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Original Research Article

Vermiculture and Vermicomposting: A Boon for Sustainable Agriculture in Fiji Islands

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Abstract

Vermiculture employ earthworms for decomposition of organic waste for production of organic manure. The importance of earthworms is known since time immemorial and it is considered natural plough by the farmers. Earthworms are one of the most important fauna of agro-ecosystems which dominate the biomass of invertebrates in many soils of temperate and tropical regions of the world. The benefits are now globally realized that earthworms can contribute much to the management of different pedo-ecosystems. They are useful in land reclamation, soil improvement and organic waste management in addition to their use as a protein-rich source of animal feed. Earthworms eat and mix large amount of soil or in burrows, depending upon the species concerned. Their casts contain high concentration of organic material, silt, clay and cations such as iron, calcium, magnesium and potassium. Earthworms also release nitrogen in to soil in their casts and urine. Earthworms change the physical characteristics of soil by aerating during rain or irrigation. Earthworms thus enhance incorporation and decomposition of organic matter, increase soil aggregate, improve porosity and water infiltration and increase microbial activity. Vermiculture may be a boon for Fiji which is a small Island nation located in the South Pacific, 3000 km east of Australia and 1930 km south of the equator. It is endowed with excellent climate which is very much suitable for vermicomposting. The land and climate of Fiji are very good for growing horticultural crops such as vegetables and fruits. Fiji farmers use imported chemical fertilizers which is costly resulting farming as an expensive venture. The export market for organically produced crops is increasing worldwide providing excellent opportunity to the farmers to use organic manure produced locally. To meet the farmers' demands of organic manure there is a vast scope of vermiculture. The availability of plenty amount of plant biomass, number of suitable earthworm species and excellent tropical climate are in favour of simple vermiculture technology. The products of vermicomposting such as earthworms, vermicompost and worm meal benefit the farmers by enriching the soil fertility, reducing the use of imported chemical fertilizers and the organically produced crops fetch higher price in the national and international markets. The use of worm meal as a cheap source of poultry, fish and pig feed value the farmers who rely on the costly animal feed mostly imported from foreign countries. This paper deals with various aspects and components of vermiculture technology and suggests measures for successful implementation under Fiji condition.
Keywords: Vermiculture, Vermicomposting, Earthworms, Organic waste, Pedo-ecosystems.

INTRODUCTION

Earthworms are one of the most important fauna of agro-ecosystems and they dominate the biomass of invertebrates in many soils of temperate and tropical regions of the world. The importance of earthworm was realized by Aristotle about 2,350 years ago when he said, "Earthworms are intestines of the earth." During the twentieth century this statement has been verified and found correct. More than hundred years ago, Darwin [1] realized the value of earthworms and he stated that "No other creature has contributed to building of earth as earthworm." The benefits are now globally realized that earthworms can contribute much to the management of different pedo-ecosystems. They are useful in land reclamation, soil improvement and organic waste management in addition to their use as a protein-rich source of animal feed.

The studies made during 20^{th} century on various aspects of earthworm have made it possible to use earthworms at commercial scale to convert organic wastes in an ecologically safe method that leads to an environmentally safe product. The importance of organic farming and sustainable agriculture world over have escalated the implication of vermiculture many folds. Vermiculture and vermicomposting are very narrowly related. Vermiculture is the raising and production of earthworms and their by-products while vermicomposting is the use of earthworms to convert organic waste into fertilizer. Vermiculture is basically the science of breeding and raising earthworms. It defines the thrilling potential for waste reduction, fertilizer production, as well as an assortment of possible uses for the future [2]. The process of composting organic wastes through domesticated earthworms under controlled conditions is called Vermicomposting [3]. Composting with worms avoids the needless disposal of vegetative food wastes and enjoys the benefits of high quality compost. This is a nutrient rich organic substance that can be added to soil to increase its organic matter content and available nutrients. The demand for vermicompost is ever increasing by the organic farmerswhich is to be supplied locally for use in the organic farms in various countries.

Worldwide, organic agriculture is growing rapidly, with international retail sales of over US$ 46 billion in 2007, doubling the 2002 market value [4]. Organics is the fastest growing sector in the global food industry and holds a big potential for agriculture in the Pacific. The Fiji Organic Association (FOA), established in 2006, is a non-profit organization that provides guidance on organic farming practices in Fiji. The number of islands of Fiji such as Taveuni, Cicia etc. has launched a novel business in organic produce that could prove to be a template for other developing communities around the world. Some of these islands declared their farming as chemical free and fully organic and are now producing food that's attracting the interest of foreign buyers. Currently Fiji is exporting organically produced fruit, fruit juices, herbs, spices, noni products, vanilla and virgin coconut oil to Australia, New Zealand, New Caledonia, USA, UK etc. The steadily growing consumer demand for organic commodities provides a viable opportunity for Pacific Island Countries (PICs) farmers and processors to benefit from this expanding international market. However, the development of the organic sector requires selected material inputs for use in farming and specific policy and institutional standards in order to meet international market requirements [5, 6]. Though the PICs traditional farming practices are very much in line with organic agriculture practices as even today many communities still have agriculture systems based on 'age-old' practices which ensure environmental integrity and do not use chemical inputs. But for commercial production of these products for export to overseas markets as 'organic' they must be certified and sufficient in quantity to meet the market demand. One of the very important inputs of organic farming is the organic manure which is required in large quantity for application in the crop fields to achieve higher yield potential of various crops. Vermiculture may be a viable alternative to produce vermicompost in large quantities to meet the demands of organic farmers of Fiji. This paper outlines the Vermiculture for Sustainable Agricultural Development in Fiji Islands.

Location, Size, and Extent of Fiji

The geographical coordinates of the location of Fiji is 18 00 S and 175 00 E. Fiji is a group of islands or an archipelago situated in the South Pacific Ocean about 4,450 km south west of Hawaii, 1,770 km north of New Zealand and 3000 km east of Australia and approximately 1,930 km south of the equator, comprises some 850 islands, of which only about 110 are inhabited (Fig.1). The Fiji archipelago is a part of the Oceanic group of islands. The island of Rotuma, added to Fiji in 1881, is geographically separate from the main archipelago and has an area of 44 km^2. The total area (including Rotuma) is 18,270 km^2. Fiji (not including Rotuma) extends 595 km south east–north west and 454 km north east–south west. The two largest islands are Viti Levu (Great Fiji), with an area of 10,386 km^2, and Vanua Levu (Great land of the people), with 5,535 km^2, and between the two of them make up 87% of Fiji's total landmass. Fiji's total coastline is 1,129 km.

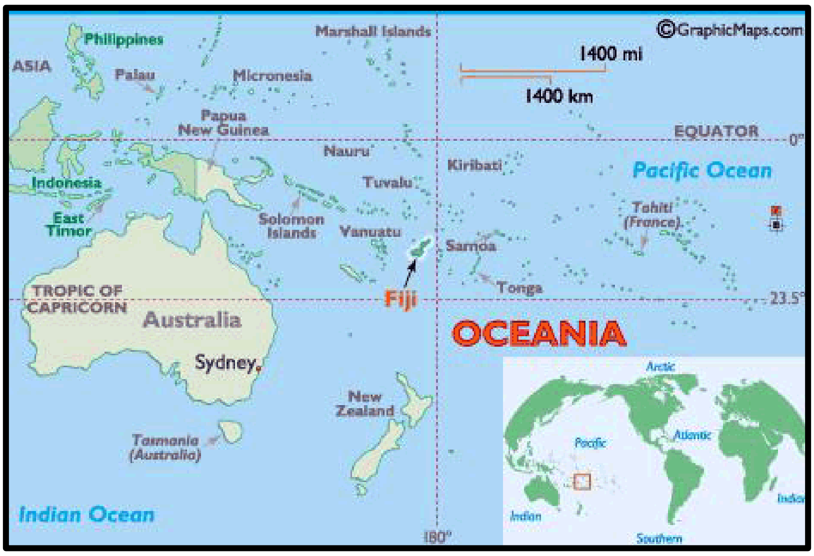


Fig-1: Location of Fiji in Indian Ocean and Oceania. (http://www.mcatoolkit.org/)

Physiography

The physiography of Fiji Islands is illustrated in Fig.1, 2 and 3. The location, latitude, longitude and altitude of Fiji Islandsare explained with the help of colour pattern. The larger islands were formed due to volcanic activity. The comparatively smaller ones are made of coral reefs and thus unsuitable for habitation.There are about 1000 small rivers in Fiji; the largest is Rewa River in Viti Levu which is around 128 km. Mount Tomanivi, located on the main island of Viti Levu, is the highest point at 1,324 m, and the lowest point is the Pacific Ocean (0 m).

These mountainous islands were formed around 150 million years ago through volcanic activity, and are subsequently covered in thick tropical forests. Most of Fiji's mountains are dormant or extinct volcanoes.The mountainous rugged relief of Fiji makes agriculture difficult in Fiji. So the economy depends on the resources from the forest and the surrounding water bodies.Perhaps what Fiji is most famous for, however, are its crystal clear waters, coral reefs and white sand beaches that draw in thousands annually.

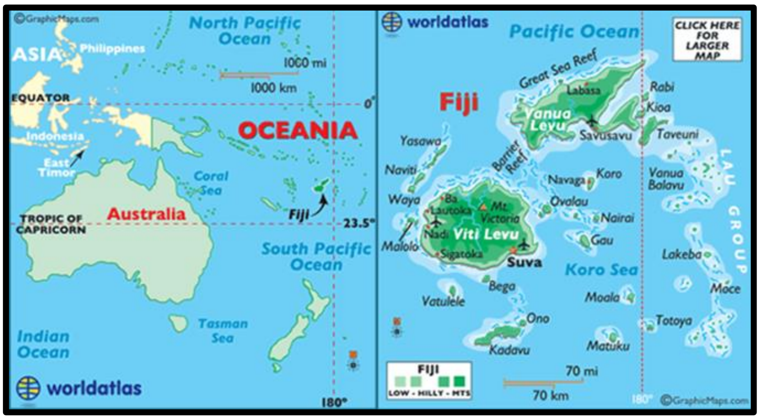


Fig-2: Location of FijiIslands in Oceania and Pacific Ocean showing low, hilly and mountain ranges with the help of colour pattern

Topography

The larger Fiji islands are volcanic, with rugged peaks and flatland where rivers have built deltas. Coral reefs surround the islands. Viti Levu's highest point, Tomanivi, is 1,323 m.About 28 other peaks are over 910 m. The lowest point is at sea level (Pacific Ocean). The main river, the Rewa, is about 150 km long, but only navigable by small boats for 113 km (Fig.3).

Environment

The main challenges to the environment in Fiji are deforestation, soil erosion, and pollution. Approximately 30% of Fiji's forests have been eliminated by commercial interests. The rainfall pattern, the location of agricultural areas, and inadequate agricultural methods contribute to the loss of valuable soils. Fiji is also concerned about rising sea levels attributed to global warming caused by the burning of fossil fuels in the industrial world. The land and water supply are polluted by pesticides and chemicals used in the sugar and fish processing industries. The nation has about 28.76 cu km (6.9 cu mi) of water with roughly 60% used for farming purposes and 20% used for industrial activity.

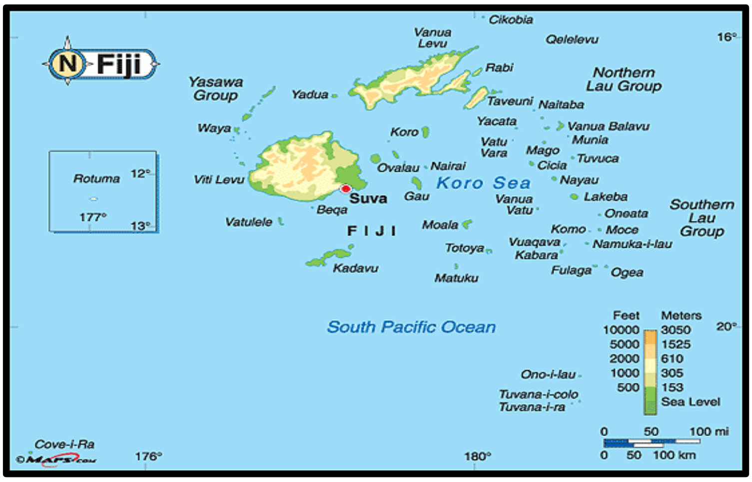


Fig-3: Distribution and topography of Fiji Islands in South Pacific Ocean showing latitude, longitude and altitude with the help of colour pattern

Fiji's natural environment is protected by the National Trust, which under the 1981–85 development plans began to establish national parks to conserve the island's unspoiled landscape, reefs, and waters, as well as indigenous flora and fauna. According to a 2006 report issued by the International Union for Conservation of Nature and Natural Resources (IUCN), threatened species included 5 types of mammals, 13 species of birds, 6 types of reptiles, 1 species of amphibian, 8 species of fish, 2 types of mollusks, and 66 species of plants. Threatened species included the Fiji banded iguana and crested iguana, the Fiji petrel, the insular flying fox, and the Samoan flying fox. The bar-winged rail has become extinct

Climate

Fiji's climate is warm and tropical year-round, even in the islands' "winter" months with gentle trade winds tempering the heat and humidity. It enjoys a tropical climate, with warm dry winters and hot wet summers .Each of the main islands are divided by mountain ranges, and both have a "wet" side to the south and east, and a "dry" side to the north and west. The country has two distinct seasons – a warm wet season from November to April and a cooler dry season from May to October .Fiji seasons are just the opposite of those in the Northern Hemisphere, as spring is Sept-Nov, summer is Dec-Feb, fall is (Mar-May) and winter is (Jun-Aug). The average amount of rainfall, temperature, amount of sunlight, wind speed, and how much frost Fiji gets is illustrated in Fig.4.

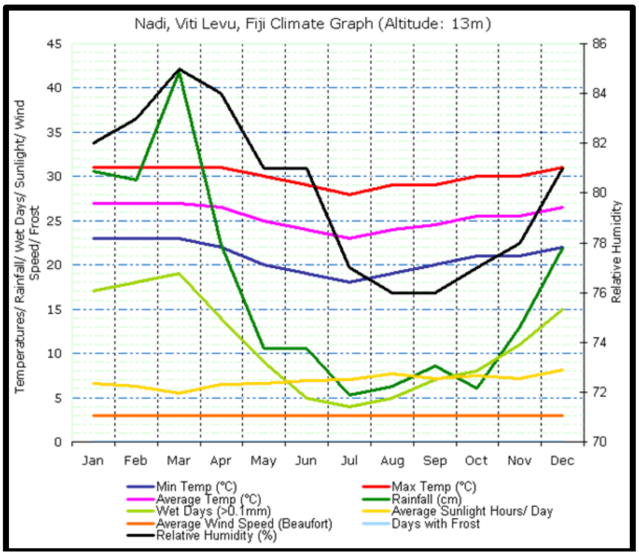
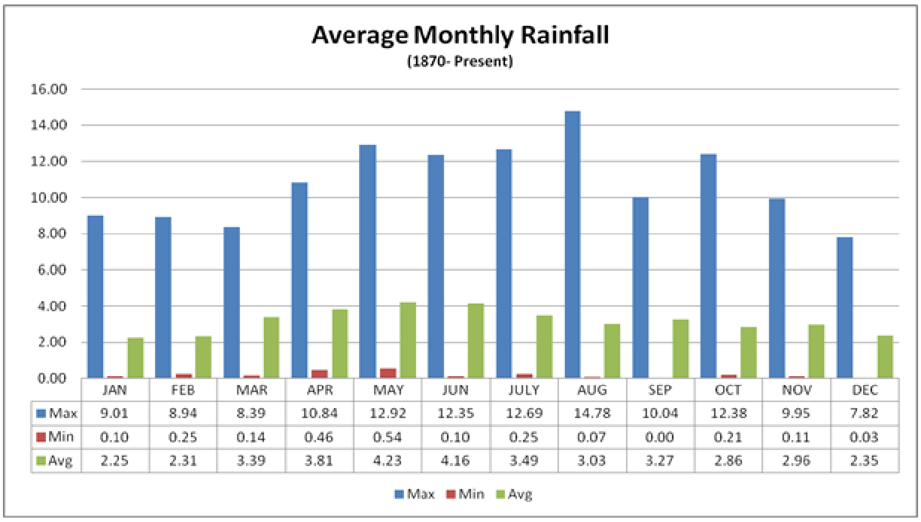


Fig-4: Average monthly meteorological parameters observed at Nadi, Viti Levu, Fiji

Fiji does have a wet season. The rainy season is normally from November to April and results from the southerly movements of the South Pacific Convergence Zone. The wet season is characterized by heavy, brief local showers and contributes most of Fiji's annual rainfall (Fig.5).



	JAN	FEB	MAR	APR	MAY	JUN	JULY	AUG	SEP	OCT	NOV	DEC
Max	9.01	8.94	8.39	10.84	12.92	12.35	12.69	14.78	10.04	12.38	9.95	7.82
Min	0.10	0.25	0.14	0.46	0.54	0.10	0.25	0.07	0.00	0.21	0.11	0.03
Avg	2.25	2.31	3.39	3.81	4.23	4.16	3.49	3.03	3.27	2.86	2.96	2.35

Fig-5: Average monthly rainfall

Fiji receives 2,540 mm of annual rainfall. Annual rainfall on the main islands is between 2000 mm and 3000 mm on the coast and low lying areas, and up to 6000 mm in the mountains. Typically the smaller islands in Fiji receive less rainfall than the main Island with various amounts according to their location and size, ranging from 1500 mm to 3500 mm. Cyclones do occur in Fiji and are normally confined to wet season. Much of Fiji's rainfall is associated with the movement of the South Pacific Convergence Zone which is closest to Fiji in the wet season. This band of heavy rainfall is caused by air rising over warm water where winds converge, resulting in thunderstorm activity. It extends across the South Pacific Ocean from the Solomon Islands to east of the Cook Islands with its southern edge usually lying near Fiji. Rainfall across Fiji can be highly variable. On Fiji's two main islands, Viti Levu and Vanua Levu, rainfall is strongly influenced by high mountain peaks up to 1300 m. On the southeastern slopes of Viti Levu, near Suva, the average annual rainfall is about 3000 mm. In contrast, the lowlands on the western side of Viti Levu, near Nadi, are sheltered by the mountains and have an annual average rainfall of 1800 mm with a well-defined dry season favourable to crops such as sugar cane. Fiji's climate is also influenced by the trade winds, which blow from the east or south-east. The trade winds bring moisture onshore causing heavy showers in the mountain regions. Fiji's climate varies considerably from year to year due to the El Niño Southern Oscillation. This is a natural climate pattern that occurs across the tropical Pacific Ocean and affects weather around the world. There are two extreme phases of the El Niño Southern Oscillation: El Niño and La Niña. There is also a neutral phase. In Suva, El Niño events tend to bring dry seasons that are drier and cooler than normal, while La Niña events usually bring wetter than normal conditions.

The summer month's maximum temperature averages are about 31ºC. The winter month's maximum temperature averages are about 29ºC. In the winter temperatures are still very warm during the day! However, the evening breezes can be cool.Temperatures at sea level range from 20–29°c (68–85°f); easterly trade winds blow during the greater part of the year. Around the coast, the average nighttime temperatures can be as low as 18°C and the average maximum day-time temperatures can be as high as 32°C. In the central parts of the main islands, average nighttime temperatures can be as low as 15ºC. The average temperature in Fiji is 25°C, but it can climb to above 30°C in summer (December and January) and sink to 18°C in winter (July and August). Maximum temperatures in Fiji rarely move out of the 31C to 26C range all year round.A cooling trade wind blows from the east south-east for most of the year. It usually drops to a whisper in the evening and picks up again by mid-morning.

Fijian winter is the dry season from May to October so outside activities are more pleasant attracting more tourists especially in June and July. Southeast trade winds from March to November bring dry weather and the rainy season runs from December to April. Annual rainfall is well distributed and averages 305 cm in Suva. At sea level on the leeward sides of the islands there are well-defined wet and dry seasons, with a mean annual average of 178 cm of rain. The cyclone season, from November to April, brings storms that generally cause extensive property damage and loss of crops as well as numerous deaths. On average there are 15 cyclones per decade, and two to four actually cause severe damage. They occur from November to April and with greatest frequency in January and February. There is more risk in the outlying northwest island groups.

Flora and Fauna

The larger islands have forests on the windward side and grassland on the leeward slopes. Mangroves and coconut plantations fringe the coasts. Among indigenous fauna are bats, rats, snakes, frogs, lizards, and many species of birds. A red and white flowering plant called the tagimaucia is found only on the banks of the Tagimaucia River in the mountains of Taveuni Island.

Origin of Vermiculture Technology

Vermiculture or Vermifarming, as a commercial practice, was first started by Canadian earthworm collectors in 1950s to meet the market demand of fish bait for fishing hobbyists. It was gradually developed and popularized as an industry, and in 1970 it spread to other countries like Mexico, England, U.S.A. and Japan, for their bait markets. Subsequently it gained recognition in South East Asian countries such as Philippines, Indonesia, Honk Kong, Malaysia and Taiwan with the hope of Dollar earnings [3]. Incidentally, worm growers and scientists identified the potentials of earthworms for production of worm meal as a rich source of proteins for animal feed as a supplement to expensive fish meal for animal feed industries. While raising earthworms the worm growers collected large quantities of worm cast or worm excrements. Eventually, they found that earthworms could be cultured on organic wastes, and while doing so, converted large quantities of organic wastes into energy rich resources in the form of worm cast, which they called vermicompost [3]. Now **t**he Vermiculture Technology or Vermin-technology is perfected in several countries suiting to the local conditions.

Modern environmentalists, ecologists and zoologists recommended that earthworms can be used to combat environmental pollution. Earthworms have tremendous ability to compost all biodegradable materials. Wastes subjected to earthworm consumption decompose 2-5 times faster than in conventional composting. The organic wastes are de-odorized, pathogenic microorganisms are destroyed and 40-60 % volume reduction takes place during the process of decomposition.

In U.S.A. and U.K. earthworms are also used as stabilizers of sewage sludge and as water purifiers in trickling filters of sewage plants. They are also used in processing potato and Cassava wastes. In India, where fishing is not a recreational hobby, worm culturing was developed in research institutions under research programs. The technology was developed in the 1980s and was released for the first time from the Directorate of Research, U.A.S., Bangalore, in 1984 for public use and the products of the technology were named V-COMP E.83 UAS for vermicompost and V-MEAL P.83 UAS for worm meal.

This technology depends on the feeding, excreting and breeding potentialities of the worms. Fast growing species of worms are voracious feeders and prolific breeders. They are also surface dwellers, organic matter feeder and surface casters. These worms feed on partially decomposed organic matter. Their digestive tracts act as grinding mills converting the wastes into granular aggregates, which are egested as worm cast. It is estimated that the earthworms feed about 4-5 times their own bodyweight of material daily. Thus one kg of worms decomposes approximately 4-5 kg of organic wastes in 24 hours [3].This technology is suited for Indian farmers and can be promoted as an integrated agricultural technology in Fiji, so that Fijian farmers can use the agricultural, animal and plant waste as resource to produce organic manure for their organic farming which is becoming very popular.

MATERIALS AND METHODS

Selection of earthworm species for Vermiculture

The species of earthworms used in India and other countries and also available in Fiji have the greater possibility of their use for successful vermicomposting. The species of earthworm suitable for vermiculture is listed in Table 1.

Table-1: Species of earthworms suitable for vermiculture

Family	Fiji Islands	India	Other countries
Moniligastridae	*Drawida barwelli* Beddard	*Drawida willsi*	-
Acanthodrilidae	*Amynthas critics* *A. capulatus* A.*esafatae* Beddard *A. gracillis, A. taitensis*	*Octochaetona surensis* (Michaelsen)	-
Glossoscolecidae	*Panoscolexcorethrunus*		
Eudrilidae	-	*Eudrilus eugeniae* Kinberg	*Eudrilus eugeniae* Kinberg
Lumbricidae	-	*Eisenia foetida* (Savigny)	*Eisenia foetida* (Savigny), *Lumbricus rubellus* Hoffmeister, *Dendrobaenarubida* Stop-Bovitz, *Allolobophorasubur Bicunda. chlorotica*
Megascolecidae	*Metaphirehaulleti*, *Perionyx excavates* (Perrier), *Pheretima darnleiensis* Fletcher, *P. Montana*, *P. bicinta, P. godeffroyi*, *P. sedguickisedguicki*, *Polypheretima neglecta* Easton,*P. taprobanae*Easton	*Perionyx excavatus* (Perrier) *Lampito mauritii* Kinberg	*Perionyx excavatus* (Perrier)
Octochaetidae	*Dichogaster affinis* *D. damonis*	*Dichogaster curgensis* Michaelsen	-

Collection of earthworms

The earthworms, *Perionyx excavates* (Perrier), were collected from near the Crop Farm CAFF, FNU, Koronivia. The worms were recovered from the soil by removing the decomposing plant leaves under the tree and the collected earthworms were kept in plastic containers along with soil and carried to the site of vermicomposting for their release in vermicomposting pit.

Composting Materials

The wide varieties of organic materials are recommended for use for composting in India [3]. The following types of wastes are available in Fiji which can be used as food for earthworms to produce vermicompost:

- Leaf litter of easily available plants such as grasses, kudzu also called Japanese arrowroot (group of leguminous plants in the genus *Pueraria*) ,crop weeds, fallen leaves of mango, guava, neem, etc.
- Cattle dung, horse dung, goat and sheep droppings, poultry and duck droppings, etc.
- Agricultural wastes such as sugarcane trash, bagasse, banana stems, decomposing vegetables and fruits, coir pith, etc.
- Waste paper, waste cardboard, saw dust, rags, etc.
- Sewage sludge, breweries sludge and biogas sludge, wastes from fruit and vegetable preservation industries.
- City refuse, after removing non-degradable materials such as rubber, plastic, glass, metals, stones, etc.

Substrate

Among the various animal excreta cow dung is one of best food for earthworms while among the plant based wastes cut grassesand edible leguminous plant kudzuwhich are climbing, coiling, and trailing perennial vines and considered invasive and noxious weeds are easily available in plenty allover Fiji. The kudzu plant climbs over trees or shrubs and grows so rapidly that it kills them by heavy shading (Fig.6). The cow dung and cut grasses or chaffed foliage of kudzu are the good substrate for the earthworms in the ratio 1:1 for Vermiculture.

Fig-6: Kudzu (*Pueraria* spp.)- A leguminous vine weed, its flower and pods

Selection of Site

The suitable place for vermiculture is under the tree shade or inside hut at elevated site which is free from water logging and unexposed to scorching sun light.

Housing

Indoor culturing of worms is recommended to protect the worms from excessive sunlight and rain. They can be raised in abandoned cowsheds, poultry sheds, basements and backyards.

Containers

Earthen pots, cement tanks, plastic trays, plastic tubs and wooden boxes of various sizes can be used for Vermiculture (Fig.7). The depth should be about 30 cm.

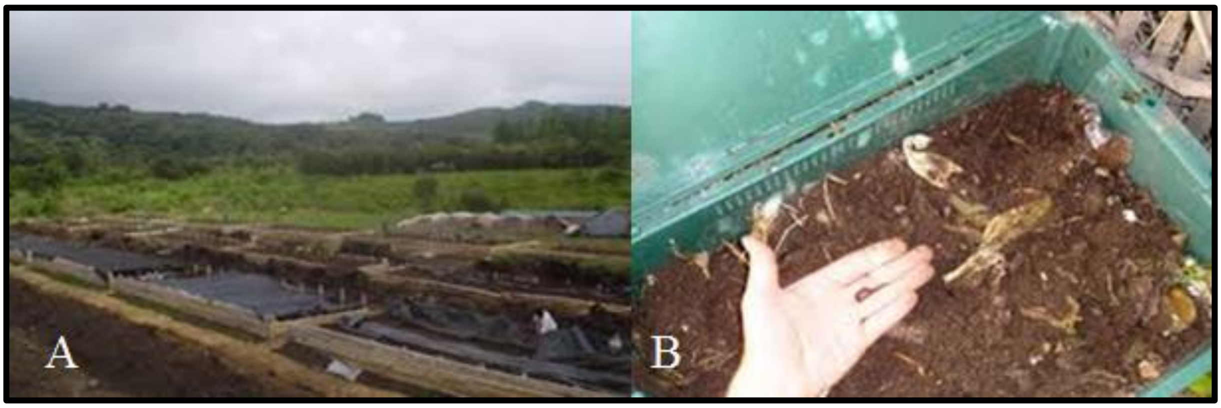


Fig-7: Vermiculture containers: A. Cement tanks for large scale; B. Plastic trays for small scale

Bedding and feeding materials

Organic wastes of animals such as dung, vegetables and agricultural wastes, leaf litter, banana stems, coir pith, rags, kitchen waste, waste paper etc. can be used.

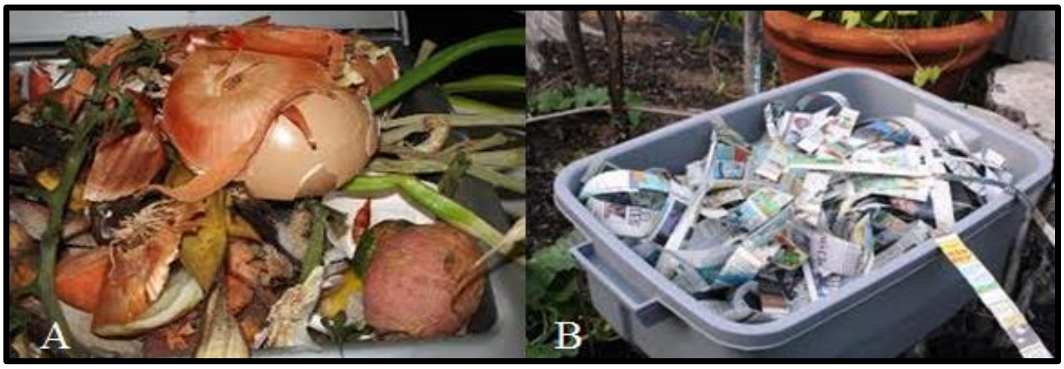


Fig-8: Composting materials: A. Kitchen waste; B. Waste paper

Preparation of Vermi-beds

The vermiculture may be started in small scale in the house for the kitchen garden and also in the earthen pits are cemented tanks of variable sizes according to need and availability of space and substrate. It can be done in plastic trays also inside the house with holes in the bottom of the tray for aeration. The previously built and used cemented or plastic vermiculture beds should be cleaned properly before reuse.

Predigestion of substrate

The earthworms can easily feed and digest soft composting materials. Raw wastes or fresh wastes are not suitable for vermicomposting as earthworms cannot feed on hard food items. Hence predigestion of the raw substrates is essential for the process of composting. All the composting materials are shredded, chaffed or cut into small pieces and properly sprinkled with clean water and thereafter stored in a conical shape covered with thick black polythene sheet for about 2 to 3 weeks based on environmental conditions to ensure partial fermentation to make these soft enough to be fed by earthworms. The predigested partially decomposed substrate serves best food for earthworms.

Substrate Application

The composting materials as substrate are added to the prepared vermi-beds. These materials may be taken as mixture or separately. The care should be taken that no plastic or polythene and iron piece or particle should be mix with the substrates. The earthworms cannot digest the plastic or polythene and the iron will damage their digestive system. A cement tank (1mx1mx0.30 cm) layered with stones for 3cm to let water flow down; overlaid with 500 g of husk to prevent escape of worms followed by 3cm of sand to serve similar purpose and finally covered with the predigested substrate and 2.5 kg of soil mixture. About 1000 ml of water is sprinkled on the surface daily as per the environmental conditions to maintain moisture which is essential for worm growth.

Introducing the earthworms

Sixteen species of earthworm belonging to three families are available in Fiji (Table 1). Among these *Perionyx excavates* (Family: Acanthodrilidae) is a good vermicomposter species which has also been used in India and many other countries successfully. Generally earthworms are introduced 10 days after putting the substrates into the vermi beds. The earthworm is introduced @ 1 kg live weight per 100 kg of substrate in one vermin bed to decompose within two weeks. The earthworms have tendency to move downwards. Aerobic decomposition lasts for 7 – 14 days depending on the materials used and the ratio of the earthworms to the substrate. During this period substrate should be moistened (not soggy) regularly to provide the right moisture for the earthworms to grow and multiply.

Fig-8: Earthworms and their introduction in vermi beds

Process of Vermitechnology

The bedding and feeding materials are mixed, watered and allowed to ferment for about two to three weeks in large cement tanks. During this period the material is overturned three or four times to bring down the temperature of the material and to assist in uniform decomposition. When the material becomes quite soft it is transferred to the culture containers and worms, a few days to a few weeks old, are introduced in to them. A container of 1m x1m x 0.3 m holds about 30 to 40 kg of the bedding and feeding materials. 1000 to 1500 worms are required for processing the material. The material should have 40-50 % moisture, and a pH of 6.8 to 7.5, and may be maintained at 20-30^{0}C. The worms live in the deeper layers of the materials. They actively feed and deposit granular worm cast on the surface of the materials. The worms are allowed to feed on the materials until the entire material is converted into a highly granular mass. Depending on the softness of the material the worms takes about 15-20 days to convert the entire material into vermicompost. The worm takes 7 weeks to reach adulthood. From 8th week onwards they deposit cocoons. A mature worm can produce two cocoons per week, resulting in about 1200-1500 worms per year. The population doubles in about a month's time. Each cocoon produces 3-7 young ones after an incubation period of 5-10 days depending on the species of worms, and environmental condition of the bedding materials.

Recovery of vermicompost and harvesting of worms

The vermicompost is almost ready 45 -60 days after the release of earthworms in the vermin bed. This is evident by its physical appearance as judged by the development of the dark brown coloured loose granular mass with uniformly disintegrated structure (Fig.9. A and B).At this time watering is stopped, after one or two days the compost is removed from the cement tank together with the worms, heaped on a plastic sheet and kept in the shade. This involves separation of worms from the cast manually. For this purpose the contents of the containers are dumped on the ground in the form of a conical mound and allowed to stand for about 12 hours (Fig.9.B). Most of the worms move to the bottom of the mound to avoid light and for shelter. The worms collect at the bottom in the form of a ball. At this stage, the vermicompost is removed to get the worms while the worms are collected for preparation of worm meal. The vermicompost collected is dried, sieved through a 2 mm sieve to separate the compost (Fig.9.C), young ones and the cocoons. The compost is then packaged; cocoons and young ones are used for seeding of new culture beds. The vermicompost recovered is rich in available macronutrients, organic carbon, enzymes and microbes such as actinomycetes and nitrogen fixers, and is used as organic fertilizer. The partially or un-decomposed materials are again used in the second cycle of vermicomposting.

Fig-9: Vermicompost with earthworms, vermicompost mound and sieved vermicompost for packaging

Advantages of Vermiculture and Vermicomposting

Vermiculture and vermicomposting is one of the most valuable ecological endeavors we have engaged in as it caters not only environmental protection but also helped to produce vermicompost to replace chemical fertilizer and a cheap source of animal protein to substitute fish meal. Vermiculture is eco-friendly since earthworms feed on anything that is biodegradable, vermicomposting then partially aids in the garbage disposal problems. No imported inputs required, worms are now locally available and the materials for feeding are abundant in the locality as market wastes, grasses, used papers and farm wastes. It is also highly profitable, both the worms and castings are saleable [7].

Vermicompost does not have any adverse effect on soil, plant and environment. It improves soil aeration and texture thereby reducing soil compaction. It improves water retention capacity of soil because of its high organic matter content. It also promotes better root growth and nutrient absorption and improves nutrient status of soil, both macro-nutrients and micro-nutrients [8].

Precautions for Vermiculture and Vermicomposting

Vermiculturists should also be aware of the several precautions in doing such process to ensure that the project would turn out successful and fruitful. From our hands-on experiences, vermicompost pit should be protected from direct sun light so that the earthworm would survive. Direct heat possibly causes the worms to die. Spray water on the pit as when required to maintain moisture level because vermi worms are fond of it. We should also protect the worms from ant, rat, bird and excessive rain.

CONCLUSIONS

The vermiculture and vermicomposting activity is a worthwhile and exciting venture. The outcome of vermicomposting is concluded as below:

- Vermiculture is a substantial way of reducing wastes, producing fertilizers and maintaining the balance of the ecological environment;
- Vermicomposting can produce high-quality fertilizers which are better compared to other commercial fertilizers in the market;
- Vermiculture converts farm wastes into organic fertilizer, making it an environment-friendly technology;
- Vermiculture increases crop yield and lessens dependence on chemical fertilizers thus mitigating climate change;
- Vermiculture can be made into a livelihood program and become a source of extra income through selling the vermicast and also the earthworms;
- Taking worms out of their natural environment and placing them in the vermi beds creates a human responsibility. They are living creatures with their own unique needs, so it is important to create and maintain a healthy habitat for them to do their work. If the right ingredients are supplied and care is taken, earthworms will thrive and make compost for ecofriendly and sustainable farming.

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