged ions, such as potassium, calcium, magnesium, and ammonia (a nitrogen compound). Soils with a low CEC are easily leached and are often lower in organic matter. Soils with a high CEC retain bases, including those added as fertilisers, and are higher in organic matter. In soils with a low CEC, the most practical method to raise the CEC is by adding organic matter by turning in a green manure crop, adding manure, or adding compost.

ORGANIC MATTER: CURE FOR SICK SOILS

Soils in any tropical region tend to be low in organic matter, especially after cultivation. Organic matter, originating

from dead plants and animals, decomposes at a rate directly proportional to soil temperature and moisture available, both of which are high in the tropics. Cultivation tends to accelerate this by breaking up organic matter exposing it to oxygen which hastens microbial action.

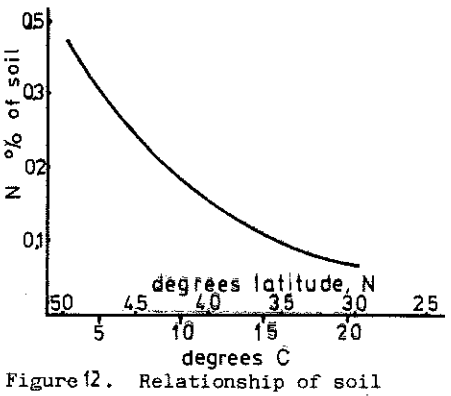


Figure 12. Relationship of soil nitrogen to mean annual temperature in semi-humid North America. At high temperatures, organic matter is more rapidly decomposed resulting in less soil nitrogen. Fiji is about 18° south and the mean average temperature (Nadi) is 25.5°.[12]

It is generally said that soils with less than 1.5% organic matter are "sick" soils. They have a low moisture holding capacity during dry periods, poor drainage in wet weather, and are poorly aerated (roots need oxygen). Organic matter also releases nutrients as it decomposes, the nutrients of course being those that plants need. The end-product of decomposing organic matter is a dark, rich-smelling substance called "humus" which has a high CEC, holds moisture, and positively affects plants in ways we do not fully understand. In Fiji, where rainfall is high and temperatures are always warm, it is important to replace organic matter as it decomposes. Chapter 6 discusses mulching and composting, two common sense approaches to recycling organic matter. A third method, green manuring - tilling in a sown crop to add organic matter - has great potential in Fiji, but is only practical with animal-drawn or mechanized cultivation, so is not discussed in this text.

chapter three

Cultural Methods of Vegetables

Anyone who is acquainted with vegetable production realizes that there is no one correct way to grow vegetables. Research by a number of agencies, institutions, and individuals, however, has shown there are methods that insure high yields on small areas of land. These practises are important not only to those with limited growing space but also due to the labour involved in manual soil cultivation.

FIVE GUIDELINES FOR TOP CROPS

The Fiji Department of Agriculture has pinpointed five basic considerations for vegetable growers - whether backyard gardeners or large commercial growers - that insure high yields when coupled together. The first component of productive vegetable growing is using a high-yielding variety. Table 3 shows how variety affects tomato yields in the Sigatoka Valley. Due to differences in pests, diseases, and climate, we cannot expect

Variety	Yield (tonnes/ha)
VC-11-1LR75	17.06
72-900-1-5A	17.00
Marilag	10.21
BPI Improved Pope	8.11
Fortune	8.08

Table 3. The five highest yielding tomato varieties in trials at the Sigatoka Agricultural Research Station in 1977 and their mean yields.[13]

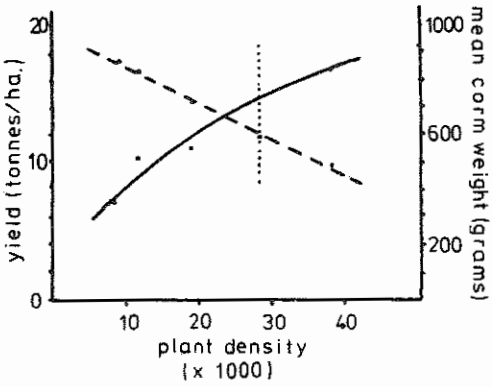


Figure 13. Dalo (taro) yields and mean corm weight as functions of plant density, or spacing. Dalo corms are large at wide spacings (broken line) but yields (solid line) are low. At closer spacings corms are lighter but yields are high. The recommended spacing (dotted line), 27,770 plants per hectare, gives high yields and marketable corms.[14]

vegetable varieties that perform well in Akron, Ohio to beat all comers "over in Tailevu". The majority of all vegetable varieties have been selected for resistance to diseases common in the temperate zone - diseases not necessarily present in the tropics.

Another important consideration is plant density, or spacing. The most common mistake of agriculturists in Fiji is using too wide a spacing, a practise which leads to lower yields. Growers often assume that a spacing that assures maximum yield per plant assures the highest yield per unit area. With most, if not all crops, this is not the case as is shown by the graph above. Maximum dalo yields actually occur at a closer spacing though yield per plant is reduced.

Fertiliser use, coupled with responsive new plant varieties, has increased world crop yields more than any other factor. Almost all soils contain the thirteen elements needed by plants but it is a rare soil that contains enough of all thirteen to produce good yields. And while most farmers in Fiji have seen the effect fertilisers have on plant growth, few understand the complex need of plants and the methods and economics of fertiliser use.

Pest, disease, and weed control are the other factors that have led to improved crop yields. New chemicals are constantly being synthesized to halt pests and disease when crop resistance

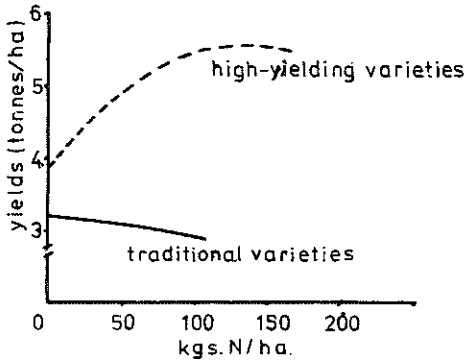


Figure 14. Response of traditional and new varieties of rice to nitrogen fertiliser. An important part of the plant selection process is finding cultivars that respond to fertilisers.[15]

has not been achieved in plant selection programs. Weed control has largely been accomplished through refinements in tractor-or animal-drawn cultivators, though control is increasing being met through selective weedicides (herbicides). Though weedicide use with vegetables is rarely practical, new applicators may make it more feasible.

High-yielding varieties, proper plant density, fertiliser use, and pest, disease, and weed control are all factors leading to increased yield no matter what the type of cropping system, including small-scale intensive vegetable production. This chapter is devoted to cultural practises that enable the grower limited by space to double and triple yields that could be expected in traditional row culture.

GROWING VEGETABLES IN RAISED BEDS

The most labour-conservative system for growing vegetables when

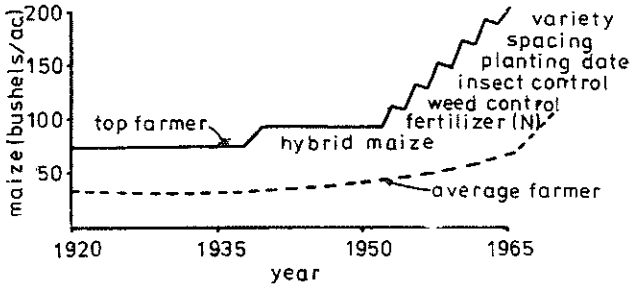


Figure 15. Increase in Illinois, U.S.A., maize yields can be attributed to adoption by top farmers of new agricultural technologies and practises.[16]

machine or animal traction is not available is planting on permanent raised beds 1.2 - 1.5 meters (4-5 feet) wide 0.3 - 0.9 meter (1-3 feet) paths between. Since permanent paths are used, the beds remain friable (soft and easily cultivated), plant spacings can be closer, and fertilisers and organic matter are always applied to the growing space, not the walking space. If the raised bed width is standardised, portable trellis units for trellised crops and plastic covers for wet season crops can be used.

Raised beds should be measured and marked off with string after the entire area has been cleaned and forked once or twice. Care should be taken that the beds run across the slope of the land rather than up and down the slope to prevent rapid runoff and erosion. If the garden is adjoining a house or tall trees, keep in mind that the northern exposure is important in the cool season (winter) due to the low path of the sun in the northern sky. Raised beds on the south side of a house will be "dead spots" in the winter (see figure below).

Dr. Jacob Mittleider, in his book, Mittleider Grow Box Gardening, suggests five foot (1.5 meter) wide beds up to thirty feet (9 meters) long with three foot (0.6 meter) wide paths.[17] Except for school children and older people who may prefer a narrower bed, this width is ideal in terms of workability and for plastic covers, since six feet or two meters are common polythene (plastic) widths. Bush timber, stones, or salvaged timber are ideal for containing the beds (opposite page) though are not necessary.

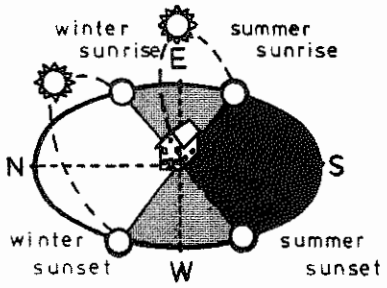


Figure 16. The north exposure in Fiji is best for plants due to the low path of the sun in the winter sky. East and west exposures receive either morning or afternoon sun.[18]

After the beds and paths are marked out with pegs and strings, the topsoil from the paths is shovelled from the path to the beds. Fifteen centimeters of soil

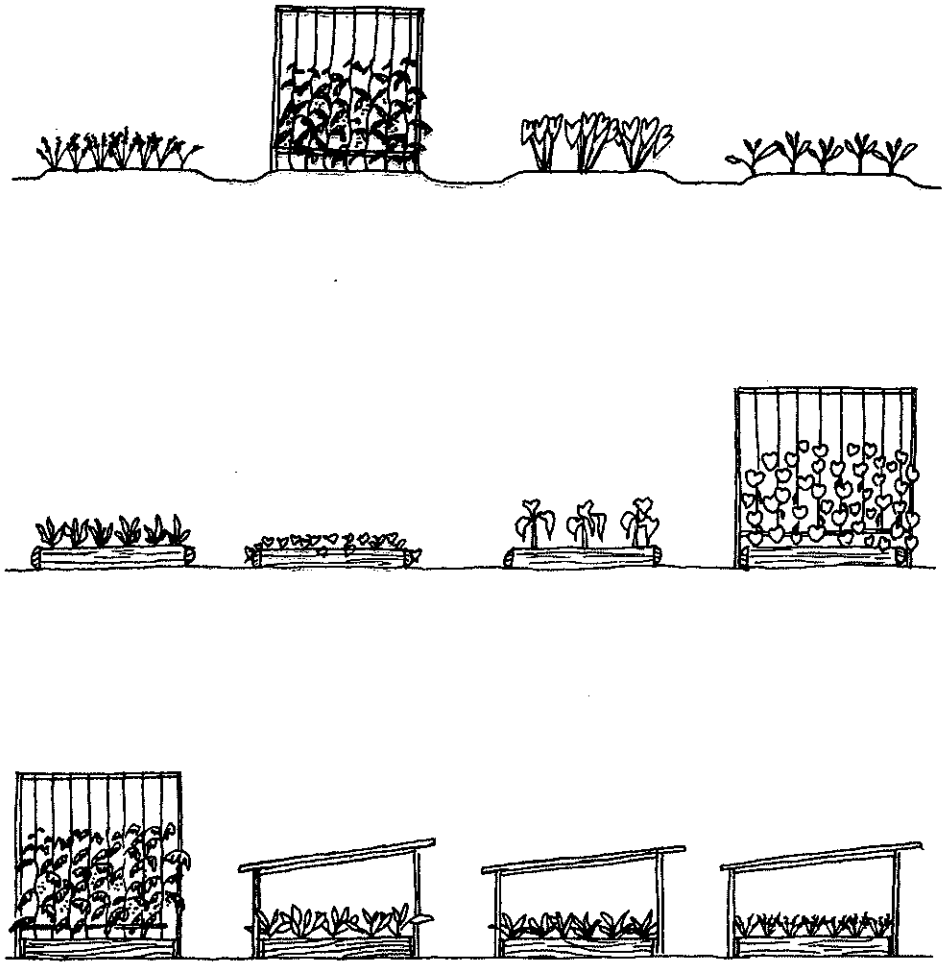


Figure 17. Raised beds are an attractive, orderly, and efficient way to raise vegetables. Studies have shown raised bed culture to be highly productive when machine or animal-drawn traction is not available and yields are reported up to 140% higher than traditional row cropping. The top figure shows simple raised beds laid out as described on page 26 Vegetables can also be grown in beds enclosed with bush timber (centre), bamboo, or stones. Urban dwellers may find it worthwhile to use recycled timber (bottom), a system that allows use of sliding covers for wet season culture.

removed from the paths is sufficient since compaction further lowers the paths. A common mistake is to make the beds too high; this only results in erosion of the edges. While it would be helpful to amend the beds with compost at this point, compost is rarely available at the onset of the garden (see chapter 6).

VEGETABLES IN-SEASON AND OUT

The chapter on Fiji garden crops discusses the suitability of certain plants in-season and out. Needless to say, criteria for selecting garden crops varies according to the situation. A teacher organizing a student garden to feed boarders requires large amounts of nutritious vegetables. The market gardener must grow cosmetically superior produce - that is, produce with good appearance - of marketable size. The backyard gardener might want a wide variety of vegetables to enhance the family diet.

Suitability of crops to the seasons is most important in Fiji. The vegetable season, April - October, is ideal for most crops with warm, sunny days, relatively cool nights, and moderate rainfall. The off-season, with day-round high temperatures and high rainfall is suitable for far fewer crops (see chapter 4).

SOWING SEEDS

Vegetable crops are divided into three categories: direct-sown, when the seed is sown in the field on the site the plant will grow; transplanted, when seeds are sown in beds, pots, or flats, and are planted to the field or garden when seedlings "harden"; and vegetative propagation, when vegetables are grown from cuttings or plant pieces other than seeds. Legumes and cucurbits are most often direct sown, Solanaceous crops and Brassicas are most often transplanted, and such tropical vegetables as bele and poi are grown from cuttings.

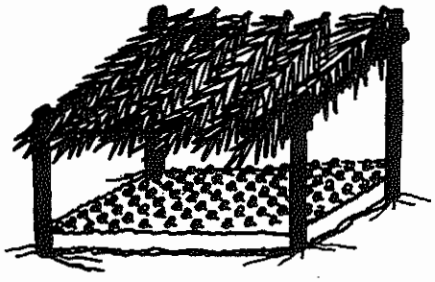


Figure 18. A seedbed can be covered with coconut leaves or a similar material either directly or on a raised cover as shown here. The shading material should be removed after the seedlings emerge. In the wet season seedlings can be sown under plastic to avoid excess moisture and disease.

In starting a new garden the first consideration is sowing seeds of the transplanted vegetables since most take 3 - 6 weeks to ready for transplanting. During this period the garden can be put into a state of readiness.

Most farmers in Fiji sow seeds on a raised bed. The Department of Agriculture recommends sowing seeds on a seedbed one meter wide and raised 15 cm. though the raised beds mentioned earlier are suited for the task. The soil should be rich as possible and amended with poultry manure, 2.5kg./square meter, or N.P.K. (13:13:13) at 0.2 kg. per square meter.

The amendments should be worked into the bed and the bed soaked one week before sowing. At sowing the bed should be lightly forked, raked smooth, and drills (lines) marked with a stick or a rake handle every 8 - 10 cm. across the bed. The drills should be 5 - 7 mm. deep for fine seeds (lettuce, celery) and 10 - 15 mm. deep for other seeds. Soil is then lightly brushed into the drills by hand to cover.

After a heavy watering the beds should be covered with coconut leaves, banana leaves, sugar bags or other materials to keep the beds moist until the seeds sprout. The shading material should be removed at the first sign of seedlings emerging (two - three days for Chinese cabbage).

In the wet season, it is difficult to grow seedlings because of "damping-off" fungi that thrive in hot, wet conditions. These

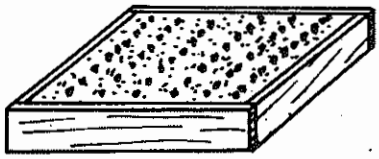


Figure 19. Seeds can be sown in shallow wooden flats made from salvaged packing crates.

SEED FLAT SOIL MIX	
1. good top soil 2. 15 grams lime 3. 0.5 kg. poultry manure 4. ½ gram Borax	1. good top soil 2. 15 grams lime 3. 12 grams superphosphate 4. ½ gram Borax
(Mix ½ dessert spoon urea per gallon of water if seedlings begin to yellow.)	(When seedlings emerge include ½ dessert spoon urea per gallon of water).

fungi live in the soil and attack seedlings as they germinate and emerge. While soil fumigants or formaldehyde treatments of the soil are probably impractical for most Fiji gardeners, some control of damping-off fungi can be achieved by adding Captan to the water used on seedbeds, $1\frac{1}{2}$ - 2 teaspoons per gallon of water. The best way to grow seedlings in the off-season is under a plastic cover. Any of the designs in chapter 5 can be used for this purpose. Producing seedlings in shallow wooden boxes, or "flats", is a practical and handy system. Flats are well-draining and fertiliser use can be properly calibrated. The best size for flats is 45 cm. square and 7 - 10 cm. deep. Wood from old packing crates is ideal for building the flats. Flats tend to dry out easily, so extra attention should be shown to watering.

TRANSPLANTING VEGETABLE SEEDLINGS

Vegetables are transplanted when the seedlings "harden", that is, when stems become less succulent (soft) and more rigid. This is best learned through experience.

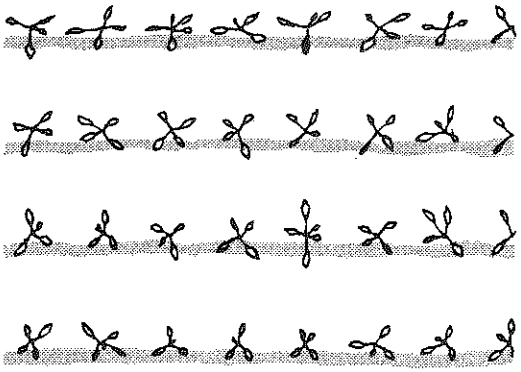


Figure 20. Row cropping is the most efficient way of growing vegetables when animal or machine cultivation is used. Here cauliflower seedlings are transplanted 45 cm. apart in rows 60 cm. apart. Rows allow a walkway to carry out field operations. Fertiliser (shaded area) is applied in bands along the rows.

If the beds are moist and friable, if they have been covered with a thick mulch or are under a plastic cover, and the level of soil organic matter is high, then cultivating the entire bed may not be necessary. If, however, the bed has been unused for some time and has dried or compacted, a forking will be needed before transplanting.

With direct-sown or transplanted vegetables, fertilisers, manures, or lime should be applied as such:

1) FOR CROPS PLANTED IN SQUARES AT SPACINGS 25 CM. OR CLOSER : broadcast the amendments over the bed and work in 15 cm. deep.

2) FOR UNTRELLISED CROPS IN SQUARES AT SPACINGS GREATER THAN 25 CM. : apply in spots and either work in 15 cm. deep or apply 7 - 10 days after transplanting in a circular band 6 - 7 cm. from the plant.

3) FOR TRELLISED CROPS OR CROPS PLANTED IN ROWS ACROSS THE BED : apply in bands across the bed and work in 15 cm. deep before sowing or transplanting.

Always water seedbeds or flats one hour before transplanting. To remove seedlings, carefully loosen with a trowel (hand spade) or knife - try not to damage the roots. It is not necessary to transplant seedlings with a ball of soil.

Seedlings should be kept covered and out of the sun while transplanting. Leafy crops should be transplanted with the first leaf node above the soil line to prevent fungal attack of the soft tissue. Tomatoes and eggplant can be planted to

PLANTING MIX

MIX A

10 kgs. N-P-K (13-13-13 or 13-13-21)
*500 grams Borax

MIX B

2 kgs. urea
6 kgs. super-phosphate
2 kgs. potash
*500 grams Borax

MIX C

4 kgs. ammonia sulphate
6 kgs. super-phosphate
2 kgs. potash
*500 grams Borax

MIX D

10 kgs. (dry weight) poultry manure
0.5 kgs. superphosphate
*500 grams Borax

* Application of Borax may not be necessary in all soils. However, in less than fertile soils and with crops with a high boron requirement (see page 58), it is recommended.

Rate of application (grams/square meter)

	RICH ALLUVIAL SOILS	MODERATELY FERTILE SOILS	POOR SOILS
Mixs A, B	20	30	40
Mix C	25	35	50
Mix D	200	300	400

LIME

The use of lime may not always be necessary. Apply if pH is below 5.5 or if the deficiency symptoms discussed in chapters two and four show up.

Rate of application (kilograms/square meter)

SANDY SOIL	SANDY LOAM	LOAM	SILTY CLAY LOAM
0.20	0.40	0.70	1.10

Apply fertilisers and lime as suggested on page 31. Never mix lime directly with fertilisers. If applied in spots or bands, divide the recommended measure of fertiliser, manure, or lime by the number of spots or bands and apply accordingly.

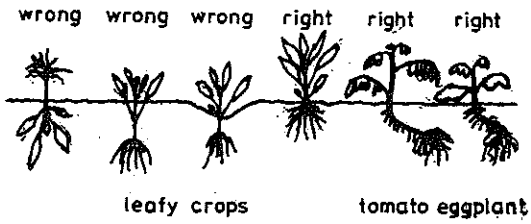


Figure 21. Whether vegetables survive often depends on the care taken in transplanting. Leafy vegetables should be planted to the crown while tomatoes and eggplant should be planted deeper.

the first true leaf as well. This allows "adventitious" roots to grow from the stem that aid in water and nutrient uptake. If the soil is excessively moist or heavy rains are imminent, bring the soil lightly around the seedling. If the soil is dry, pack the soil slightly to prevent drying. Seedlings should be planted in the late afternoon or on cloudy, rainy days to minimize wilting. Water immediately after transplanting, at least ½ cup of water per plant, and morning and afternoon for four days in dry weather to establish the plants.

With all transplanted vegetables a starting solution of manure or compost "tea" or one level tablespoon of N.P.K. per gallon of water gets the plants off to a better start. This can be applied at every watering or on alternate waterings. If damping-off fungi are attacking seedlings or transplants, add 1½–2 teaspoons of Captan (a fungicide) per gallon of transplanting water. The pesticide Dicidex is added at recommended rates to transplanting water to prevent cutworm damage. Sufficient water, nutrients, and pest, disease, and weed control are important considerations for the growing crops. Failure to respond to any of these needs may result in reduced yield. By following a few simple guidelines, however, a superior crop is guaranteed.

As plants develop, a constant supply of soil moisture is required. It is generally said that 600 mm. of rain per annum is the low threshold for supporting food crops. Fiji's dry zone averages 1700 mm. of rain per year, and though it is not terribly well distributed, it is sufficient for growing vegetables. While occasional droughts lower yields and postpone planting, they rarely result in total crop loss.

In any case, some supply of water must be available for transplanting, though direct-sown crops will grow with rain alone. Irrigation systems usually pay off, assuring vegetables when market prices are high due to dry conditions.

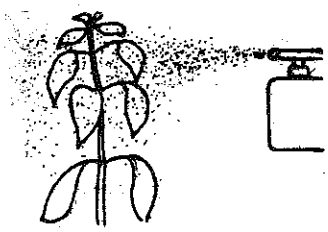


Figure 22. Foliar spraying can solve deficiencies.

As rain or irrigation water travels downward, soil nutrients are leached. While phosphorus is relatively insoluble (doesn't mix well with water), nitrogen, potassium, magnesium, and boron are all leached at faster rates. For this reason, these elements are applied, usually in two side-dressings, during the crop's growth. The first application occurs at the time of accelerating vegetative growth, such as at stem elongation with climbing legumes or cucurbits, and at expanding leaf size with leafy vegetables. The second application should be prior to flower production with legumes or cucurbits or head formation as with Brassicas (members of the cabbage family). Water must accompany the side-dressings to prevent burning - either apply during a good rain or irrigate immediately after.

FOLIAR SPRAYING TO CORRECT DEFICIENCIES

Though we usually think of plants as taking up nutrients through their roots, plants can also utilize nutrients sprayed on their leaves. This process, foliar spraying, is an

FEEDING MIXTURE

MIX A	MIX B
5 kgs. urea	10 kgs. ammonia sulphate
3 kgs. superphosphate	3 kgs. superphosphate
3.5 kgs. potash	3.5 kgs. potash
25 grams Borax	25 grams Borax

Apply 10 grams of MIX A or 15 grams of MIX B per square meter of growing space. Apply in circular bands 7 cm. from the crown of the plant the first application and 10 - 15 cm. from the crown the second application. If the crop is planted in rows, apply the fertilizer in bands the same distances from the rows.

efficient way of feeding plants. Magnesium, for example, is often only available in small packets (Epsom Salts, or magnesium sulphate) from chemists (pharmacists) in Fiji. Epsom salts can be sprayed in a 1% solution (10 grams/litre) on plant leaves. The solution can also be mixed with pesticides or fungicides (other than copper compounds). It is best sprayed in the early morning or late afternoon.

Trace mineral deficiencies other than boron are rare and can be treated with foliar sprays as well. Use a water-soluble fertiliser containing trace minerals (such as Lush or Aquasol) and spray as directed on the package twice a week and once thereafter when deficiency symptoms occur. A high organic matter content of soils is the best weapon against micro-nutrient deficiences.

CONTROLLING PESTS AND DISEASE

These topics are covered in the chapter on individual crops. While many think that the organic approach to gardening is the answer, the tropics pose a challenge to control pests and disease even with modern chemicals.

To put it simply - if you do not want to use pesticides, avoid planting large areas of Brassicas, eggplant, legumes susceptible to aphids (long beans, cow peas, french beans), cucumbers, and melons. Intercrop these plants at all times with other non-susceptible plants. In the off-season do not grow Brassicas, instead plant non-susceptible leafy crops. Always harvest crops promptly and remove crop waste from the garden for composting. Always rotate sensibly.

Fungicide use can best be avoided by growing recommended varieties of cucurbits, many of which are selected for resistance to powdery and downy mildews. Trellis crops whenever possible. Plant recommended Solanaceous crop varieties, especially in off-season. Remove crop wastes from the field and rotate sensibly.

TRELLIS TO INCREASE YIELDS

When garden space is limiting, the next direction is up. One of the most enjoyable and aesthetically - pleasing cultural practices is trellising, a practice that can double yields on given areas.

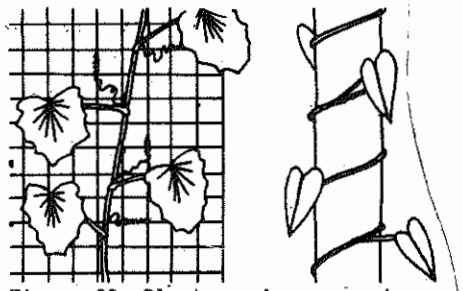


Figure 23. Plants such as cucumbers and peas climb with the aid of tendrils (left). Other plants such as yams and beans climb by winding around vertical objects (right).

In order to design and use trellises, it is important to understand how climbing plants grow. The figure above shows the two basic habits of growth. Note that the shoots of yams, poi, and pole and long beans wind around vertical object 15 cm. or less in diameter. Shoots of peas, melons and cucumbers, on the other hand, grow straight up using tendrils to grasp to vertical or horizontal objects about one cm. or less in diameter.

By process of elimination, therefore, a vertical trellising material one cm. or less in diameter will support the growth of any trellised crop. Materials suitable for this purpose are reeds (na sau), sticks, bamboo, wires and strings. The figure on the next page shows a trellis unit that spans the width of a raised bed. The trellises are easy to use, easy to store when not in use, and they maximize yield from trellised crops on raised beds.

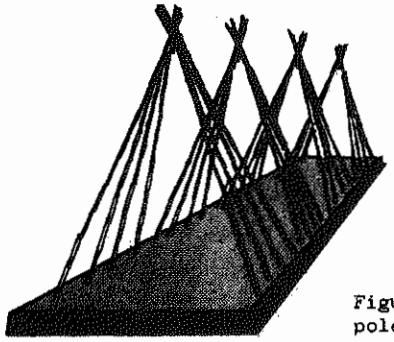


Figure 24. A teepee of bamboo, reeds, or poles is ideal for growing climbing beans.

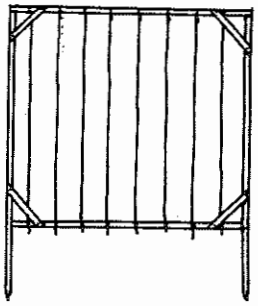


Figure 25. This trellis is useful in a raised bed situation. It can be made with 2 x 2's or bush poles. Strings are tied to the cross bars and are spaced every 18-20 cms. and climbing crops are sown or transplanted next to the lower cross bar and trained to the strings. The trellises are spaced every 1.2 meters along the length of the bed.

While pruning lowers yield per plant, it also allows plants to grow at closer spacings resulting in higher yield per unit area. A good example is tomatoes grown on a raised bed 1.5 meters wide. In traditional culture, the tomatoes would be planted intwo rows, 60 centimeters apart and 60 centimeters between plants. The relatively wide spacing is necessary due to light competition from the foliage produced by suckers (side branches). A 10 meter bed would have 32 plants. Using the trellis and prune system, the tomatoes are planted 18 cm. apart with the trellises spaced 1.2 meters apart. This allows eight plants per row and eight trellises, or 64 plants per bed. Assuming pruning reduces yield by 35%, the trellised tomato yield is 30% higher than the unpruned, untrellised bed.

This figure may actually be low for a number of other reasons, the most significant being that the plants are kept off the ground. Not only does this naturally reduce leaf diseases and fruit loss due to insects and rotting, but spraying for

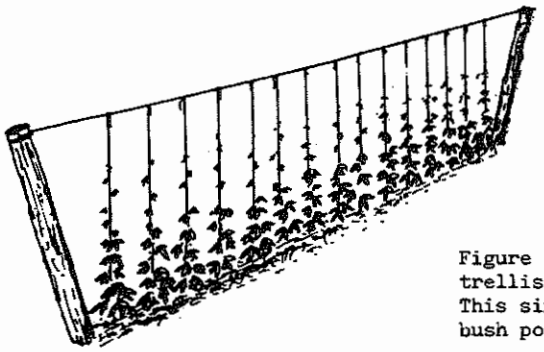


Figure 26. There are many types of trellises suitable for garden crops. This simple trellis is made from two bush poles, wire, and string.

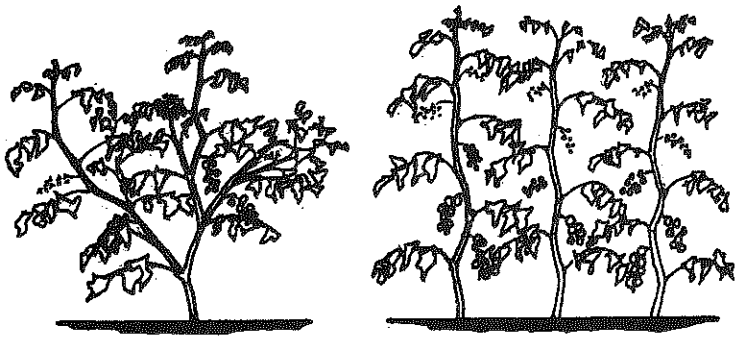


Figure 27. Pruning tomato plants reduces yield per plant but allows closer spacings and higher net yields.

pest and disease control is easier. Trellised plants are also more efficient users of sunlight, which should increase yields. And using vertical strings to trellis instead of horizontal wires or poles makes it more difficult for birds to get to ripening fruit.

These are the pruning and trellising methods for each crop:

TOMATO:

Tomatoes grown in Fiji are indeterminates; that is, the flowers and fruits emerge sequentially as the plant grows so that harvesting is extended over a period of time. Determinate tomato plants originally bred for mechanized harvesting, grow to their maximum size, then bear flowers and fruits over the entire plant so only one or two pickings are carried out.

Figure 28. Tomatoes are pruned by removing lateral (side) shoots.

To grow trellised tomatoes, plant them at 16-20 cm. spacings <u>across</u> the beds. It's always a good idea to include one or two extra plants in case any seedlings are later affected by disease. Extra plants can be thinned out at trellising. Remove suckers as they emerge but **TAKE CARE TO LEAVE A GROWING TIP** as

many tomatoes exhibit unusual growth patterns later in their development. As the tomatoes grow, wind them on the strings, one string per plant.

MELONS AND CUCUMBERS:

Rock melons (cantaloupes, Crenshaws, honeydews, etc.) and cucumbers climb by means of tendrils. To grow them on a string trellis, however, they should be wound on the strings, one plant per string, rather than allowing them to climb at will. As with tomatoes, if left unpruned they will be unmanageable and yield is greatly reduced.

Sow one seed every 8 - 10 cm. across the bed. Wind one plant per string, the strings being 16 - 20 cm. apart, making sure the plants are unaffected by virus diseases, etc. before thinning any remaining plants. Pruning is slightly different than tomatoes. Side shoots are trimmed with a scissors after the first leaf and female flower on the side shoot. The first leaf may also be removed, leaving the female flower to develop the fruit. When the vines are 30 cm. above the top cross bar, cut the growing tip.

POLE BEANS/LONG BEANS:

As with tomatoes and cucurbits, pole and long beans can be pruned and planted close to maximize yield on a small area. The bean seed is sown one seed every 4-5 cm. across the bed, while the strings are set 13 cm. apart. The seedlings are not thinned out; up to three plants can be grown on each string. As the beans begin to grow, observe the way they climb (counter - clockwise south of the equator) and train them onto the strings. They'll take care of themselves after that. Again, side shoots must be trimmed from the axil.

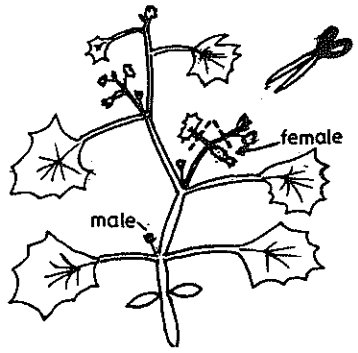


Figure 29. Side shoots on cucumbers and melons are removed taking care to leave the male and female flowers.

The trick with pole and long beans is distinguishing side shoots from flowers which also arise from the axil. Flowers are borne in clusters while side shoots have a leaf and growing tip. Flowers also do not appear until the bean plants are fairly full grown. Trim the sideshoots at the axil.

Figure 30. Climbing beans can be pruned to make more manageable.

TRELLISING OTHER CROPS

Other crops grow better when trellised. Dr. Mittleider, in Mittleider Grow Box Gardening, reports zucchini yields better when the growing tip is tied up to a string.[19] He also suggests watermelon can be trellised (this would be possible since melons usually are borne at the bottom of the plant and would rest on the bed) and that in terms of pruning watermelons, experience is the best guide . Some crops suitable for or requiring trellising may not be suitable for the frame and string trellis on page 37. While poi will grow well on this trellis,it is tolerant of shadier situations where other plants will not thrive. Winged beans need a solid trellis (a fence is ideal) since they amass tremendous amounts of foliage and can be perennial (living more than one year). Chapman and Cowling (1965) report sweet potato yields 300-400% higher when trained on to a wire netting frame and supplemented with nitrogen.[20] Yams require trellising for good yields. The traditional method of trellising on a single bamboo or reed yields about 14 tonnes/hectare. Sivan reports yields to 25 tonnes/hectare when a taller trellis of bamboo and reeds is supported by posts.[21]

chapter four

The Garden Crops of Fiji

All vegetables are not cultivated the same. Many are susceptible to pests and diseases while others are fairly resistant. In order to best grow individual garden crops, it is worthwhile showing attention to variety, spacing, pest and disease control, and other details that assure a top crop. This chapter discusses individual crops and while the comments and cultural guides may seem abbreviated, when applied with the information in chapter 3, a more complete picture of crop agronomy is available. This is especially the case with fertiliser practices and chapter 3 presents a standardized approach.

FIVE ROTATION GROUPS

The individual crops are presented in five general groups based on joint susceptibility to pests or diseases:

1) crops susceptible to bacterial wilt
2) crops susceptible to cabbage moths
3) cucurbits
4) legumes
5) other crops

It is intended that members of one group not be grown successively on the same garden plot. Ideally the members of

the same group should be rotated three or four times or more with other crops or a fallow period (when no crops are grown). By avoiding successive planting, disease and pest build-up are avoided. It should be noticed that the last group is a composite of crops which are not susceptible to the pests and diseases that define the other groups. Many of these crops are ideal for crop rotation, especially maize and the root crops. The exception to these rotation groups is nematode susceptibility, a problem which spans members of all the groups.

AVOIDING SOIL NEMATODES

Nematodes are small animals, most often resembling worms though generally invisible to the naked eye. Though some forms are "free-living", many others are parasites of plants and animals. Three members of the genus Meloidogyne, the "root knot" nematodes, are among the most severe nematode parasites of plants. Root knot nematodes are obligate parasites of green plants and feed on tissue in the roots. Severe infestation results in retarded growth, chorosis, wilting, and can bring about plant death. Signs of root knot nematodes are, as the name suggests, knots on the roots of susceptible plants. These knots, or "galls", are more pronounced on tomatoes and cucumbers and less visible on taro, bele, rice and maize . Root galls caused by nematodes should not be confused with nodules produced by nitrogen - fixing bacteria on legume roots.

Incidence of nematode infestation is most severe in sandy or other well-draining soils. Root knot nematode infestation will be higher following planting of susceptible plants and when poor rotation practices are used. Among food crops affected by root knot nematodes are: bele, cassava Chinese cabbage, dalo, eggplant, kumala, okra, passionfruit, sweet

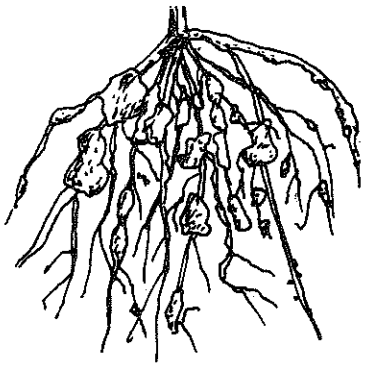


Figure 31. Swelling on roots, or "galls" are an indication of root knot nematodes.

peppers, rice, sugarcane, sweet corn, tomato and watermelon.[22] Many of these crops are susceptible to only one or two of the aforementioned species of root knot nematodes. A complete list of these crops and the degree of susceptibility to each of the three species of nematodes can be found in "Control of Root Knot Nematodes in Fiji" by M.F. Kirby in the Fiji Journal of Agriculture, volume 39, number 2.

Some practical methods of controlling and avoiding root knot nematodes in the garden include:[23]

Rotation - avoid successive plantings of susceptible crops on the same plots. If symptoms of nematode infection appear, susceptible crops should be avoided for two to three years or more.

Fallow - fallowing includes clean fallow, where no plants are allowed to grow on the garden plot, or weed fallow, when cultivation is not practiced and weeds are allowed to grow. Root knot nematodes are obligate parasites meaning they cannot live without the host plant. However, they can survive six months to one year without the host, so fallow should be this long. Clean fallow is probably more acceptable in a garden situation, especially since many weeds are nematode hosts.

Organic manuring - nematode incidence has been reported lower in soils amended with organic matter. This practice is compatible with crop needs as well.

Varietal resistance - many plants have natural or selected resistance to root knot nematodes. While these do not always correspond to the recommended varieties mentioned in this chapter, they are nevertheless important to the gardener or farmer with nematode problems. A list of resistant crop varieties can be found in the aforementioned Fiji Journal of Agriculture article.

Chemical control - while some nematicides have appeared on the market, their application in the garden is not practical. Nematicides and fumigants may have a greater role in intensive production under plastic covers.

WHAT ARE PLANT DISEASES ?

What we describe as "diseases" are actually the "symptoms" plants show when another living organism lives off the plant or the "signs" of the organism itself. Thus, we describe as a wilt the symptoms a plant takes on when its vascular system becomes plugged by a fungus or bacteria. The plant can no longer function properly and literally wilts. A good example of a disease known by the signs left by the disease organism is a "rust", a fungal disease. The fungus grows inside the "host" plant, but to facilitate the spread of the fungus, it produces "spores" - something like seeds - on the bottom side of infected leaves that will be spread by wind or rain. These spores are brownish-red and give the fungus the rust appearance that the disease is named after. Other diseases may be caused by non-parasitic factors such as nutrient deficiencies (see chapter 2), toxicities, and environmental pollutants, among others.

Parasitic diseases are most often caused by the following three "pathogens" (disease-causing agents) plus nematodes:

1) FUNGI - actually a plant that doesn't require light. Instead fungi are saprophytic - living off dead organic matter - or parasitic - living on other plants or animals. Plant parasitic fungi grow vegetatively as "hyphae" - microscopic white strands - that feed on plant tissue. In some cases the fungi form fruiting bodies that give rise to spores. Fungal diseases are best controlled by crop rotation (fungi are often "host specific", requiring specific plants to live off), proper disposal of crop wastes, using resistant crop varieties, and spraying or

dusting with fungicides - chemicals that protect plants from parasitic fungi.

2) BACTERIA - are neither plants or animals. They are very small, even compared to fungal hyphae. Bacteria, like fungi, are saprophytic or parasitic. Bacteria reproduce rapidly and cause plant disease in the field and in storage. The best control for bacterial diseases is crop rotation, disposal of crop wastes, and the use of resistant varieties.

3) VIRUSES - are so small and structurally simple that is questionable whether they can be considered "living". They do, however, have the capacity to cause plant and animal diseases. Viruses can be seed-borne so it is advisable to use certified seed. Viruses are often spread by feeding insects such as aphids, so pest control reduces virus incidence. Virus -infected plants should be removed from the field ("rogued") and should not be used for planting material.

   For more information on plant diseases, consult plant pathology (the study of plant diseases) guides and texts. A particularly good book is Plant Diseases of Fiji by K.M.Graham. Much of the information on vegetable crop disease in this chapter is from this publication.

Controlling Insect Pests

Chapter 4 mentions insect pests of the individual crops. While the list is not complete, using the controls (pesticides) listed should offer sufficient protection for those and other potential insect pests.

Anytime a pesticide or fungicide is used, it is IMPORTANT TO

FOLLOW THESE GUIDELINES:

1) READ THE LABEL on the container - by Fijian law, all plant protection chemicals must have labels written in three languages: English, Hindi, and Fijian. The label describes rates of application, pests or diseases the chemical will control, waiting period, and safety precautions.

2) USE THE CHEMICAL SAFELY - read the label, wear long-sleeved shirts, long pants, shoes, and gloves when mixing or spraying fungicide and pesticides. Always store these chemicals in clearly marked water-tight containers AWAY from the reach of children. ALWAYS wash with soap and water after spraying.

3) OBSERVE THE WAITING PERIOD - the waiting period is the number of days between spraying and when the produce is safe to eat. The waiting period ranges up to two weeks for some chemicals. The produce is not safe to eat before the end of the waiting period.

   If a pesticide or fungicides does not control a pest or disease, do not increase the recommended rate or frequency of application. Instead, consult your local Department of Agriculture official.

RECOMMENDED VEGETABLE VARIETIES

In the discussion of individual crops, recommended varieties are listed. These are varieties recommended by the Department of Agriculture and are selected primarily on the basis of yield. For the most part these varieties are available from commercial outlets in Fiji or in the case of the "Alton" and "Vuavina" tomato, the "Chahat" eggplant, and the "Hot Rod" chilli varieties, are sold by the Department of Agriculture. In some cases, such as with coriander (dhania) or some legumes such as lablab, seed is available in the market or can only be obtained from local farmers.

Figure 32. Potatoes, peanuts, peppers, tomatoes, eggplant, tobacco, and cowpeas are crops susceptible to bacterial wilt.

CROPS SUSCEPTIBLE TO BACTERIAL WILT

These crops form a rotation group due to their susceptiblity to bacterial wilt.

(Solanaceous crops)
- Tomato
- Potato
- Eggplant
- Peppers

Peanuts

Cowpea

Bacterial wilt (Pseudomonas solanacearum) is perhaps the most important economic vegetable crop disease in Fiji. The spread of the disease in the late 1960's wiped out a thriving potato industry in the Sigatoka Valley and the Nadrau Plateau and has complicated the culture of tomatoes, tobacco, eggplant, peppers, cowpeas and peanuts.

The soil-borne bacterial wilt organism enters the plant through roots either injured during transplanting or by mechanical injuries caused by weeding, etc., or through feeding punctures caused by nematodes. First symptoms of infection include yellowing of lower leaves and appearance of adventitious roots on the lower stems of tomatoes. Entire plants eventually wilt and die even after irrigation. Diagnosis of bacterial wilt can be made cutting a lower stem section and placing in water. A creamy oozing from the stem indicates bacterial infection. Bacterial wilt is most severe during the hot, wet season.

Primary control of bacterial wilt is through planting of resistant varieties and secondarily through rotation with non-

susceptible crops, especially cereals such as rice and maize. Control of weeds, especially hosts such as "prickly solanum", will reduce wilt incidence. Grafting of tomatoes to resistant eggplant or prickly solanum is labour-intensive but allows the use of high-yielding, large-fruited tomato varieties that are otherwise susceptible to wilt.

TOMATO (tomato (F) tomatar (H))

The world's most popular vegetable crop, the tomato, is popular with all races in Fiji. A large amount of research has been done by the Agriculture Department in Fiji, primarily varietal selection for high yields and resistance to bacterial wilt. In 1979, two tomato varieties, "Alton" and "Vuavina", were selected from a pool of tropical and sub-tropical cultivars for use in year-around tomato production. Of these two varieties, "Alton" has become the most popular off-season tomato while "Vuavina" is more suitable in-season. Off-season tomato imports remain high and the Agriculture Department has investigated tomato culture under plastic during the wet months (chapter 5). Tomatoes should be staked or otherwise trellised to prevent fruits from rotting on the ground (see page 38).

CULTURE:

Recommended varieties:

Cool, dry season: "Alton, "Vuavina", "Red Cloud", "Tropic", "Walter", "Roma".

Hot, wet season: "Alton", "Vuavina"

1) Sow seeds in seedbed or flats; transplant 26-30 days after sowing.
2) Spacing: 1.0-1.5m.x 30cm. in rows; 45-60cm. squares

in beds. Or plant, prune, and trellis as on page 38.

3) Fertilise as directed, chapter 3.

4) Apply feeding mixture (page 34) two weeks after planting and two weeks after that.

5) Tie to stakes or otherwise trellis as the plants grow (see page 38).

6) Harvest every second day. If birds are a problem, harvest tomatoes at the first sign of pink on a daily basis.

PESTS:

Twenty-eight spot beetle - occasionally feeds on foliage. Control with Diazinon, Dibrom, Orthene or Ambush.

Corn ear worm and other caterpillars - bore holes in fruits. Control with Dibrom during harvesting.

Leaf miners - leave burrowing trail on leaves. Control with Orthene or Sevin.

DISEASES: Bacterial wilt - (as discussed, page 47).

Anthracnose - soft sunken spots on shoulders of fruits. Use good rotation practises; apply Benlate to control the spread of the fungus from infected foliage to fruits.

Bacterial spot - appears as small, black marks that later sink into slightly larger lesions. Use good rotation practises; use clean seed or save seed from uninfected fruits.

Blossom-end rot appears as a large, dark water-soaked area on the

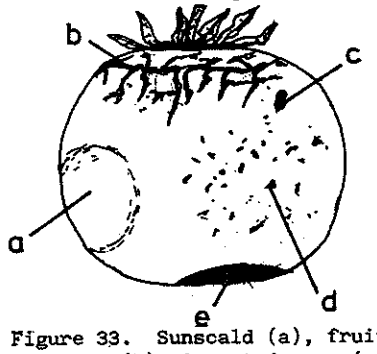


Figure 33. Sunscald (a), fruit cracking (b), insect damage (c), bacterial spot (d), and (e), blossom-end rot are tomato problems.

blossom end (opposite the stem end). The disease is caused by calcium deficiency, nitrogen/potash imbalance, or extremes in soil water balance. Apply lime in acid soils; use sound fertiliser and irrigation practises.

Leaf spot and leaf mould - two distinct but interrelated leaf diseases that result in defoliation of tomato plants. Spray weekly with Benlate; use good fertiliser practises including magnesium (Epsom salts) spray when deficiencies exist.

Virus diseases - cause bunchy tops or twisted appearance in leaves. Remove infected plants.

Sunscald - appears as light-coloured soft areas where the fruit is exposed to direct sunlight. Tomatoes ripen evenly when shaded by their own foliage - do not prune foliage; spray with Benlate regularly to avoid fungal defoliation.

Fruit cracking - either longitudiual or concentric, often caused by excess soil moisture. Use the variety "Alton" in the wet season.

Fusarium wilt - an increasing problem in the wet zone. Use sound rotation practises, try different tomato varieties.

POTATO (vateta (F), alu (H)).

The Sigatoka Valley and Nadala area of the Nadrau plateau were centers of potato production until the spread of bacterial wilt in the 1960 - 70's. Today Fiji relies almost solely on imported potatoes to meet local demand. The salvation for potato growing in Fiji lies in the introduction of bacterial wilt-resistant cultivars, a number of which have been selected at various research centers around the world. The Department of Agriculture is currently bulking-up one of these varieties for release. Since potatoes are propagated from tuber "seed" pieces, planting material supply is a problem unless a suitable facility is built for storage of planting material

during the wet season (see "Soft Rot" below).

Recommended varieties: (contact the Agriculture Department for wilt-resistance cultivar release date)

CULTURE:

1) Seed pieces are small tubers or larger tubers cut into 50-75 gram sections with 2-4 eyes (buds) per piece. Cut pieces should be dried, or dusted with wood ash or a fungicide such as Captan and dried, before planting.

2) Sow seed pieces 15-30 cm. deep in rows 60-75 cm. apart and 25cm. apart in the rows; or in beds, in squares 25cm. apart.

3) Fertilise as directed, chapter 3.

4) Apply feeding mixture (page 34) three weeks after planting and mound up soil around the stems. Repeat after two weeks.

5) Harvest with digging fork when foliage begins to yellow and die back, usually 70-90 days after planting.

PESTS: (as with eggplant)

DISEASES: Bacterial wilt - (as discussed, page 47)

Scab - rarely serious, tubers have patchy, corky spots on skin . Scab mostly affects the cosmetic quality of the crop. Use good fertiliser practises and rotate crops.

Early Blight - a fungal disease that defoliates the plants, the disease begins as dark brown angular spots on leaves and can affect tuber quality. Use proper fertiliser practises and spray weekly with maneb or Mancozeb (Dithane M-45).

Soft Rot - bacterial soft rot in its primary stages may

resemble scab but cracks appear in the tubers, discoloration and soft rotting follow. A slimy bacterial oozing may occur. The disease occurs after harvest and is common when tubers are immature or damaged in harvest and is worse at high storage temperatures. Drying for a day in the sun and storing in ventilated racks reduces incidence. If potatoes are kept through the hot season for later planting they can be refrigerated at about (5°C.) or stored in ventilated racks under cover (a thatched roof is ideal). Some light should be allowed in and the structure should be rodent-proof.

EGGPLANT (Brinjal, aubergine, baigani (F), baigan (H)

When all other crops fail in the hot season, there is always eggplant. Unlike most vegetable crops that originate in temperate areas, eggplant is a tropical vegetable, performs better in the tropics, and the gene pool is larger and more varied than with temperate cultivars. The crop can yield one year or more if properly maintained. Though the crop is susceptible to bacterial wilt, local cultivars are often resistant to wilt while temperate selections are highly susceptible. The most popular eggplant variety is the dark-skinned, pear-shaped "Chahat", selected and released by the Agriculture Department. "Chahat" is high-yielding and fetches a high market price.

Recommended varieties: "Chahat"

CULTURE:

1) Sow in seedbed or flats; transplant 28-32 days after sowing.
2) Spacing 1.0-1.5cm x 30cm in rows; 50-60cm. squares on beds.
3) Fertilise as directed, chapter 3.
4) Apply feeding mixture (page 34) three weeks after

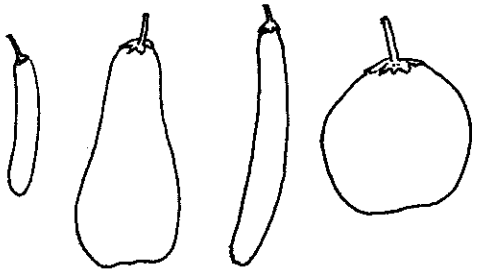


Figure 34. Some popular eggplant varieties are (from left to right): Kurumoto Long Purple, a highly palatable but low-yielding variety; Chahat, the most popular market eggplant; Local Long Purple, a hearty cultivar; and Black Beauty, a highly-valued but bacterial wilt-susceptible variety.

planting and three weeks after that. Apply planting fertiliser every three months with one or two application of the feeding mixture in between.

5) Remove or prune the crop at six months. Prune by cutting plants to one-half their height.

6) Harvest twice a week and before seeds form in fruits.

PESTS: Flea beetle/twenty-eight spot beetle - feed on foliage. Both can be controlled with Diazinon, Dibrom, Ambush or Orthene.

DISEASES: Bacterial wilt - (as mentioned above).

Leaf spot - a fungal disease, appears as light brown, $\frac{1}{2}$ centimeter necrotic spots on lower leaves. The disease is not serious enough to merit control measures.

Rusetting - appears as rough, brown skin on fruits, especially the blossom-end. The disease may be caused by the same factors as cause blossom-end rot of tomatoes. Insect feeding injuries on flowers or young fruit has also been suggested. Though fruits may be unmarketable, no control is known.

<u>PEPPERS (chilli, rokete (F), mirchaa (H) capsicum - sweet pepper, bell pepper (boro (F))</u>.

Though chillis are thought of as a primary component of a good curry, they have a place on all tables in Fiji. All three

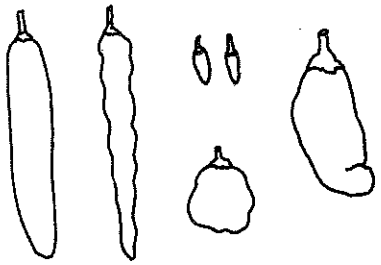


Figure 35. Chillies come in a variety of shapes and sizes. Depending on pungency, they can be used as a spice or vegetable. Chillies contain high amounts of vitamins A and C.

members of the Capsicum genus are popular in Fiji: the chilli, the birdseye chilli and the sweet pepper - and all appear in any number of varietal shapes, sizes, and colours. Though bacterial wilt can be a problem with peppers, local chillis and birdseye chillis are resistant. Commercial chilli and sweet pepper varieties are often quite susceptible. A local chilli selection, "Hot Rod", released by the Agriculture Department, is wilt-resistant, high-yielding, and yields even in the cool season, unlike many chillis. Sweet peppers perform best in the cool season and in areas free from wilt. They demand a high market price year-around.

Recommended varieties:

Chilli: "Hot Rod", "Long Red Cayenne", "Local long Thin".
Capsicum: "Yolo Wonder B", "Yolo Wonder Y","Hybrid New Ace", "Hybrid Ace".

CULTURE:

1) Sow in seedbeds or flats; transplant 6 weeks after sowing.

2) Spacings: chillis - 1-1.5m x 30cm in rows, or 50-60cm squares in beds; capsicum - 60-80cm x 30cm in rows, or 45cm squares in beds.

3) Fertilise as directed, chapter 3.

4) Apply feeding mixture (page 34) two to three weeks after transplanting and three weeks after that. Apply planting mixture every three months and the feeding mixture six weeks later.

5) Harvest chillis when they have turned red. Capsicum is harvested when full grown and before turning red. Harvest capsicum showing care not to break the branches - scissors, knives or shears may help.

PESTS: Birds may occasionally damage fruits of chillis and capsicum. Harvest promptly to minimize bird damage.

DISEASES: Bacterial wilt - (as discussed, page 47)

Viruses - caused wrinkled, distorted leaves, especially on new growth. Remove infected plants, select seed from uninfected plants; use sound rotation practises.

Shothole - a fungal disease that causes large, round necrotic areas on capsicum leaves. Control by spraying copper compounds as directed.

Anthracnose - appears as soft, dark, round necrotic marks on capsicum. Ruins marketability of fruits. Harvest promptly; use sound rotation practises.

PEANUTS - (ground nut, pinati (F), mungphali (H).

Peanuts are a popular and nutritious garden crop. Though they have a relatively low market value, they are one of the few crops that do well on poorer, well-draining soils. Peanuts are also tolerant of dry conditions. Local varieties have been shown not to respond well to fertilisers. New higher-yielding varieties are currently being selected and released by the Agriculture Department.

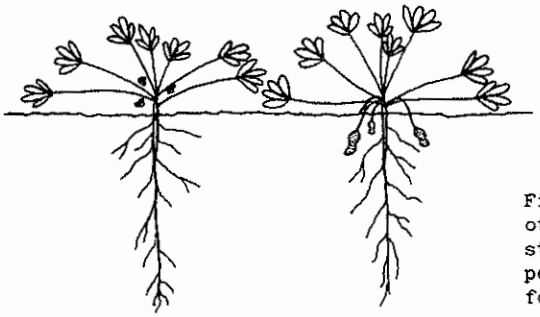


Figure 36. After pollinization of peanut flowers, an ovary stalk, or "peg", elongates and penetrates the soil. Peanuts form at the end of the pegs.

Recommended varieties: local red Spanish (consult Agriculture Department for future releases of peanut varieties).

CULTURE:

1) Sow one seed every 10cm. and 5-12cm. deep, in rows 45-65cm x 8cm; or in beds, in rows 30cm. x 8 cm. Soil should be deep and well-draining.

2) Irrigate deeply at planting and again at flower and peg formation.

3) Peanuts are ready for harvest when soft tissue inside shell darkens.

PESTS: Peanuts have many insect pests but rarely merit control measures.

DISEASES: Bacterial wilt - (as discussed, page 47)

Cercospora leaf spot - as evidenced by necrotic leaf spots and later, leaf fall. Control by rotation; spray Benlate 6-10 weeks after crop emergence.

Sclerotium rot - produces a wilt and death of seedlings or larger plants. White fungal threads on nuts and pegs and crown of the plant distinguish this disease from bacterial wilt. Resistant white or brown sclerotia resembling radish seed may also be evident. Control through sound rotation practises.

Verticillium wilt - fungal disease appears as irregular light marks on foliage. Foliage may later scorch leading to plant wilt. Do not plant on heavy, fertile soils; use sound rotation practises.

Rust - the most serious peanut disease in Fiji today. Trials show a 50% increase in yields if Benlate plus Mancozeb (Dithane M-45) is sprayed at 10-14 day intervals on infected crops. The new Tonga 5 variety is fairly resistant.

COWPEA (black-eyed pea (boraa (H)).

Though a legume, cowpea, like the peanut, is susceptible to bacterial wilt. The cowpea is a very important crop in tropical and subtropical areas around the world. The leaves are a popular and nutritious green in Africa, the immature seeds are delicious cooked as in Indian curries, and the dry beans are used in soup, stews and dhal. Cowpeas are tolerant of high temperatures and rainfall extremes. Cowpea cultivars are of two growth habits, dwarf and climbing. The cowpea is also an excellent green manure crop when ploughed in at flowering.

Recommended varieties: Local selections, as preferred
(consult Agriculture Department for future releases)

CULTURE:

1) Sow directly, in rows 1m. apart, two seeds/30cm. or in beds, two seeds in 45cm. squares. Thin later to one plant.
2) Fertilise as directed, chapter 3.
3) Apply feeding mixture three weeks after emergence and at first flowering.
4) Train climbing varieties 1.5-2.0m. on stakes or plant as with long beans, page 39.
5) Green pods can be harvested starting 70 days after sowing, dry pods are harvested at 100 days.

PESTS: Aphids - control with Ambush or Malathion
Maruca stem borer - bores into pods. Control with Orthene.

DISEASES: Bacterial wilt - (as discussed, page 47)
Mosaic virus - appears as wrinkly, distorted leaves with mosaic pattern, especially new growth. Incidence is usually minor. Use seed from uninfected plants; do not plant near other susceptible crops.

CROPS SUSCEPTIBLE TO CABBAGE MOTHS

These crops form a rotation grouping due to their susceptibility to attack by larvae (caterpillars) of various flying insects. These crops are also heavy boron feeders (the numbers in brackets indicate their need for boron among all vegetable crops, beets having the highest requirement). Many of these crops also have a high lime requirement and are susceptible to a number of fungal leaf spots and bacterial soft rot.

Cabbage (3)
Chinese Cabbage (-)
Cauliflower (5)
Broccoli (4)
Turnips (2)
Radish (7)
Beets (1)
Chard (-)

Cabbage moths are among the most dynamic insect pests due to their short life cycle and high rate of progeny which leads to genetic resistance to pesticides. This was classicly demonstrated in 1978 when vegetable growers suddenly found available pesticides did not control the Diamondback moth (Plutella maculipennis), a pest of the cabbage family. The result was a general shortage of these vegetable crops during the 1978 vegetable season. Subsequent research revealed synthetic pyrethroids controlled the moth and a pesticide, "Ambush", was subsequently registered. The effectiveness of the chemical was evident when the 1979 market was once again glutted.

Due to the solubility of boron and the high rainfall in Fiji, the element is quite often deficient in local soils (see chapter 2). While many vegetables will grow with low levels of boron in the soil, the members of this rotation grouping have a high requirement exceeding 0.5 p.p.m. in the soil. Boron deficiency can result in total crop loss and is often the condition that brings on bacterial soft rot, especially in the hot season. The fertiliser recommendations in chapter 3 include sufficient Borax to satisfy these crop requirements.

CABBAGE (English cabbage (kaveti olo (F), gobi (H)).

Though nutritionally a poor leaf crop, cabbage is popular among all races and easy to grow. Despite introduction of tropically-adjusted varieties, supply during the off-season, December - June, is poor, while the market is glutted during most of the remaining period. Imports of cabbage are high during the off-season.

Recommended varieties: K-K Cross, K-Y Cross, Express Cross 60, Tropical Drumhead, Tropic Globe, Ace High, Hi Yield.

CULTURES:

1) Sow in seedbed or flats; transplant at 25 - 28 days.
2) Spacing: in rows 60 x 45cm.; or in beds in 40 - 45cm. squares.
3) Fertilise as directed, chapter 3.
4) Apply feeding mixture two to three weeks after planting and at onset of head formation.
5) Harvest when top of cabbage head fills out and is hard to the touch, 70 - 80 days after sowing.

PESTS: A variety of cabbage moths - control with Ambush. Snails and slugs can also be a problem, control with snail and slug bait. Leaf miners - minute insects that leave an irregular trail on leaves from their burrowing. Control with Sevin or Orthene.

DISEASES: "Wire stem" of seedlings. Rotate seedbeds; sow under plastic during wet season.
Fungal leaf spots - can be severe in hot, moist weather - control with Cuprox spray.

CHINESE CABBAGE; Heading Chinese cabbage (wong bok, pak choi) (kaveti ni jaina (F))

Chinese cabbage is the most popular dark green leaf vegetable in Fiji. Easy to grow, it is popular due to its fast growth.

Chinese cabbage has a low market value during the months June - November and has a high value during the remainder of the year. Heading Chinese cabbage is fairly new to Fiji. It forms a tight head in cool conditions and is delicious cooked or as a lettuce substitute.

Recommended varieties: Chinese cabbage: Pak Choi Kwang Moon, Pe-Tsai. Heading Chinese cabbage: Wong Bok, Saladeer, Tropicana.

CULTURE:

1) Sow in seedbed or flats; transplant at 21 - 24 days.
2) Spacing: 45 x 30cm. in rows, 25 - 30cm. squares in beds.
3) Apply full feeding mixture in one side dressing 10 days after transplanting.
4) Harvest before plants "bolt", four to six weeks after transplanting.

PESTS: (as cabbage)

DISEASES: There are a number of fungal leaf diseases and bacterial soft rot best avoided by rotating crops, removing crop wastes from the field and thoroughly composting, and using recommended fertiliser practises. Virus diseases are transmitted by aphids - spray regularly with an insecticide and remove infected plants.

CAULIFLOWER (phul gobi (H))

Cauliflower is very popular in the Indo-Fijian and European communities. Production is increasing faster than any other vegetable crop due to the introduction of tropically-adjusted varieties and the crop's suitability as a substitute for English cabbage when prices fall in the vegetable season. Cauliflower grows quite well under plastic during the wet season (see chapter 5).

Recommended varieties: "Snow King","Snow Queen", "Tropical Sureheart", "Taiwan 45"

CULTURE:

(Cauliflower is grown like cabbage with minor changes)

1) Sow in seedbeds or flats; transplant at 25 - 28 days.

2) Spacing: 60 x 45cm in rows, 35 - 45cm squares in beds.

3) Fertilise as directed, chapter 3. Spray with magnesium sulphate (Epsom salts) weekly.

4) Apply feeding mixture two weeks after transplanting and again prior to curd formation.

5) Harvest 70 - 80 days after sowing.

PESTS: (as cabbage)

DISEASES: "Brown spot" on cauliflower heads and "hollow stem" are caused or aggravated by boron deficiency. Apply fertiliser as directed in chapter 3.

"Whiptail disease" symptoms are long, twisted leaves on new growth and absence of terminal bud. The disease is caused by molybdenum deficiency. The disease usually indicates acid soil - apply lime (see chapter 3) to make molybdenum in the soil more available or fertilise with any fertiliser containing molybdenum as directed on package.

"Wire stem" - (as cabbage)

Figure 37. Some common diseases of cauliflower include (from left): a "wire stem"-infected seedling compared to a healthy seedling; "whiptail disease", indicated by absence of growing tip and long, twisted leaves; "brown spot" on the cauliflower curds; and "tillering", indicating excess soil nitrogen.

Fungal leaf spots - (as cabbage)

BROCCOLI

Broccoli is probably the most nutritious European vegetable. The crop will form solid heads in the Fiji cool season and is a great leafy vegetable in the warm and cool months. Broccoli has a very high market value with a demand in urban areas and among hotels. Though easy to grow it is not very tolerant of wet conditions.

Recommended varieties: (Research trials have not been performed in Fiji; sprouting broccoli performs well giving a large head)

CULTURE:

1) Sow in seedbed or flats; transplant at 23 - 28 days.
2) Spacing: 60 - 80 x 45 - 60cm. in rows, 45 - 60cm squares in beds (use the wider spacings for sprouting broccoli)
3) Fertilise as directed, chapter 3. Spray with magnesium sulphate (Epsom salts) every week if deficiency symptoms show up (see page 35).
4) Apply feeding mixture (page 34) as with cauliflower.
5) Harvest before yellow flowers appear on head, usually two and half months after transplanting.

PESTS: (minimal, as with cabbage)

DISEASES: "Hollow stem", "brown rot" - as with cauliflower. Magnesium deficiency - spray with Epsom salts (see page 35). Bacterial soft rot - fertilise as in chapter 3; use sound rotation practises.

TURNIPS

Turnips are a popular garden crop with limited market potential.

They perform well in the cool season and do not tolerate excess rain. The leaves can also be used as cooking greens.

Recommended varieties: (research not performed in Fiji)

CULTURE:

1) Sow directly in rows, 45cm. apart with two seeds every 10 - 15cm; or in beds, 20cm. between rows and 10 - 15cm. between plants. Thin to one plant every 10 - 15cm.
2) Fertilise as directed, chapter 3.
3) Apply feeding mixture three weeks and six weeks after sowing.
4) Harvest 55 - 80 days after sowing depending on variety.

PESTS: Flea beetles - spray with Diazinon, Orthene, Dibrom or Ambush.
Cabbage moths - (control as with cabbage)

DISEASES: There are a number of diseases that are best controlled by rotation and good cultural practices. Boron deficiency manifests as cracked, deformed stems and roots - fertilise as in chapter 3.

RADISH

The long white "icicle" radish is popular among the Indo-Fijian community. All radishes grow well in Fiji, the red "globe" radishes being the fastest growers. Tolerant of a wide range of conditions, it nevertheless does better in the cool season.

Recommended varieties: "Japanese Wakayama", "Long White Chinese", "White Tropical".

CULTURE:

1) Sow directly in rows, 25 - 30cm apart with two seeds

every 2 - 4cm; or in beds, 15 - 20cm. between rows and seeds every 2 - 4cm. Thin to one plant every 2 - 4cm.

2) Fertilise as directed, chapter 3.

3) Apply feeding mixture three weeks after sowing and two weeks later with white radish varieties.

4) Harvest 30 - 60 days after sowing depending on variety.

PESTS: Flea beetles - (control as with turnips)
Cabbage moths - (control as with cabbage)

DISEASES: Few, use sound cultural practises.

BEETS

Though not very popular in Fiji, beets will grow in the cool season. As with all root crops they yield highest in lighter, well-prepared soils. Beets are tolerant of salty soils and respond to liming. They also have the highest boron requirement of all vegetable crops. Their leaves are a highly nutritious green.

Recommended varieties: "Early Wonder", "Tall Top", "King Red".

CULTURE:

1) sow seeds directly in rows, 39 - 45cm. apart with two seeds every 5 - 10cm.; or in beds in rows 20cm. apart with two seeds every 5 - 10cm. Thin to one plant every 5 - 10cm.

2) Fertilise as directed, chapter 3.

3) Apply feeding mixture three weeks after sowing and two weeks after that.

4) Harvest 70 - 80 days after sowing. Twist leaves off root rather than cutting them.

PESTS: Cabbage Moths - (control as with cabbage)

DISEASES: Few serious problems. Follow fertiliser guidelines, chapter 3, to avoid boron deficiency.

CHARD (silver beets, Swiss chard)

Chard is a prolific grower and nutritious green leaf vegetable. The crop grows best in the cool, dry season and because of the short days in Fiji will not bolt as it will in temperate zones. Chard is under-utilised in Fiji gardens.

Recommended varieties: "Medium Green", "Master Green"

CULTURE:

1) Sow seeds directly in rows, 60cm. apart with two seeds every 25 - 30cm.; or in beds, two seeds in 25 - 30cm squares. Thin to one plant every 25 - 30cm.
2) Fertilise as in chapter 3.
3) Apply feeding mixture 3 weeks after sowing and repeat every three weeks until crop is pulled out.
4) Harvest leaves from plant after 50 days or so. Repeated harvestings can be made over several months.

PESTS: Chard is resistant to cabbage moths. Aphids may be a problem - control with Malathion or Ambush.

DISEASES: Rarely serious.

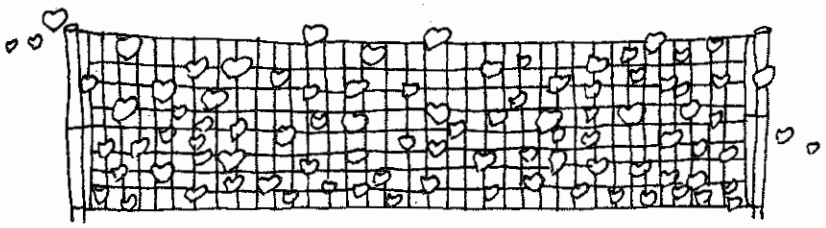


Figure 38. Cucumbers and gourds grow well on a trellis made of old goat fencing.

CUCURBITS

The cucurbits are all members of the plant family Cucurbitaceae. They are susceptible to attack by aphids and cucumber beetles and a limited number of diseases, the most notable being the downy and powdery mildews.

Cucumber
Pumpkin
Squashes
Zucchini
Melons
Watermelon

The cucurbits are an adaptable group of vegetable crops, tolerating a wide range of environmental conditions. Considerable research has been done to select cucurbit varieties for resistance to powdery and downy mildew. Today the most successful cultivars are those with some degree of resistance to one or both of these fungal diseases.

The two diseases, both of which affect primarily older leaves but can defoliate the entire plant, occasionally appear simultaneously. Downy mildew (Pseudoperonospora cubensis) is severe when the humidity is 90% or higher - whether from rain, mist, or dew - and a relatively cool temperatures 15 - 22°C, though it can occur at higher temperatures. Powdery mildew (Erysiphe cichoracearum) is prevalent in dry conditions with warm days and cool nights. Reproductive spores, however, germinate with high humidity. Downy mildew on cucurbits appears first on older leaves as angular whitish-yellow spots. As the disease spreads, leaves shrivel and die. Plants are

stunted and fruits are small and unsweet. Powdery mildew, as the name suggests, has a powdery appearance on the surface of older leaves. The "powder" is actually vegetative spores that are spread by wind to other plants. As with downy mildew, powdery mildew can often kill an entire crop.

Primary control of both diseases is through planting recommended varieties which have some resistance. Control can also be achieved by spraying with a mixture of Milcurb or Benlate for powdery mildew, and Mancozeb (Dithane M-45) or maneb, for downy mildew. This has the added benefit of controlling gummy stem blight and Cercospora leaf spot, two other disease problems of cucurbits.

Mosaic virus is another problem, especially on cucumber and rock melon. Leaves are mottled, deformed, stunted and curl downwards. The virus is spread by aphids or through seed from diseased plants.Control aphids by spraying Ambush or Malathion.

Insect problems with cucurbits are generally limited to attack by an orangish cucumber beetle, especially on young plants. Diazinon, Dibrom, Ambush, or Orthene are effective in controlling the beetle.

CUCUMBER (kiukaba (F) khira (H)).

Cucumbers are a popular crop with all races in Fiji and are planted year-around. Recommended varieties are fairly resistant to disease whereas other varieties may outright fail. Research in Fiji has shown that cucumbers yield higher when trellised (see chapter 3, page 39).

Recommended varieties: "Early Perfection", "Supermarket", "Southern Cross", "Ashley", "Polaris", "Green Gem".

CULTURE:

1) Sow directly in rows, 1.5m apart with two seeds every

30cm.; or in beds, in squares 60cm. apart, two seeds per spot. Thin later to one plant. Or trellis as in chapter 3, page 39.

2) Fertilise as directed, chapter 3.

3) Apply feeding mixture (page 34) three weeks after emergence and two weeks after that.

4) Harvesting begins at about 50 days after emergence and extends 4 weeks or more.

PESTS and DISEASES: (see page 66).

PUMPKIN (vavukeni (F), kaddu, kohora (H) squashes, marrow (zucchini).

Pumpkins and squashes are highly adaptable to a variety of climatic and soil extremes. They are popular in Fiji, especially in the Indo-Fijian community. These cucurbits have two abits of growth: straggling, or trailing, as with pumpkins, acorn and butternut squashes; and bush, such as with crookneck squashes or marrows. There is a good local market for pumpkins and marrows (zucchini) and at one time zucchini was exported to New Zealand. Yellow fleshed pumpkins and squashes are high in vitamin A.

Recommended varieties: "Queensland Blue", "Hybrid Taichung", "Butternut", "Black Zucchini".

CULTURE:

1) Sow directly: trailing types - in rows, 2m. apart, two seeds every 30cm.; in beds, two seeds every 30cm. in the center of t e beds. Thin later to one plant every 30cm.

Bush types: in rows, 1m. apart with two seeds every 45cm.; or in beds, in 45cm. squares, two seeds per spot. Thin later to one plant.

2) Fertilise as directed, chapter 3.

3) Apply feeding mixture three weeks after emergence and two to three weeks after that.

4) Harvest: Crookneck and zucchini-at preferred size, before fruits are hard. Pumpkins and squashes - as preferred, dry fruits store well.

PESTS and DISEASES: (see page 66).

Blossom-end rot - a problem with marrow (zucchini), fruits rot from the blossom end. Use proper fertiliser practises; irrigate regularly and evenly; control foliage diseases; apply lime if soils are acid.

MELONS (rockmelon, muskmelon, kakari (H)).

The quality of rockmelons (cantaloupes, honeydews, etc.) in Fiji is poor, the plants subject to disease and fruits often less than sweet. Using recommended varieties assures a degree of disease-resistance though does not guarantee sweet fruits. Chapter 3 and 5 discuss growing rockmelons on trellises and growing under plastic. Rockmelons grown under plastic are less susceptible to disease and the fruits are larger and sweeter. Melons grown out of cover perform best in drier conditions.

Recommended varieties: "Yates Rock Hybrid", 'Gulf Stream", "Hales Best PMR 45", "Winstone No. 1"

CULTURE:

(as with cucumber)

PESTS and DISEASES: (see page 66).

WATERMELON (meleni (F), tarbuj (H).

September and October are the months when the markets overflow

with piles of "Charlestown Grey" watermelons. Popular among all races, watermelons have a good market value except in these two months. The crop is susceptible to the typical cucurbit diseases, however will usually produce year-around. Pruning to two fruits per vine is reported to increase fruit size and earliness. Assuming enough soil moisture, watermelons are prolific and sweet on sandy soils.

Recommended varieties: "Charlestown Grey", "Sugar Baby".

CULTURE:

1) Sow as with cucumber: spacing - in rows 3m.x 30cm.; in beds every 45cm. in the center of the bed; or in mounds, 2m. apart.
2) Fertilise as directed, chapter 3.
3) Apply feeding mixture three weeks after emergence and two to three weeks after that.
4) "Thump" watermelons to test for ripeness. Ripe melons have a dull sound, green melons have a hard "ping". The colour of ripe melons is duller than unripe melons.

PESTS and DISEASES: (see page 66)

Blossom-end rot - (as with marrow).

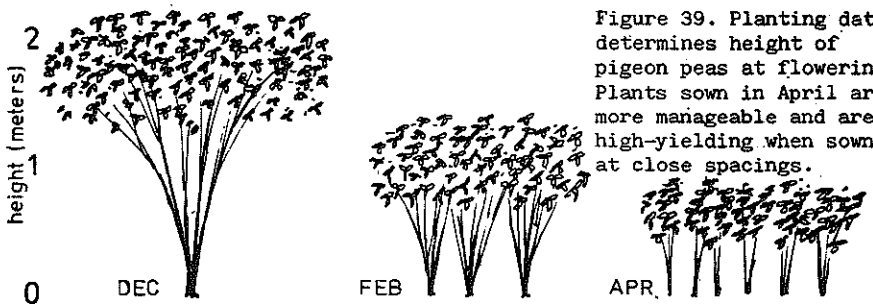


Figure 39. Planting date determines height of pigeon peas at flowering. Plants sown in April are more manageable and are high-yielding when sown at close spacings.

LEGUMES

The legumes (beans and peas) are a good rotation for other crops not only in terms of breaking disease cycles but because nitrogen-fixing bacteria associated with legumes leave the soil richer in nitrogen after the crop is pulled out.

French bean
Lima bean
Long bean
Winged bean
Pigeon pea
Lablab bean
Jack bean
Peas

Garden legumes are of two general types: bush (dwarf) and pole (climbing). Bush types require no staking but are generally lower yielding than pole types. Pole legumes climb by winding around vertical objects, with the exception of peas which climb aided by tendrils (see page 36).

Legumes are high in protein and complement the diet of vegetarian peoples around the world. Beans such as the winged bean (Psophocarpus tetragonolobus) and the soybean (Glycine max) have a well-balanced protein and are being utilized in a variety of animal protein substitutes. Although the pods and seeds and the mature beans are the commonly eaten portions of the plant, many legume leaves are edible and highly nutritious.

Research by the Agriculture Department has shown garden beans and peas respond to fertiliser despite the nitrogen-fixing bacteria that live symbiotically in legume roots. These bacteria

take nitrogen from soil air and convert it to proteinous tissue. This benefits the legume and results in increased soil nitrogen when the crop refuse is later ploughed in. This is also the reason legumes make good green manure crops.

Whereas cowpeas and peanuts are popular and nutritious garden crops, their susceptibility to bacterial wilt precludes their presence in this grouping. Cowpeas and peanuts should not be planted before or after other wilt susceptible crops (see page 47).

FRENCH BEAN (snap bean, haricot bean, string bean, wax bean, pini (F)).

French beans are a popular and easy crop to grow. French beans are tolerant of a wide range of soil types and perform reasonably well even in the hot season, depending on prevailing weather conditions. The crop has two statures of growth: bush, or dwarf, and pole, or climbing. Dwarf beans are most commonly grown but pole beans are higher yielding and are more suited for wet conditions.

Recommended varieties: Dwarf bean: "Contender", "Top Crop", "Golden Wax".
Pole bean: "Mangere", "Shiny Podded Fardenlosa".

CULTURE:

1) Sow directly, in rows, .60 - 1m. apart, two seeds every 25cm. with dwarf beans or 15cm. with pole beans, thin later to one plant; or in beds, in rows 45cm. one seed every 7cm. Pole beans on beds can be trellised as in chapter 3 page 39, or if planted in rows, staked or trellised on "teepees".

2) Fertilise as directed, chapter 3.

3) Apply feeding mixture two weeks after emergence and at first flowering.

4) Harvest dwarf varieties 40 - 50 days after sowing and pole beans 70 - 80 days after sowing. Immature pods are harvested over a few weeks.

PESTS: Stem and pod-boring larvae - damage bean pods. Control with Orthene, Ambush, Diazinon and Dibrom.

DISEASES: Rust - a fungal disease evidenced by pustules on the bottom of leaves that are red (with spores) to the touch. Control with Zineb or Mancozeb (Dithane M-45).

Angular leaf spot - a fungal disease that appears as angular brown spots on leaves especially in the cool season. It may defoliate plants. Use proper fertiliser practices; spray with Maneb or Mancozeb (Dithane M-45).

Halo blight - a bacterial disease that may cause water marks on seedlings below cotyledons. Seedlings later brown and die. On older plants, yellow haloes around dark green angular spots may appear. Later the entire leaf may yellow. Stems may develop circular marks and may darken and ooze. Use sound rotation practices; use disease-free seed; use resistant varieties.

Viruses - plants have stunted appearance, leaves have a light/dark mosaic pattern and are twisted. Control aphids; use resistant varieties; remove diseased plants; use disease-free seed.

Pod rot - fungal disease affecting bean pods that touch the soil, worse in wet conditions. Large cankers develop, usually on the end of the pod. Apply a thick mulch of undecomposed material prior to pod formation; plant pole beans on trellises or stakes; thoroughly compost organic wastes.

Root and stem rot - affect seedlings before and after emergence. Emerged seedlings rot at or below the soil surface. Use sound rotation practises.

LIMA BEAN (butter bean)

Lima beans have a certain popularity among the Indo-Fijian and European communities and the seeds are eaten freshly cooked or dried. There are two species, a large - and a small-seeded plant, and there are bush and pole types. Lima beans perform best in the cool season.

Recommended varieties: "Dwarf White"

CULTURE:

1) Sow as with bush and pole French beans but in rows space the seeds 30cm. apart with bush types and 35 - 45cm. apart with pole types. In beds sow bush types at 30cm. spacing and trellis pole types as on page 39, one plant per string.
2) Fertilise as directed, chapter 3.
3) Apply feeding mixture two weeks after emergence and again at first flowering.
4) Harvest for green beans before seeds harden. For dry beans allow pods to mature and dry on the plant before harvesting.

PESTS and DISEASES: (as with French beans)

LONG BEAN (snake bean, yard-long bean, pini balavu (F)).

Long beans are an important vegetable in Fiji, yielding well in the hot season. The long bean is commonly cultivated without using any trellising or with a single reed. Research by the

Agriculture Department has shown very high yields can be achieved when long beans are grown on bamboo teepees. Of the two varieties, the white-podded long bean is better suited in the hot season and the green-podded suited for year-around production. Bush sitao, a popular vegetable in the Phillipines, is a cowpea/long bean hybrid that yields long beans on bush-type plant. At this writing seed is not commercially available in Fiji.

Recommended varieties: green or white varieties.

PESTS and DISEASES: (as with French bean).

WINGED BEAN (Goa bean, char fukya (H)).

The winged bean is at once a trendy but potentially important plant. Though only recently publicized, the winged bean has long been in Fiji, Papua New Guinea and South-east Asia being centers of genetic diversity . Though the immature pod is most commonly eaten in Fiji, the tubers, flowers, dry seed, young leaves and shoots are all edible. On top of this the winged bean has basically the same well-balanced protein as the soybean, the "poor man's meat". Winged beans must be trellised to yield well. Vines have been know to live four years or more so trellises must be sturdy - fences are ideal. The winged bean is photosensitive and begins flowering in April and producing pods in May.

Recommended varieties: "Mumu" (local selection)

CULTURE:

1) Sow directly on a fence line or sturdy trellis designed to hold up against strong winds, 1 - 2m. high is ideal. Sow one or two seeds every 30 - 60cm. Place vertical reeds next to the plant, to assist them onto horizontal materials such as fences. Sow before June to guarantee a crop in the same year -

the end of the rainy season is a good time for sowing.

2) Fertilise with planting mixture (chapter 3) at planting.

3) Apply feeding mixture when plants begin to climb and one month later. Apply planting mix every three months and feeding mix six weeks later until plants cease flowering. Commence fertilising again at the end of the rainy season.

4) Harvest green pods before they become hard. For dry seeds allow pods to dry on the vines.

PESTS and DISEASES: (none of importance)

PIGEON PEA (arhar (H))

The pigeon pea is at once a popular pulse (dry seed) and vegetable (green seed) crop. Like winged beans and lablab, pigeon peas are photosensitive and begin flowering in May. For this reason, the Agriculture Department recommends pigeon peas be sown between February and April and at closer spacings to assure a shorter, easily managed crop with high yields.

Recommended varieties: Station 8 (consult Agriculture Department for future releases of vegetable quality pigeon pea seed.

CULTURE:

1) Sow seed March or before: in rows 65cm apart, one seed every 10cm.; or in beds, in rows 45cm. apart, one seed every 10cm.

After March: in rows 45cm. apart, one seed every 10cm.; or in beds, in rows 30cm. apart, one seed every 10cm.

2) Fertilise as directed, chapter 3.

3) Apply feeding mixture two weeks after crop emergence and three weeks after that.

4) Harvest pods green or dried, as preferred.

PESTS: Maruca stem borer - a serious pest of pigeon peas. Control by spraying Orthene at flowering.

DISEASES: Rarely serious.

LABLAB BEAN (dolichos bean, hyacinth bean, sem, papari (H)).

The lablab bean is of minor importance in Fiji and is mostly used by Indo-Fijians. The green seed and/or pod are the utilized portions of the plant and must be cooked to be edible. Like the winged bean, lablab is photosensitive and begins to flower in April - May. Lablab may occasionally become perennial, yielding over two seasons.

Recommended varieties: (local selection)

CULTURE:

1) Cultivate as with winged bean if sown before March and cultivate as with cowpea if sown in March or later.

2) Harvest green pods before seeds harden.

PESTS and DISEASES: Stem and pod boring larvae (Maruca) - control with Orthene.

JACK BEAN (sword bean, baraa sem (H)).

Another under-utilized tropical legume is the Jack, or sword bean. The shrub-like plant, which reaches 1m. high, yields

25 - 30cm. long flat immature green pods. The entire pod can be sliced and cooked like French beans. The large seeds are inedible. The Jack bean yields over an extended period of time.

Recommended varieties: (local selection)

CULTURE:

1) Sow directly, in rows, 1m. apart, two seeds every 30cm.; or in beds, in 60cm. squares, two seeds per spot. Thin later to one plant.
2) Fertilise as directed, chapter 3.
3) Apply feeding mixture as with eggplant (page 52).
4) Harvest young pods before they become woody.

PESTS and DISEASES: Stem and pod borers - control with Orthene.

PEAS (matar (H)).

Though peas are a cool weather crop they perform well in the cooler, dry season in Fiji. Peas are most popular among the European and Indo-Fijian communities. There are several varieties of peas including the vegetable or dwarf pea, from which the green pea seed is cooked as a vegetable, the blue pea, an imported dry pea used in cooking though occasionally planted as a vegetable pea, and the newer varieties of sweet edible-pod pea, including the snap pea. Peas are of two types, dwarf and climbing. Climbing peas may reach 1.5m. or higher and must be supported.

Recommended varieties: (no recommendations)

CULTURE:

1) Sow directly, in rows 60 - 80cm. apart, with one seed every 2 - 4cm.; or in beds, in rows 45cm. apart,

one seed every 2 - 4cm.

2) Fertilise as directed, chapter 3.

3) Climbing peas should be trellised on reeds, strings, wires, or thin branches. Or trellis as in chapter 3, page 39.

PESTS: Aphids or pod-boring larvae - controlled by spraying Orthene, Ambush, Diazinon or Dibrom.

DISEASES: Powdery mildew - is a serious problem with peas though some pea varieties are resistant. The disease appears as discoloured specks on leaves and later the fungus takes on a powdery appearance on the leaf surface. Control with resistant varieties; spray with Benlate.
Leaf spot - may be serious in wet weather. Control by spraying Maneb or Mancozeb (Dithane M-45).

Figure 40. Root crops, such as kumala, cassava, yams, and dalo, are ideal crops to rotate with vegetables.

OTHER CROPS

These crops are for the most part unrelated to each other and are suitable for rotating with the previous rotation groups, having few diseases in common. Subsequent plantings of the Allium plants (onions, leeks, garlic) should be avoided as well as bele and okra, both Malvaceous plants.

Maize
Carrots
Lettuce
Onions
Leeks
Garlic
Celery
Okra
Coriander
Fenugreek
Parsley
Bele
Poi
Sweet Potatoes
Taro
Cassava
Yams

MAIZE (corn, sila (F), makai (H)).

Maize is an important garden crop, not only because of its popularity as a vegetable, but because of its value as a rotation crop. Having a unique and efficient respiration

system, called a "C-4" system, maize has the potential to grow swiftly, but requires abundant nutrients, plenty of moisture, and thrives in warm temperatures. Sweet corn is the most palatable vegetable maize, originally being bred from field corn varieties. Sweet corn, however, is very susceptible to disease and while there are varieties that are less susceptible, field corn is most often used in Fiji as both a vegetable and cereal crop. Steady rainfall also is deleterious to sweet corn, interfering with pollination. Maize can often be intercropped with legumes such as soybeans or garden beans without a reduction in the yield of either. Because of the requirements of maize, it should be planted on rich soil, fertilised, and planted in the wet season especially in the dry zone. Because maize is cross-pollinated, it should be planted in blocks rather than rows.

Recommended varieties: Sweet Corn: "Golden Cross Bantam", "Hawaiian Sugar".
Field Corn: the "Dent" varieties are considered most palatable as a vegetable maize.

CULTURE:

1) Sow directly in rows, 1m. apart, two seeds every 30cm. or in beds, in rows 45cm. apart, two seeds every 20cm. Thin later to one plant.
2) Fertilise as directed, chapter 3.
3) Apply feeding mixture (page 34) two to three weeks after emergence and again prior to tassel formation.
4) Harvest sweet corn varieties when kernels are still milky - not starchy. Harvest field corn varieties for vegetable use when cob is young and kernels tender.

PESTS: Corn ear worm - attacks the plant and later the ear at silking. Sweet corn varieties have looser shucks

and are more susceptible than field corn. Spray with Orthene, Ambush, Diazinon, or Dibrom at silk formation.

DISEASES: There are many blights and mildews that attack maize. These are best controlled by planting recommended varieties, which may be resistant, or planting field corn varieties which are less frequently affected. Maize is also highly susceptible to nutrient, including micronutrient, deficiencies. These are best avoided by using proper fertiliser practises, planting on rich soils, and assuring adequate soil organic matter.

CARROT (kareti (F), gajar (H)).

Fiji relies largely on carrot imports to satisfy local demand. Carrots do grow well in Fiji, however especially in the cool season and on light, well-draining soils. For these reasons, carrots are a good market crop, and the Agriculture Department is encouraging more extensive carrot planting. Carrots are small-seeded, slow-germinating, and slow to establish so require a steady supply of moisture and a high measure of weed control. Quick growth produces better carrots. Carrots are high in vitamin A and have good keeping qualities

Recommended varieties: "Chantenay Long Type", "Chantenay Red Cored", "Western Red".

CULTURE:

1) Sow directly in deeply prepared, light soil, in rows, 30cm. apart with 3-4 seeds every 5cm.; or in beds, in rows 18cm. apart with 3-4 seeds every 5cm. Thin later to one plant every 5cm.
2) Fertilise as directed, chapter 3.
3) Show extra attention to weed control. Weeds in

carrots can be controlled by spraying with kerosene at the three-true leaf stage. The rate is 450 litres/hectare (45ml/ square meter). Spray on a sunny day for best control.

Figure 41. Weeds in carrots can be controlled with kerosene at the three true-leaf stage.

4) Apply feeding mixture at three-true leaf stage and three weeks later.

5) Carrots are usually ready 90 - 110 days after sowing. Lift carefully with a digging fork.

PESTS: Rootknot nematodes - see page 42.

DISEASES: Alternaria blight - defoliates plants, especially in hot and humid conditions. Control by spraying maneb, Mancozeb (Dithane M-45), or a copper solution. Use sound rotation practices. Bacterial soft rot - occurs in poorly draining soils in the wet season. Plant on beds or well-draining soils.

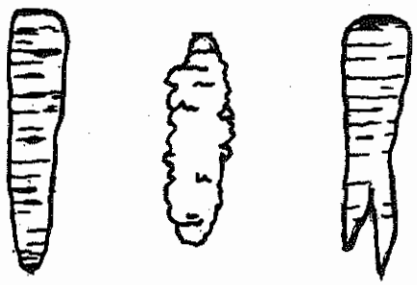


Figure 42. Some problems with carrots are (from left to right): "cavity spot", caused by calcium deficiency; root galls, caused by root-knot nematodes; and split roots, caused by excess soil nitrogen.

LETTUCE (letisi (F)).

Though lettuce is very resistant to both pests and diseases, there is a certain incidence of nematode infestation so should

be rotated with non-susceptible crops. Though lettuce is primarily a cool season crop, there are some leaf varieties that will produce during the off-season, depending on prevailing weather conditions. Head lettuce only grows properly in the cool season and has the highest market value.

Recommended varieties: "Yates Lake", "Cal-K-60","Cabrillo", "Anuenue", "Great Lakes" strains, "Minetto", "Green Mignonette", "Buttercrunch".

CULTURE:

1) Sow in seedbed or flats. Transplant at 26 - 30 days.
2) Spacings: in rows, 45 x 30cm,; or in beds in 25 - 30cm. squares.
3) Fertilise as directed, chapter 3.
4) Apply feeding mixture (page 34) two weeks after transplanting and two weeks later.
5) Harvest before lettuce "bolts".

PESTS: Few insect pests. Snails and slugs may harbour in mulching material - they can be controlled with snail and slug bait.
Nematodes - as evidenced by galls or cracks on roots. Use sound rotation practises.

DISEASES: Heart rot - inside leaves decay. Use proper (not excessive) fertiliser practises.

Leaf spot - a problem in the hot season. Use sound rotation practises.

ONION

Fiji depends largely on onion imports to satisfy local demand. Onions are photosensitive, requiring long days for bulb formation.

For this reason it is recommended that onions be sown in May so the bulbs form when the days are getting longer yet before the warmer, wetter weather of November and December. Recommended varieties are less sensitive to photoperiod than most temperate varieties. Onions have been shown to yield well in research trials, however, keeping properties of recommended varieties are varied with "Awahia" and "Tropired" keeping up to six months and "Texas Early Grano" storing only one to two months. Onions are direct-sown or transplanted, direct-sown onions requiring constant attention to weeding while transplanted onions require extra labour in transplanting. Pre-emergent weedicides are useful in direct-sown onion culture.

Recommended varieties: "Awahia", "Tropired", "Texas Early Grano"

CULTURE:

1) Direct-sown: in rows 30cm. apart, two or three seeds every 15cm.; or in beds, in squares 10 - 15cm. apart, two seeds per spot. Thin later to one plant. Transplanted: sow in seedbed or flats and transplant when seedlings are 5-8cm. high. Plant at depth they were in the seedbed.
2) Fertilise as directed, chapter 3.
3) Apply feeding mixture three weeks after emergence if direct-sown or two weeks after transplanting. Repeat two to three weeks later.
4) Show attention to weed control at all stages.
5) Harvest when tops "fall" on about 50% of the plants. The onions are pulled up and left for a half day in the sun with the tops covering the bulbs. Clip leaves to 1.5cm. above the bulb.

PESTS: Onion thrips - minute insects that leave small white marks on leaves. Spray with Orthene or Ambush.

DISEASES: Downy mildew - affects leaves and yield. Apply maneo or Mancozeb (Dithane M-45)

LEEKS

Leeks grow well in Fiji but the crop is relatively unknown to local farmers. Leeks are imported and fetch a high price in urban areas. The crop is similar to onions but the buried, blanched portion of the stem is eaten rather than a bulb. Leeks are insensitive to photoperiod so are a good onion substitute. They do, however, perform better in cool temperatures. Leeks are grown in seedbeds and are transplanted into holes made with a "dibber" stick, somewhat like dalo.

Recommended varieties: "Musselburgh".

CULTURE:

1) Sow in seedbed or flats and transplant when seedlings are 20cm. high. Plant in beds in holes 15 - 18cm. deep made with a sharpened "dibber" stick. Drop the seedlings in the holes without filling with soil.
2) Fertilise as directed, chapter 3.
3) Apply feeding mixture three weeks after transplanting and three weeks after that.
4) Harvest when shoots are fully mature, usually 3-5cm. thick. Lift with a fork and trim roots and tops of leaves before marketing.

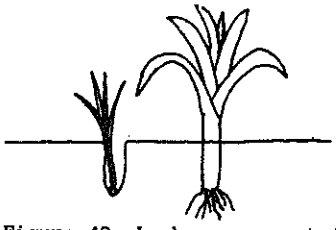


Figure 43. Leeks are planted in holes, somewhat like dalo. The underground stem is the portion of the plant eaten.

PESTS and DISEASES: Rarely serious.

GARLIC

Garlic is photosensitive and commercial varieties will grow in Fiji but will not bulb due to short daylength. New cultivars have been released, in other countries, however, that are photoinsensitive. The Agriculture Department has reported one of the cultivars has yielded well in Fiji. At the present time storage of bulbs over the wet season for replanting the following year is a problem.

Recommended varieties: (see text, above)

CULTURE:

1) Plant cloves singly with tops slightly exposed in rows 30cm. apart, 10 - 15cm. between plants; or in beds in 10 - 15cm. squares.
2) Fertilise as directed, chapter 3.
3) Apply feeding mixture three weeks after leaves appear and three weeks after that.
4) Harvest when leaves turn brown and dry. Store in racks in a well ventilated spot.

PESTS and DISEASES: (as with onions).

CELERY

Celery, known as a cool season crop, is rarely cultivated in Fiji. The exception is occasional plantings by Chinese Fijian farmers, though less frequently today. Imports are quite high, however, due to urban consumer, restaurant, and hotel demand. Celery can be grown in Fiji in the cool season and especially at high altitudes. Celery is tolerant of high rainfall and because of shallow roots will not tolerate prolonged dry spells. The crop performs best on rich, heavy soils high in organic matter. Boron deficiency is quite

common with celery and causes "cracked stem". Celery is sometimes blanched by planting in trenches or covering the stems two or three weeks before harvest with heavy paper or other materials to lighten stems. Planting close in beds achieves somewhat the same results. Celery is started in seedbeds and takes about two months to ready for transplanting, so should be sown beginning in January or February. Celery is probably the highest income vegetable crop that can be planted in the cool season.

Recommended varieties: (No Agriculture Department recommendations. "Fordhook Giant" is sold locally and grows well).

CULTURE:

1) Sow in seedbeds or flats, transplant when 7 - 8cm. high.
2) Spacing in beds in 25 - 30cm. squares.
3) Fertilise as directed, chapter 3.
4) Apply feeding mixture two weeks after transplanting, three weeks after that, and a third application three weeks later.
5) Harvest when plants stop growing, usually 11 - 13 weeks after transplanting.

PESTS and DISEASES: Rarely serious

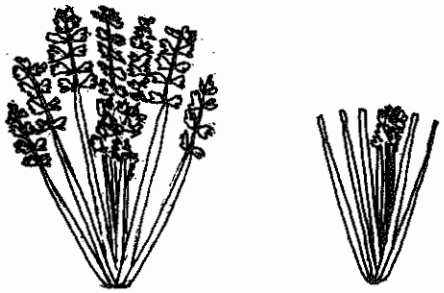


Figure 44. Celery is a high-income crop that can be grown in Fiji's cool season. The stems (petioles) of celery are the most commonly eaten portion of the plant, the leaves most often being trimmed from the plant before marketing

OKRA (bhindi (H)).

Okra is a favourite among the Indo-Fijian community and grows well year-around. Okra, from which the seed pod is consumed, is a close relative of bele, a leafy vegetable.

Recommended varieties: "Clemson Spineless", "Dwarf Long Pod", "Local Long White".

CULTURE:

1) Sow directly in rows 1m. apart, two seeds every 30cm. or in beds in 25 - 30cm. squares, two seeds per spot. Thin later to one plant.
2) Fertilise as directed, chapter 3.
3) Apply feeding mixture three weeks after emergence and again at flowering.
4) Harvest pods before they become "woody".

PESTS: Spiny ballworm and corn earworm - larvae burrow into pods. Spray at flowering. Commence spraying with Orthene before flowering and at 10 day intervals.

DISEASES: Powdery mildew - fungus appears as white powdery appearance on leaf surface. Spray with Benlate.

CORIANDER (silantro, dhania (H)).

Coriander is the most important herb/spice of the Indo-Fijian community. The young leaves are used in chutneys (especially with tomatoes) and are cooked with fish. The dried seed is pounded and is the main constituent of the curry powder, masala. Dhania does not grow well in the hot, wet season but has been shown to perform well for herb use under plastic dry frames.

Recommended varieties: (Local selection).

CULTURE:

1) Sow directly in beds in rows 5 - 7cm. one seed every 1cm.
2) Fertilise as directed, chapter 3.
3) Harvest the plants before they begin to bolt.

PESTS and DISEASES: None serious

FENUGREEK (metti (H)).

Fenugreek is consumed as an herb mostly by the Gujarati community. Seed is broadcast and the sprouts are harvested before the true leaves appear. It is sold by the bundle in markets and grows well in the cool season. Like coriander, it grows well under plastic frames in the hot season.

Recommended varieties: (Local selection).

CULTURE:

1) Broadcast seed in a well-prepared bed, 200 grams to the square meter. Lightly work in to the top 5cm. of soil.
2) Fertilise as directed, chapter 3.
3) Harvest when cotyledons are large but before true leaves appear. Pull seedlings out by the stem.

PESTS and DISEASES: None serious.

PARSLEY

Related to the carrot, parsley is cultivated as an herb and

is most popular among the European community in Fiji. Though parsley plants will yield leaves for several months or more, they are more prolific the first few months. Parsley is a good market crop in urban areas. Parsley is slow to germinate, sometimes taking two weeks.

Recommended varieties: (No Agriculture Department recommendations. Several varieties are available in Fiji).

CULTURE:

1) Sow in seedbed or flats, transplant when seedlings are hardy.
2) Spacing: in rows 30cm. apart, 15cm. between plants; or in beds, in 15cm. squares.
3) Fertilise as directed, chapter 3.
4) Apply feeding mixture two weeks after transplanting and every four weeks after that.
5) Harvest leaves from base of the plant.

PESTS and DISEASES: None serious.

BELE (F)

Bele, Abelmoscus eschulenta, is a popular and nutritious native of the South Pacific. Leaves and young shoots are picked and cooked and have been shown to be the most nutritious green vegetable grown in Fiji. The shrub-like plant is a relative of okra, and its leaves are sticky like okra pods. Bele yields well year-around and is an attractive ornamental as well as a food plant.

Recommended varieties: (Local selection).

CULTURES:

1) Plant cuttings in rows 1m. apart, one cutting every

30cm.; in raised beds in 45cm. squares; or plant as a hedge or ornamental on the side of house, property lines, etc.

2) Fertilise as directed, chapter 3.

3) Apply feeding mixture (page 34) three to four weeks after planting and three to four weeks after that. Re-apply the planting mix every three months and the feeding mix once between those applications.

4) Harvest leaves and young shoots. Do not defoliate entire plants as this makes them susceptible to disease, especially in times of prolonged rainfall.

PESTS: Leaf miners - leave tracks as they burrow through leaves. Control with Sevin or Orthene.
Spiny bollworm and corn earworm - larvae burrow in shoots. Spray between harvestings. Spray Orthene as with bele.

DISEASES: None serious.

POI (Ceylon spinach)

Poi is a succulent climbing vine that yields abundant round leaves that can be cooked as spinach or used fresh as a salad green. Indo-Fijians use the leaves to thicken dhal. Poi is particularly useful as a green in the summer months when it thrives. The plant tolerates partial shade rather well so can be planted against houses or in spots which other plants may not tolerate. Poi can be planted from seed or cuttings. Trimming flowers from the plants is said to produce more leaf growth.

Recommended varieties: (Local selection).

CULTURE:

1) Sow seeds in seedbed or flats, transplant when the plants have four or five leaves; or plant cuttings in seedbed, pots, or flats and transplant later or plant cuttings directly on spot they will grow on.

2) Spacing: 30cm. between plants.

3) Fertilise as directed, chapter 3.

4) Trellis on vertical sticks, reeds, wire or strings to one to two meters.

5) Apply feeding mixture when plants begin to climb and every four weeks thereafter.

6) Harvest leaves and young shoots.

KUMALA (F) sweet potato).

Kumala is one of the staple crops of early Fijians though the crop originated in the Americas. This fact has inspired conjecture of pre-Magellan contacts between the Americas and the Pacific Islands. Kumala is considered a minor root crop in Fiji and supply is dropping due to the spread of a fungal disease, scab. Kumala is important in the garden not only because of the vitamin A content of yellow varieties and its value as a rotation crop, but also because it thrives on less fertile, well-draining soils. Research shows that good yields cannot be achieved before four to five months, even with "Vulatolu" ("three months"). The leaves of kumala can also be eaten as a cooked green.

Recommended varieties: "Drividrivi" (highly susceptible to scab), "Vulatolu", "Navuso Local", "Hawaii".

CULTURE:

1) Kumala is planted using 12 - 15cm. stem tip cuttings: in ridges 60 - 75cm. apart, one tip every 30cm.; in

mounds 60 - 90cm. apart, two or three cuttings per mound; or in beds, in rows 45cm. apart one cutting every 30cm.

2) Fertilise as directed, chapter 3.

3) Mound the kumala with a hoe at four weeks. Wind the kumala vines over the spot they were planted and pull soil up around and on top of the planting spot.

4) Apply feeding mixture four weeks after planting (at mounding up) and again three to four weeks later.

5) Harvest carefully with a digging fork at four to five months. If weevil infestation is possible, submerge tubers in water for 12 hours to kill grubs. Kumala can be buried in a dry spot to store the tubers.

PESTS: Kumala weevil - larvae burrow into stems and tubers. Use sound rotation practises; use uninfected planting material; mound up kumala at four weeks. Spray every two weeks with Diazinon.

Leaf miner - control as with other crops.

DISEASES: Kumala scab - results in twisted, deformed leaves and stems and reduced yield. The disease is most serious during the cool season. Use uninfected planting material; consult Department of Agriculture for plant pathologist's recommendation.

DALO (F) (taro, tannia, dasheen, eddoes)

Dalo is a prized root crop in Fiji, fetches a high market price, and has a certain popularity among all races in Fiji, not only native Fijians. Though certain varieties are wet land cultivars and are cultivated in flooded plots or moving water ways, most dalo cultivated today are dry land varieties on flats and hill slopes. Due to moisture requirements, dalo

is planted largely in the wet and intermediate zones. Though there are five species of Aroids present in Fiji, taro is most commonly cultivated. In the Rewa Delta, the giant swamp taro, via, is commonly grown. A popular leaf vegetable Aroid, dalo ni tana, is grown on farms and gardens in all parts of Fiji.

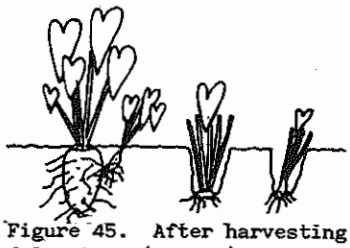


Figure 45. After harvesting dalo, tops (center) or suckers (right) are replanted in holes.

Recommended varieties: Rich soils: "Samoa", "Tausoma ni Samoa", "Samoa Oriori".

Less fertile soils: "Toakula", "Vutikoto".

CULTURE:

1) Dalo is planted using large suckers or tops. Small suckers can be planted in nurseries and later transplanted. Suckers or tops are planted in holes 15 - 20cm. deep made with a large "dibber" stick or spade.

2) Spacing: in rows 60cm. apart, 60cm. between plants or in beds in 45 - 60cm. squares.

3) Fertilise as directed, chapter 3.

4) Apply feeding mixture five, ten, and fifteen weeks after planting.

5) Harvest 8 - 12 months after planting. Taro only stores at room temperature for one to two weeks.

PESTS: Plant hoppers and white fly feed on leaves. Spray with Ambush, Dibrom, or Malathion.

DISEASES: Leaf diseases are common but uneconomical to treat. Dasheen mosaic virus - symptoms are vein-clearing or banding with yellow or white areas. Do not replant suckers or tops from infected plants.

CASSAVA (manihot, tavioka (F), kasera (H)).

Cassava is the most important root crop in Fiji constituting 77% of all root crop production. Tavioka yields the highest number of kilocalories for the labour involved in cultivation compared to all root crops, but is not very nutritious. The most commonly grown variety is "Vulatolu", however, there are several varieties that yield higher, the highest being "Beqa". Research has shown optimum yield occurs at different times for different varieties but is usually 8 - 12 months after planting. Cassava leaves are also eaten as a cooked vegetable green.

Recommended varieties: "Beqa", "Navolau", "Yabia Damu", "Merelesita", "Vulatolu".

CULTURE:

1) Cassava is planted with stem cuttings 20 - 30cm. long inserted two-thirds their length.

2) Spacing: in ridges 1m. apart, one cutting every 60cm.; in mounds 90 - 100cm. apart three cuttings per mound; or in beds in 60 - 80cm. squares, one cutting per spot.

3) Fertiliser is rarely applied to cassava, but it will respond, especially on poor soils. Apply as in chapter 3.

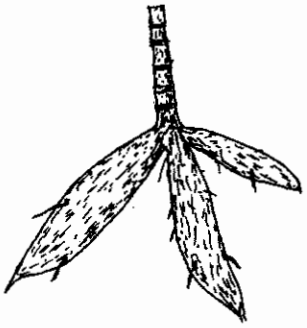


Figure 46. Cassava is a high-yielding root crop. Tubers are the edible portion of the plant.

4. Apply feeding mixture five, ten and fifteen weeks after planting.

5. Harvest 8 - 12 months after planting by pulling from stem.

PESTS and DISEASES: None serious.

YAMS (uvi (F), kawai (F)).

The "smart" island farmer sometimes

travels long distances to find the right spot for his yam plantation. It is said the teitei of the late Ratu Tiale Vuiyasawa was miles from his home near Levuka but was so fertile that it supplied yams year-around for his family. Yams, like all root crops, require a fertile, light, and well-draining soil. There are two cultivated yams in Fiji, "uvi", the true yam, is trellised, and "kawai", the lesser yam, spreads on the ground. Traditional yam culture involves planting on well - prepared mounds and trellising with a reed, later snapped in half, to keep the foliage off the ground. Research in Fiji shows yam yields can be doubled by trellising between posts on wires and reeds. Any trellis used should be strong enough to withstand the weight of the foliage and strong winds. Though yams constitute only 5% of all root crops grown, the demand and market price are quite high. Early season varieties have lower yields but are harvested in late March or early April. Late season yams tends to be higher yielding and are harvested in May or June. Yams are grown from small tubers or tuber pieces of 200 - 250 grams and are generally planted between July and early September. Cut pieces of tubers should be dried and dipped in woodash or a fungicide to prevent rotting.

Recommended varieties: Early season: "Vurai Balavu", "Vurai Dra",;

Late Season: Drv and intermediate zones:"Uvi ni Futuna", "Taniela Vulaleka", "Kivi";

Wet Zone: "Uvi ni Futuna", "Kivi".

CULTURE:

1) Yams are grown from small tubers or tuber pieces of 200 - 250 grams. Spacing: in ridges 1m. apart, one seed piece every 60cm.; in mounds 80 to 1m. apart, one piece per mound, or in beds in 60 - 90cm. squares depending on the trellis used.

2) Fertilise as directed, chapter 3.

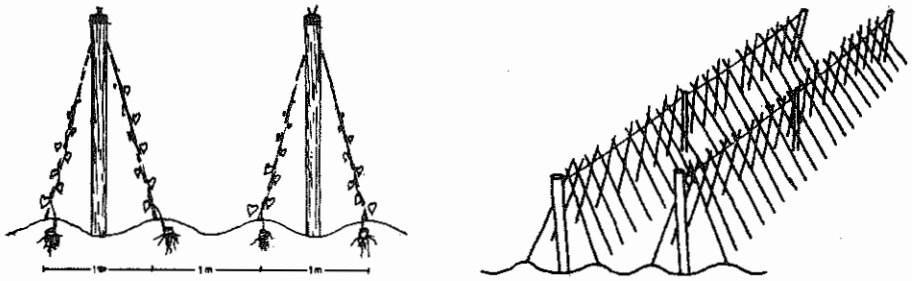


Figure 47. Yams are high-yielding when trellised; an economical method is to plant on ridges and support the crop with bush timbers, wire, and reeds.

3) Trellis to two to three meters on sturdy materials see chapter 3.

4) Apply feeding mixture 10, 14 and 18 weeks after planting.

5) Harvest at times described in above text when vines have dried. Yams should be lifted carefully with a digging fork. Different varieties have different dormancy periods, but generally store three to four months. Shoots should be removed from tubers in storage.

PESTS: Yam leaf spot (Anthracnose) - is serious in the wet zone, defoliating the plant. Plant recommended varieties; avoid "Taniela Vulaleka" in the wet zone.

Dry rot- in the field and in storage, is a problem in some parts of Fiji. The condition is brought on by burrowing nematodes - consult the Agriculture Department for advice.

chapter five

Growing Vegetables Under Plastic

While we may think of Fiji as being an ideal place for plants, the hot and wet summers often make it difficult to grow introduced vegetables. And though we can't change the weather, we can change the plant environment - thanks to the economical use of plastic.

BEATING THE WEATHER

Fiji is a true tropical country in that its rainy season coincides with its hot season. The combination of heat and rain adversely affects the production of vegetables, especially the so-called "European vegetables" selected in cooler, drier temperate areas. The result is a general shortage of vegetables between November and June plus increased imports during this period of the more popular garden crops including tomatoes, cabbage, cauliflower, lettuce, and carrots. While introduction of tropically-adjusted varieties of some vegetables provides an opportunity for off-season production, high rainfall often makes field preparation impossible.

In an attempt to beat the weather, the Department of Agriculture began researching tomato culture under plastic covers in 1978,

The first such structure was an 18 x 12 meter commercial greenhouse with an aluminium frame covered with corrugated fibreglass sheeting, though the walls were removed to prevent overheating. High yields of trellised tomatoes over an extended harvest time, two to three months, demonstrated the efficacy of the project. However, the high cost of the structure, $46 per square meter of growing area, was prohibitive. A second structure, also 18 x 12 meters, was constructed of purc ased timber and covered with horticultural grade (UVI) polyethylene (polythene) film, at a cost of $7 per square meter, the timber representing about two-thirds of the cost. In an effort to further lower costs, two new versions, one of bush timber and the other bamboo, were constructed in 1980, but destroyed a few months later in Cyclone Arthur. The calamity, if nothing else, served to show that plastic covers must be either strong enough to withstand high winds or cheap and easy enough built to be economically dispensable.

The initial attempts to produce off-season tomatoes under plastic stemmed primarily from the need to reduce tomato imports rather than from a feeling that tomatoes were particularly suited due to their popularity as a glasshouse crop in temperate countries. Actually, most, if not all crops, perform better if grown under a translucent cover. The reasons are varied and partially undetermined, however, certain generalizations can be made about the effect of a plastic cover on crops during the tropical wet season:

1) The cover excludes rainfall which compacts soils, leaches nutrients, increases the incidence of soil and leaf diseases, and makes field work difficult.

2) Depending on the type of plastic used, the cover excludes a variety of wavelengths of solar radiation which may result in better growth.

3) Depending on design, the cover reduces wind which has been shown in cases to adversely affect yields (though

reduced air flow may result in heating under the cover and result in even worse yields).

AVOIDING POTENTIAL PROBLEMS

A number of problems have emerged in the design and use of plastic covers. The initial problem, cost, has been countered by the use of film instead of corrugated plastic or fibreglass. Film, however, has some drawbacks, notably durability. Despite inclusion of ultraviolet inhibitors in the polythene formulation[1] the film tends to crack in areas where it contacts wood. This appears to be a result of heat, the dark wood rafters absorbing radiation and becoming hot. The obvious answer is painting the rafters and battens white, which the Agriculture Department has tried. The author has taken a slightly different approach. After the plastic has been secured with the battens, the battens and all plastic touching wood and plastic up to 3 - 4 centimeters from the wood are painted with a white oil-base paint. Both approaches will extend the life of the polythene though neither has been tested over the long run.

A second problem is the availability of UVI grade polythene. To date, UVI grade film has been imported from New Zealand at a high cost due to import and duties. Though polythene is manufactured locally, the firms do not presently stock the inhibitor due to lack of demand. The probable solution lies in local manufacturers stocking the inhibitor, possibly at the request of the Agriculture Department.

A third problem is crop irrigation. Though the primary purpose of the cover is to keep rain out, the crop needs a regular supply of water. Rotary sprinklers can adequately irrigate a crop, however, the foliage is soaked in the process hastening onset of foliar disease. Trickle irrigation systems

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*Ultra-violet radiation degrades plastics including polyethylene. Polythene expected to stand up to solar radiation should be UVI.

are the obvious answer, delivering water directly to the soil surface. With the non-availability of trickle systems in Fiji, an economical solution is yet to be found. Import of mist or drip heads for installation on locally available plastic pipe may be the cheapest approach.

DESIGNING THE COVER

There are two distinct types of structures practical for growing vegetables under plastic. The first, as has been described, is an overhead structure suitable for trellised crops. The second is a low structure, a "cloche" or "dry frame", ideal for use over seedbeds or with low growing vegetables. Both have their advantages and disadvantages. The overhead structure can be used for all crops, however, is necessarily more expensive due to additional wood costs. It is also more susceptible to wind damage due to its high profile. The second structure, suitable only for low-growing crops, is practical in a raised bed-type garden situation. It is, however, quite cheap and if provisions are taken, less susceptible to wind damage.

Three designs for covers are shown on these pages. The first is an inexpensive overhead structure ideal for growing trellised crops or for use as a nursery. The second structure is a cover that rocks up on edge to facilitate crop care. It is the cheapest design and is surprisingly functional. The third is a "grow box" with a sliding cover. This design is more expensive but the box provides better drainage for growing plants and the cover is designed for high wind resistance. Though these structures have proven suitable for off-season production, they are presented here only as examples. There are undoubtedly different designs that may prove to be superior.

CHOOSING THE RIGHT CROPS

The guidelines set down in the previous chapters will enable the

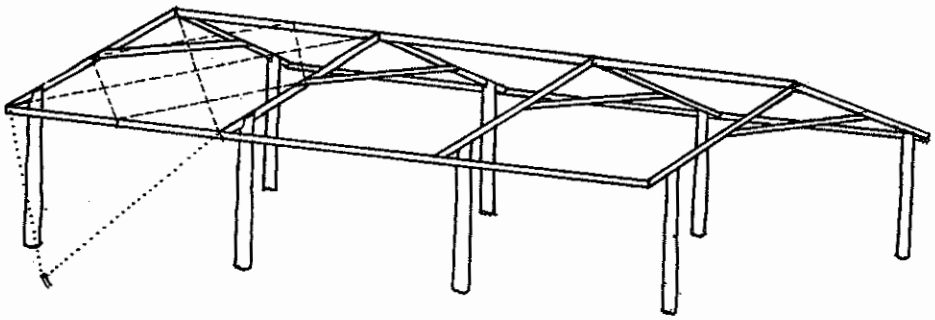


Figure 48. This overhead structure is practical for trellised crops and is inexpensive to construct. The posts are bush timbers and the frame is made from boxing timber (2 x 1's). Before attaching the polythene, a web of binding wire (broken lines, far left) is stretched over the frame. To secure the entire structure, number 10 wire is tied from the frame to stakes (dotted lines).

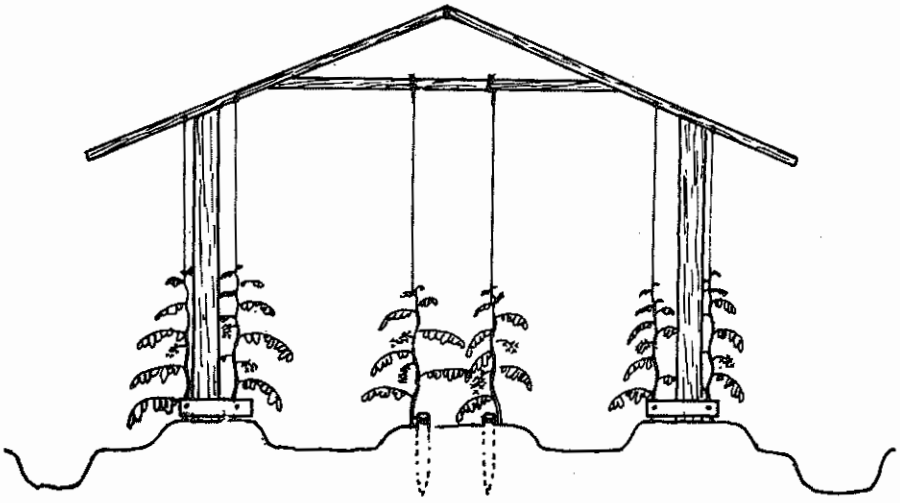


Figure 49. In the double row method of trellising, wires are stretched the length of the structure attached to the cross bars or joists. Other wires extend from end to end near the soil surface attached to the posts, or in the centre rows, to stakes. Strings spaced every 18-20 cm. support the crop, in this case tomatoes planted on ridges.

grower to produce vegetables under plastic as well as in the open. Some additional practises and decisions regarding suitability of crops, however, should be addressed before the project is undertaken.

In trellised production under overhead structures, tomatoes are the most obvious crop. The varieties selected by the Department of Agriculture, "Alton" and "Vuavina", have been shown to perform well, yielding an average of 1.3kgs. of fruit per plant when pruned, with 4000-4500 plants per square chain. Cucumbers would probably be a marginal undertaking considering their relative tolerance of wet season conditions. Rockmelons grow extremely well under a cover and there is always a good market, expecially in urban areas. Pole beans would be a possibility depending on yield with long beans out of the question due to their ready supply in the hot season. The drawing on page 103 shows the double row system of trellising all the above-mentioned crops. The strings are spaced 18 - 20 centimeters in the rows (see chapter 3 for pruning practices).

A wide variety of vegetables can be grown under dry frames in the off-season, many with economic suitability. Heat-tolerant varieties of cauliflower, such as "Snow Queen", form tight curds when protected from rain and direct sunlight. Heat-tolerant cabbage hybrids, such as "K-K Cross" and "K-Y Cross" form good heads under plastic. Lettuce forms large and relatively tight heads with no bitterness. French beans also grow well. Carrots have not been grown though are a likely crop, depending on yield. Local growers found silantro (dhania) and fennugreek (metti) very profitable.

GROWING UNDER PLASTIC

Transplanting in the hot season is a problem due to the intense mid-day sun which wilts seedlings. This problem can be solved under plastic covers by covering the top with either

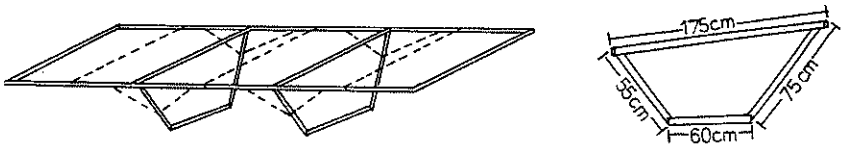


Figure 50. This plastic cover rocks up on either side to facilitate crop care. Its low profile makes it less susceptible to wind damage and in strong winds it can be secured to stakes in the ground.

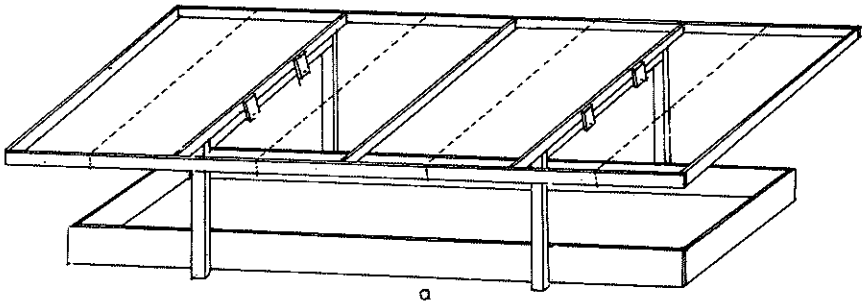


Figure 51. Though slightly more expensive, this design (a) will stand up to strong winds. The bed is enclosed with 6 x 1's and the cover is supported by four 2 x 2's (b). To make planting and subsequent care easier, the cover slides to either side across a fixed 2 x 1 (c). A pin secures the cover.

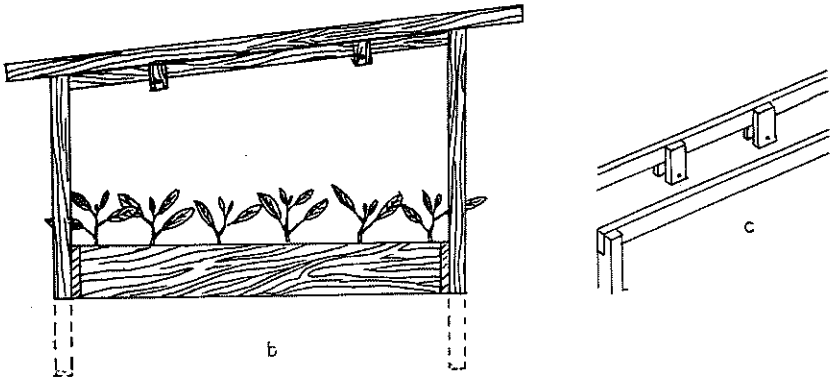
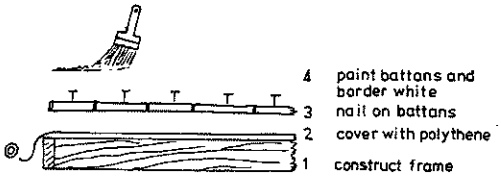


Figure 52. Polythene should be fastened to a frame with battens and clouthead nails. Painting the battens and adjoining plastic white will extend the life of the plastic.



a sheet of plastic painted white, shade cloth, or materials such as onion bags or sugar sacks sown together. When the seedlings are established the shading material can be removed.

Plants grow much faster under plastic and the rate of growth taxes available soil nutrients. Trace mineral deficiencies may manifest that otherwise would not appear if the crop were grown out of cover. The solution is to follow closely the guidelines of chapter 3. This would include liming to prevent molybdenum deficiency, adding Borax to prevent boron deficiency, and spraying foliage with a solution of magnesium sulphate. Using ample organic matter in the form of manures or compost is important. Insect pest control is also a must as the protected crop provides ideal harbourage for cabbage moths and the like.

Seedlings produced under plastic are superior to those grown in the open. In the wet season, seedling production is severely affected by heat and rain, and "damping-off" fungi are only practically controlled by growing under cover. HEALTHY SEEDLINGS LEAD TO SUCCESSFUL CROPS, even when the seedlings are transplanted in the open.

chapter six

Composting and Mulching

For a variety of reasons, it is important to maintain soil organic matter. Many of Fiji's soils are today depleted of the fertility required for market crops, simply because farmers have not returned to the soil as they have taken from it. The chapter discusses methods of returning organic matter to assure high yields and protect soils.

THE FATE OF ORGANIC WASTE

In tropical areas such as Fiji, warm temperatures and high rainfall couple together to produce severe weed problems for agriculturists. Even in the age of chemical weed controls, the most practical and safe solution for controlling weeds in the garden is physical control with knives, hoes, etc. As a result, a large amount of plant waste is generated, cut and gathered for disposal by one means or another.

The fate, then, of organic matter - whether plant debris, kitchen waste, or animal manure - is the topic of this chapter. By one means or another this organic matter is reduced to its simplest inorganic form through different routes, some fast, some relatively slow. The fastest means of reducing organic

matter to inorganic (mineral) form is through "ashing", or burning. Through rapid oxidation (burning) the components of organic molecules are mineralized. A slower method is biological decomposition where micro-organisms aid in decay. Though new organic molecules are produced in the tissue of successive generations of bacteria and fungi, the eventual result is conversion of organic matter to inorganic minerals.

Chapter two discussed the value of organic matter for growing plants and its role in soil conservation. Burning weeds and crop debris maybe a "quick fix" for the next crop, the minerals in the ash being immediately available for utilisation by plants, but in the long run accelerates soil erosion, reduces beneficial soil organisms such as earthworms, and spoils the soil as a medium of plant growth.

METHODS OF WASTE RECYCLING

Conserving organic matter, then, is preferable to burning or disposing of plant wastes away from the garden. There are three commonly used systems for treating or utilizing organic wastes. The first, mulching, involves covering the surface of the root zone with treated or untreated plant or animal waste. The second, anaerobic digestion, is controlled biological decomposition in the absence of oxygen (air) as occurs in submerged systems such as septic tanks or methane (bio-gas) digesters. The third, composting, is controlled biological decomposition in the presence of oxygen.

Each has its good points. Mulching with untreated plant wastes is best for preventing moisture loss from soils since the material is not reduced in form and covers the greatest possible area. Anaerobic digestion can serve duel roles in that the finished "slurry" is an excellent soil amendment and methane gas given off can meet energy needs. Composting is the fastest system, accelerating decomposition and quickly converting organic waste to a form useable by plants.

Figure 53. A mulched soil (right) produces an ideal environment not only for plants, but for other organisms involved in the cycle of organic matter. The unmulched soil (left) dries and cracks in the sun, garden crops suffer, and the level of biological activity is low.

While methane digesters are an important innovation in terms of energy self-sufficiency, their utilisation is beyond the scope of this book. Most Fiji gardeners will find mulching and composting indispensable in producing better vegetables.

MULCHING AND COMPOSTING

The shallow layer of soil from which plant roots scavenge nutrients is a complex ecosystem. Minute bacteria, fungi, microscopic animal forms such as nematodes and rotifers, and familiar insects number in the millions per cubic centimeter of soil. The ebb and flow of their population is determined largely by three factors: temperature, soil moisture, and organic matter available. Temperature is, of course, no problem in Fiji, where it is warm enough year-round to guarantee microbiotic activity. The next variable, moisture, can be limiting when there is no rain for a few days, depending on the moisture holding capacity of the soil. Moisture losses can be modified by mulching while actually improving soil drainage. And mulching simultaneously satisfy the third need of the microbiotic food chain, organic matter.

By looking under a pile of cut grass or dead leaves that has been sitting in one spot for sometime, it is easy to understand the effect of mulching. The zone where the plant wastes touch

the soil is a biologically active layer. Earthworms feed on the decaying waste and tunnel through the soil leaving their castings and aerify the soil. Small insects and undoubtedly less visible life forms thrive on the detritus (dead material) and castings of larger detrivores. Long white strands of fungal mycelia will probably be visible and the sweet decaying smell indicates the richness of the final products.

When applied to a garden soil a thick mulch produces all this. The off-products of this food chain are available at the soil surface for feeder roots of garden vegetables, their naked root hairs protected from the sun by the mulch itself. The zone is moist and the soil aerified, two needs of growing roots.

If, instead of spreading the plant wastes in a thin layer over the garden, organic matter is collected into a pile, the decomposition process can be accelerated. Primary biological activity by bacteria, actinomycetes, and fungi creates heat which, if the pile is large enough, builds up and accelerates the microbial activity[1]. The process then slows when oxygen in the pile is exhausted since these microbes need oxygen. If the pile is turned and air allowed in, most of the heat is retained and with a fresh oxygen supply, activity again begins. This can be repeated until the organic matter is stabilised.

This, in essence, is composting - the controlled bio-decomposition of organic matter. The advantage is that garden wastes, kitchen wastes, and animal manures can quickly be stabilised and returned to the garden in a form useable to plants. The criteria for successful composting are as follows:

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*As the compost heats up, less heat-tolerant micro-organisms die off and are replaced by "thermophyllic" ("heat-loving") species of bacteria, actinomycetes, and fungi which thrive at high temperatures. This in effect sterilises the compost, killing off plant and animal disease pathogens (organisms) intolerant of high temperatures.

1) at least one cubic meter of organic matter

2) a carbon:nitrogen ratio in the pile of about 30:1

3) a moisture content of about 50-60%

4) sufficient oxygen (air)

With the volume and aeration needs in minds, a system has been designed to handle waste generated in a market or home garden. The University of California compost system, designed by Dr. Clarence Golueke, is a series of two or more adajacent bins with lids and removable slats in front to facilitate turning of the pile. One bin always ·ains empty to allow turning of the piles so that three bins can ·handle two composts, five bins four composts, and so on.

The adjoining drawing shows the design. While plywood may prove too expensive, used gosse plates (zinc plated tins) from a newspaper printers have been used as an inexpensive substitute.

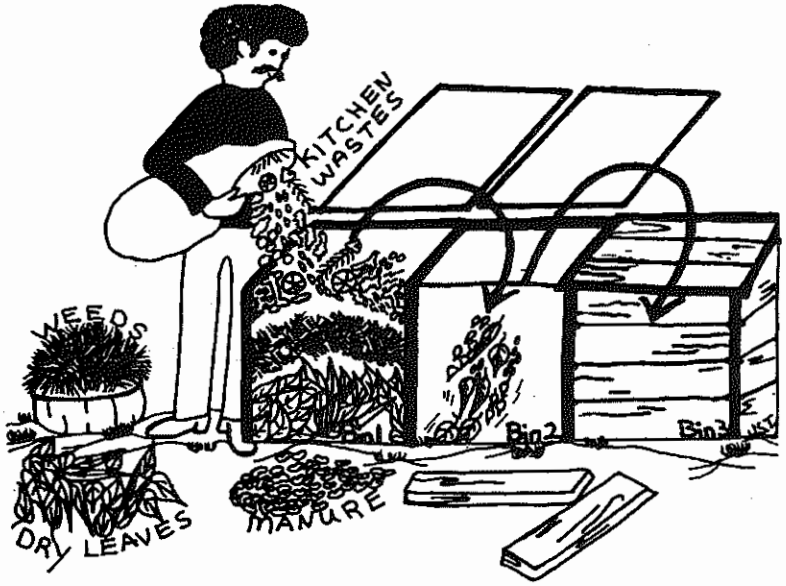


Figure 54. Composting in bins is fast, convenient and eliminates problems with flies and rodents. The lids lift off and slats in the front can be lifted out for ease in turning the compost from box to box. In tropical Fiji, organic matter can be composted in two to four weeks.

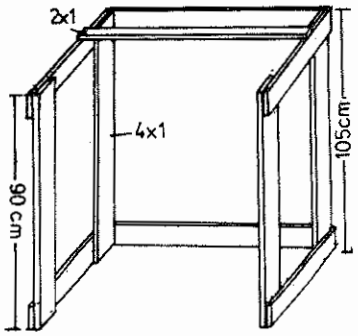


Figure 55. The bin frame is constructed of 4 x 1's. Runners are nailed to the inside of the front uprights to guide removable slats.

All wood portions should be painted with used automotive crankcase oil to extend the lifetime of the boxes. A floor is optional.

Materials to be composted, including weeds, reject produce, vegetable plant wastes, kitchen wastes, and animal wastes, are piled in an empty bin. When the accumulated materials reach the top of the bin, the pile is turned to an adjoining box. A round-tined fork is the best tool for this purpose. It should be evident due to the insulative properties of the pile that the center is actively decomposing. For this reason, the outsides of the pile should be turned to the inside of the next pile to assure a uniformly decomposed product after two to four weeks.

BUILDING A COMPOST PILE

One never knows the exact carbon: nitrogen ratio of a compost. Decomposing microbes, however, need not less than one part nitrogen to thirty parts carbon, so it is important to balance nitrogenous with carbonaceous materials. Some nitrogenous materials are green plant wastes, "hot" manures, and urine. Carbonaceous materials are sawdust, brown leaves, and dried brown grass. The abbreviated list (page 113) shows some C:N ratios for various garden waste materials. As can be seen, the greener the material, the more nitrogen that is contained.

Compost will decompose quickly if nitrogen is in excess, as in a 20:1 or 15:1 mix. Nitrogen, however, is volatized and lost until the ratio reaches 30:1. Volatized nitrogen is evident by the smell of ammonia in the pile. Since nitrogen is usually the primary limiting nutrient in growing any crop, including vegetables, the carbon level should be broughtup by adding

sawdust or another brown material. Experience is the key to composting and after a try or two, a good compost can be built without giving it much thought.

Crop	C:N
Amaranthus	11
lettuce	12
cabbage	12
tomato	12
onion	15
blue grass	19
turnip tops	19
whole carrot	27
oat straw	48
wheat straw	128
rotted sawdust	208
raw sawdust	511

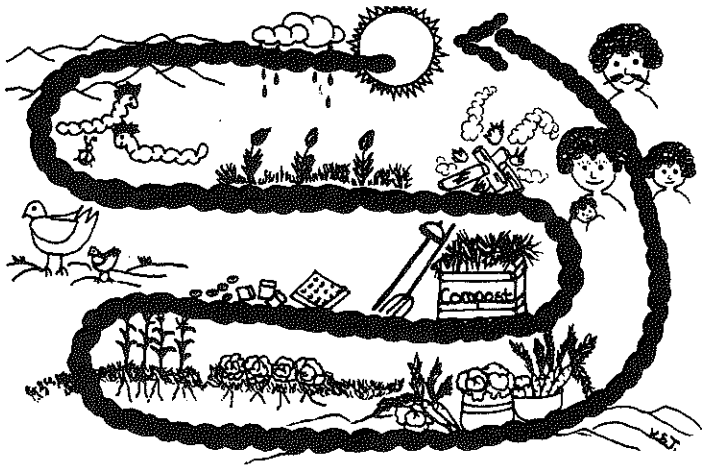
Table 5. Carbon:nitrogen ratio of different organic materials.

Moisture is the other variable and here again experience is the key. If freshly cut green materials make up the bulk of the pile, no water will need to be added to the pile.

If the materials are largely dry, perhaps having laid in the sun for a few days, a light watering will be necessary. A good guide is a compost that feels as moist as a wet towel with the water wrung out - moist, not wet.

Problems in the pile:

Symptoms	Cause		Cure
Not composting	1)	too dry	- add water
	2)	too wet	- add dry material
	3)	not enough nitrogen	- add fresh green material, green manure, urea or sulphate of ammonia, or urine
	4)	not enough oxygen	- turn pile
Smell ofammonia	1)	too much nitrogen	- add sawdust or other brown material
Smell of bile gas (methane)	1)	pile to wet	- add dry material and turn
Ashing (compost turns to ash)	1)	too dry	- add water



Composts can stabilize in 12-21 days depending on the material quality and treatment. Material quality would also include particle size at the onset of composting, the smaller the better. For instance, chopped-up maize stocks break down faster than whole stocks. A compost is usually said to be complete when the pile stops heating when turned. It should look dark and crumbly and the original materials used in the pile should be unrecognizable.

USING COMPOST

Compost is best thought of as a soil conditioner or mulch rather than a fertiliser. When applied to a garden bed there are soluble nutrients in compost that plants can immediately use. Though these are expended rather rapidly, the remaining material can positively affect the soil ecosystem as previously discussed. Compost has also been shown to prevent nitrogen losses by leaching, its cation exchange capacity being high.

Applying compost as a mulch is a sensible approach. If applied in the first weeks after planting or transplanting, soluble nutrients are transported by rain or irrigation water

	Clean-weeded		Mulched	
	No fertiliser	Fertilised since 1953	No fertiliser	Fertilised since 1953
1947–48	1032	---	1127	---
1953–54	200	440	1117	1434
1955–54	186	797	1464	1977
1956–57	124	706	986	1344

Table 4. Affect of mulch and fertiliser on maintenance of soil fertility in Africa. Cotton yields are expressed in kilograms per hectare.[24]

into the area of actively growing roots. The remaining undigested material protects the soil surface from compaction from the force of rain and reduces drying. When the crop is pulled out, the mulch, which further breaks down during the growth of the crop, is easily forked into the top layer of soil.

Finished compost can also be forked directly into the soil at bed preparation or prior to planting. This is particularly helpful if soils are clayey since large additions of organic matter improve the texture and drainage of these soils. In particularly sandy soils compost raises both the moisture holding capacity and cation exchange capacity. With any soil type, the addition of compost improves the workability and productivity of the soil.

Mulch rate (tonnes/ha)	Runoff (%)	Soil loss (tonnes/ha)
0	50.0	4.83
2	19.7	2.48
4	8.0	0.52
6	1.2	0.05

Figure 56. Mulching reduces runoff and erosion (soil loss) in heavy rains.

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23---Ibid, pp. 89-92.

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COMMONLY USED MEASUREMENTS

level measures (grams)

	teaspoon	dessert spoon	small fish tin	large fish tin
				
Borax	3	11	280	—
urea	—	7	180	315
ammonia sulphate	—	9	250	480
superphosphate	—	8	210	390
potash	—	13	345	670
planting mix A (pelleted N-P-K)	—	8	225	415
planting mix B	—	8	215	400
planting mix C	—	9	230	430
feeding mix A	—	8	215	390
feeding mix B	—	9	260	500
lime	—	15	385	740

one ounce = 28.35 grams
one pound = 454 grams
one kilogram = 1000 grams
one tonne (metric ton) = 1000 kilograms

one inch = 2.54 centimeters
one meter = 3.28 feet
one meter = 1.09 yards
one chain = 20.1 meters

one square meter = 10.8 square feet
one square meter = 1.196 square yards
one square chain = 405 square meters
one hectare = 2.47 acres
one acre = 10 square chains

one fluid ounce = 28.4 millilitres
one litre = 1.76 pints
one gallon = 4.55 litres

$^{o}C = 5(^{o}F-32)/9$
$^{o}F = (9\ (^{o}C)/5) + 32$

GLOSSARY

ACID - hydrogen-carrying compound.

ADVENTITIOUS (roots) - roots growing from a plant stem above the soil line.

AEROBIC - in the presence of air.

AGRONOMY - study of the management of the land and the scientific cultivation of crops.

ALLUVIAL (soil) - soil deposited by running water.

ALKALINE - hydroxyl-carrying compound.

ANAEROBIC - in the absence of air.

ARID - dry, lacking water.

BASE - substance which reacts with an acid to form a salt and water only.

BLANCH - to whiten by excluding light.

BIOLOGICAL - referring to living organisms or life processes

BOLT - elongation of the plant stem at flowering.

BROADCAST - to scatter evenly by hand.

BULB - modified leaf-bud emitting roots from base.

BULKING UP (of seeds) - planting of a preferred variety and subsequent saving of seed.

CATION - positively-charged ion.

CHLOROSIS - less than normal chlorophyll resulting in light green, yellow, or white condition.

CLAY - class of complex silicates.

CORM - enlarged underground stem.

COSMETIC - referring to appearance.

COTYLEDONS - primary leaf of plant embryos.

CULTURE - raising of plants for a purpose.

CULTIVATE - 1) to farm the land; 2) to raise a crop.

DAYLENGTH - number of hours from sunrise to sunset.

DEFICIENCY - falling short in some thing.

DETRITUS - dead organic material.

DETRIVORE - organism that feeds on detritus.

DISEASE - disorder of health.

DORMANCY (plant) - state of non-growth.

DROUGHT - long dry spell of weather.

ECOLOGY - study of organisms in relation to their environment.

ECOSYSTEM - self-sufficient system of interactions between different organisms and their environment.

ENVIRONMENT - surroundings; conditions of life and growth.

EROSION - wearing away of a material such as soil, by wind, water, or ice.

FALLOW - uncultivated.

FERTILITY - potential for producing abundantly.

FERTILISER - materials put into the soil to provide compounds of elements essential for plant growth.

FOLIAR - referring to leaves (foliage).

FRIABLE - easily crumbled.

FUMIGANT (soil) - fumes or smoke that disinfect the soil.

FUNGICIDE - chemical fungus destroyer.

GRAFTING - setting the shoot of a plant in the stock of another.

HERB - plant with soft stem; plant of which parts are used for medicine, food, or scent.

HYBRID - offspring of two dissimilar plants or animals.

INFECTION - affect with disease.

INFESTATION - swarm with insects.

INTERNODE - space between two joints or nodes.

ION - electrically_charged ion or group of ions.

IRRIGATE - to supply water to plants.

LARVAE - immature but active insect stage; caterpillar.

LEACH - transportive effect of water moving downward.

MANURE - animal waste or compost used to enrich the land.

MARGINAL (soil) - soil without excess fertility.

MICROBE - minute organism.

MINERAL - inorganic substances.

NECROSIS - death of living tissue.

NODE - joint in a plant stem.

NUTRIENT - something required by an organism for growth.

NUTRITION - promotion of growth.

ORGANIC - referring to compounds created by living organisms; carbon-containing compounds.

ORGANISM - a living animal or plant.

PALATABLE - tasty.

PARASITE - an organism living on or in and getting its food from another living organism.

PATHOGEN - a disease-causing organism.

PERENNIAl(plant) - plant that can live more than one year.

PEST - troublesome or harmful insect or other animal.

PESTICIDE - chemical pest destroyer.

pH - a system indicating the acidity or alkalinity of a solution.

PHOTOSENSITIVE (plant) - plant that depends on daylength to trigger biological changes.

PROGENY - offspring.

PROPAGATION - reproduction.

PRUNE - to cut or otherwise remove unwanted growth.

RADIATION (solar—) - visible energy (light) or invisible energy originating from the sun.

RESEARCH - scientific study to discover facts.

RESISTANCE - ability to withstand pest or disease.

RODENT - gnawing animal; eg. mouse, rat.

ROTATION (crop —) - non-repititious planting of related crops to avoid pest and disease.

RUNOFF - water that is lost by not being absorbed by soil.

SATURATE - to fill to capacity.

SCLEROTIA - firm mass of fungal hyphae resistant to unfavourable conditions and common to certain fungal species.

SEED - reproductive germs or grains of plants.

SEEDLING - young plants.

SELECTION (plant —) - choosing of preferred plants or plant qualities for later seed bulking.

SOLUTE - substance dissolved in water.

SOLUBILITY - ability to dissolve in water.

SOW - in crop production, to scatter or deposit seed.

SPACING - distance between plants at sowing or planting.

SPORE - reproductive unit, or "seed", of a fungus.

STATURE - bodily height.

SUCCULENT - soft-tissued plant or stage of plant growth.

SUSCEPTIBLE - sensitive to pest or disease.

SYMBIOSIS - close relationship between two organisms of different species with mutual or one-sided effects.

TERRACE - level cut out of a hill or slope, often supported by a wall.

TOPOGRAPHY - features, or "lay", of the land.

TRANSPLANT - to plant seedlings.

TRELLIS - structure used to support plants.

TUBER - underground starch - storage organ of a plant.

VARIETY - group of plants within one species referred to by a character or group of characters.

VEGETATIVE - the growing, non-reproductive, parts of plants.

WEED - unwanted plant.

WEEDICIDE - chemical weed destroyer.

YIELD - measurable product of a plant or crop.

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