MODULE 3

SUSTAINABLE AGROFORESTRY CROPPING SYSTEMS

CLIMATICALLY, ENVIRONMENTALLY AND ECONOMICALLY SMART FARMING PRACTICES

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1 WHAT ARE SUSTAINABLE CROPPING SYSTEMS THAT ARE CLIMATICALLY, ENVIRONMENTALLY AND ECONOMICALLY 'SMART'

Utilizing nature into the way you farm: working with nature rather than against it

Fig 1: *Managing the Impact of Climate Change on Root Crop Production*[1]

A sustainable cropping system is one that yields sufficient production, at a low enough cost, to provide a worthwhile income for the farming household now and into the future. However, to achieve this objective, you as a farmer, will require more management skills and a willingness to initially devote more time to your farm. Agroforestry cropping systems are about managing your farm as a natural system (ecosystem). By working with nature rather than against it, farms can be managed in ways that avoid damaging the environment and at the same time, support improved productivity and profitability. Working with nature requires incorporating both traditional knowledge, and modern soil and ecological science into the way you farm.

Agroforestry cropping systems improve soil and water quality, reduce erosion and prevent damage due to flooding. Trees provide shelter to crops and reduce damages due to high temperature. Biodiversity is enhanced due to the creation of a diverse habitat where wildlife species can live, which supports pest control and improves pollination. Furthermore, agroforestry systems that involve diverse fruit and nut tree species and root crops, provide income insurance as it is highly unlikely that you would lose all your crops at any one time as the result of a climate-induced event. As a result, you and your future generations will be better able to cope with the impact of climate change and climate variability.

1 PHAMA Plus.2021, Managing the Impact of Climate Change on Root Crop Production and Value Chains: Option Paper. https://phamaplus.com.au/wp-content/uploads/2021/12/Root-Crop-Market-Study-FINAL-v1.0-15-Nov-21.pdf

These diverse food systems also provide opportunities for women to resume a more active role in farm management and for improved household nutrition. Opportunities for value-added agroforestry products to deliver economic benefits were evaluated by ACIAR - market opportunities in the fruit, nut, honey and tree nursery industries were identified[2].

This situation contrasts with the consequences of farmers ignoring the environment when they farm – this was discussed in Module 2, with examples from Fiji's dalo, yaqona, ginger and sugar industries. Due to the adoption of unsustainable cropping practices in these industries, the income earned by these farmers began to fall over a short period of time - with negative consequences for their farming households, the community and for the wider economy .

Prakash's 'food forest' An agroforestry sustainable farming system is beneficial for the farmer and future generations (photo: Moko Productions)

Traditional knowledge incorporates sustainable farming systems as part of an agroforestry system (photo: Andrew McGregor)

Long term,medium term and short term planted together was practiced by our forefathers and is an integral component of a successful agroforestry cropping system (photo Livai Tora)

Introduced vetiver grass planted along the contours to mimimise soil erosion and build up soil fertility (photo: Andrew McGregor)

2 https://www.aciar.gov.au/sites/default/files/2021-11/Final-Report-FST-2014-067_0.pdf

2 PLANTING YAQONA AS PART OF AN AGROFORESTRY CROPPING SYSTEM: THE EXPERIENCE OF THE TUTU RURAL TRAINING CENTRE

Over the last decade, the Tutu Rural Training Centre (TRTC), on Taveuni, has introduced growing yaqona and dalo as part of agroforestry cropping systems. This approach has now become an integral part of TRTC's farmer training program. These cropping systems utilize alley cropping, isolation/ hedge row planting, and mixed intercropping in various combinations. These cropping systems were first introduced on Oceania Farm (TRTC's own farm). They proved highly successful in rejuvenating the soil fertility which had been depleted over the years by over-cropping with insufficient fallow periods. In addition, increasing amounts of chemical fertilizer had been applied in an effort to maintain crop yields – this situation was basically found throughout the Tutu catchment area (on Taveuni and Vanua Levu).

During the TRTC's 'Young Farmers' course participants apply these agroforestry cropping systems both on their blocks at TRTC and back on their home farms. It has been particularly encouraging to see how they have continued these practices after graduating. The graduates have also been working with other young people in their area to adopt similar farming practices, expanding the outreach and impact of the TRTC training program in collaboration with the Fiji Ministry of Agriculture[3]. As a result, participating farmers are producing good quality, high-yielding yaqona and dalo, with less economic risk, without the need to purchase herbicides, and without damaging the environment.

The soils of Taveuni are inherently low in P and K (as they are throughout much of Fiji). These low levels of potash still need to be managed – either through purchased fertilizer inputs or, if possible, making compost tea from seaweed (see Module 6). A sustainable alternative would be to return to a traditional long fallow period of more than five years before replanting yaqona on the same land. However, such long fallow periods are often not feasible now because of the increasing demand for land and its declining availability.

A Young Farmer course graduate's two year yaqona block Nadavaci Natawa Bay Cakaudrove (photo Fr. Isaia)

The new yaqona cropping system adopted by Oceania Farm where scattered trees are kept and only trees with dense canopies that prevent sufficient light entering the cropping system are removed (photo Fr. Isaia)

3 McGregor et al. 2018, A Review of the Tutu Rural Training Centre Courses https://pacificfarmers.com/wp-content/uploads/2019/10/Tutu-Rural-Training-Centre-Courses.pdf

2.1 Planting yaqona as part of an agroforestry cropping system

2.1.1 Yaqona: a traditional crop that offers farmers high returns but with high risks.

Kava is a major traditional crop grown in a number of Pacific Island countries (Fiji, Tonga, Samoa, Federated States of Micronesia (FSM) and Vanuatu). Kava, known as yaqona in Fiji, is Fiji's leading growth agriculture industry with production almost doubling over the last five years to now stand at around 13,000 tonnes of dried product per year [4]. The high market demand for yaqona has been driven by a rapidly growing urban population (around 55 per cent of Fiji's population now live in urban areas), together with an expanding export market. Opportunity exists for farmers to earn substantial income from yaqona, as illustrated in Table 1, which shows the estimated selling value, when harvested, of 6,000 yaqona planted ranging in age from six months to three years in 2019.

Table 1: Value of yaqona crop grown by a TRTC Tutu Young Farmer graduate from Natewa Bay[5]

Stage of growth (years)	Number of plants	Value of a plant sold Nov 2018 (FJD$)	Value of a plant sold at 3 years @ Nov 2018 prices	Total value of the crop sold now (FJD$)	Total value of the crop at 3 years (FJD$)
3	500	200	200	100,000	100,00
2	2,000	100	200	200,000	400,000
1	2,000	50	200	100,000	400,000
0.5	1,500	50	200	75,000	300,000
Total	6,000			475,000	1,200,000
* A 6 month crop can be sold for planting material -estimated it would produce 100 cutting at FJD$0.5/cutting					

As yaqona has to be grown for around three years before harvesting for sale, there is a risk that the amount of yaqona for sale will be considerably less than what you had estimated. Apart from theft, yaqona can be lost due to cyclones, drought, pest and diseases, and declining soil fertility. The adoption of the agroforestry cropping systems, described below, substantially reduces these risks – risks, which are likely to be accentuated into the future by the impact of climate change, in particular, extreme events.

2.1.2 The benefits from planting your yaqona as part of an agroforestry system: maintaining good crop yields and minimizing risks

A well-designed and efficiently implemented agroforestry cropping system will enable you to maintain your crop yields, reduce risk and, over time, reduce costs. This approach also means that you will be able to maintain, and even increase, the income earned into the future.

This is achieved through a combination of reasons

- Soil fertility is maintained and the need for chemical fertilizer reduced.
- Soil moisture and stabilization are maintained throughout the cropping and fallow period
- Weeding needs and costs are greatly reduced
- Risk and impact of kava dieback is greatly reduced
- Risk of losing your crop to natural disaster is greatly reduced
- Income and food security risk is reduced by the wider range of crops being produced

4 MoA, 2020 Key Statistics on the Fiji Agricultural Sector Report https://www.agriculture.gov.fj/documents/stats/2020KEYSTATISTICS.pdf

5 McGregor et al. 2019 A Review of the Tutu Rural Training Centre Courses. https://pacificfarmers.com/wp-content/uploads/2019/10/ Tutu-Rural-Training-Centre-Courses.pdf

These various reasons are elaborated on below:

Soil fertility is maintained and the need for chemical fertilizer reduced

Both yaqona and dalo extract large amounts of nutrients from the soil. These nutrients need to be replaced to maintain crop yields and thus the income you earn. Research, undertaken by the MoA's Dr Rohit Lal on Taveuni, found that one hectare of yaqona over three years extracted approximately: 40 kg of nitrogen (N); 20 kg of phosphorus (P), and 100 kg of potassium (K) from the soil[6]. Further, soils of Taveuni are inherently low in P and K (as they are throughout much of Fiji). High yields were only possible on Taveuni due to the high organic content of the soils, which has to be replaced if yields are to be maintained. Furthermore, the soil had become more acidic due to the cropping practices adopted. Increasing acidity reduces the availability of nutrients in the soil, including the nutrients added through incorporating fertilizer; the addition of agricultural lime can improve availability through decreasing the acidity.

However, when yaqona is planted as part of a well-designed agroforestry system, soil fertility is maintained for a longer period due to natural mulching from the plants in the system and the increase in soil organisms, such as earthworms. The natural compost resulting from the breakdown of plant material in the system enhances soil fertility. Further gains can be made by the planting of mucuna bean, as a green manure cover crop, which fixes N from the atmosphere. The addition of some mineral P and K will be necessary (because of the inherently low levels) and soil testing would help to determine the appropriate amount of P and K to apply. The addition of P and K can be avoided but only if you are able to return to long traditional fallow periods of more than five years.

Earth worms thriving in soil that was planted with mucuna with a green manure cover crop (photo Dr. Rohit Lal)

Dalo thriving in slashed green manure cover crop (photo Dr. Rohit Lal)

Soil moisture is maintained throughout the cropping and fallow period

The presence of shade cover in agroforestry systems, through incorporating trees and green manure cover crops reduces overall soil evaporation and transpiration from the crops, therefore creating a beneficial microclimate that maintains soil moisture – both while your root and vegetable crops are growing and during the fallow (rest) period, when soil fertility is being further restored.

6 Lal, 2018 Introducing Sustainable Commercial Farming Systems at Tutu and its catchment area. page126. A Review of the Tutu Rural Training Centre Course 2018. https://pacificfarmers.com/wp-content/uploads/2019/10/ Tutu-Rural-Training- Centre-Courses.pdf

Weeding needs and costs are greatly reduced

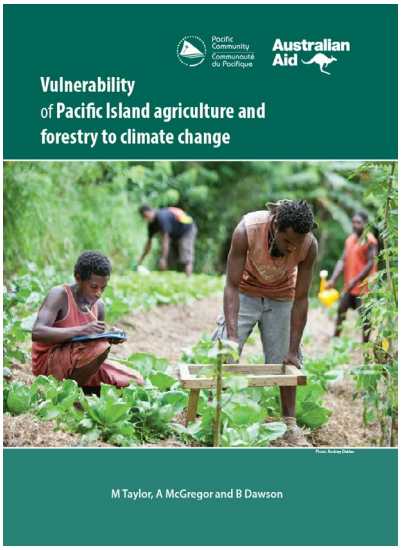
The need for weeding is substantially reduced in an agroforestry system because of the shade from the trees in the system and the planting of appropriate green manure cover crops, notably mucuna beans. Section 4 of this Module provides guidance on how to use mucuna beans as a green manure cover crop.

The risk and impact of kava dieback greatly reduced

As discussed in Module 2 the biggest disease threat to yaqona is kava dieback, caused by CMV. An outbreak of dieback can completely destroy an infected block of yaqona, which is devastating for you as a farmer – especially when you have forecasted a high return from your yaqona crop and end up with nothing. However, the good news is that an agroforestry cropping system provides a barrier (a 'mask') to stop the virus reaching your yaqona plants. The aphids carrying the virus will land on the barrier trees in the agroforestry system to feed. In doing so the aphids will lose at least some of the virus from their mouths and will cause far less damage should they still happen to reach a yaqona plant or other plants impacted by CMV. Andrew McGregor discusses in Fiji TV Green Pillars presentation here the devastating effects of kava die-back and what can be done to minimize the risk and the impact

Fig 2. *The right way to crop kava*[7]

Overall, it is expected that climate change will change pest and disease dynamics with potentially negative impacts on Pacific Island agriculture; agroforestry cropping systems offer a way to adapt to this situation[8]



Risk of losing your crop to natural disaster greatly reduced

The best time to harvest yaqona in terms of expected yield is after at least three years – this compares with dalo which is only eight to nine months. Thus, the risk of losing your crop, or at least some of it, due to a cyclone or a prolonged drought, is much higher for yaqona. As discussed in Module 1 the projected impacts of climate change include more extreme events, such as cyclones and droughts. Trees in an agroforestry system provide some protection against this risk.

7 PIFON/CTA, 2019, Agricultural Value Chain Guide to the Pacific Islands https://pafpnet.spc.int/attachments/article/504/Agricultural%20Value%20Chain%20Guide%20for%20the%20Pacific%20Islands.pdf

8 Taylor et al. 2016 Agriculture and climate change: an overview. In: Vulnerability of Pacific Island agriculture and forestry to climate change Taylor et al (Eds) https://www.sprep.org/attachments/VirLib/Regional/vulnerability-pacific-island-agriculture-forestry-climate-change.pdf

2.1.3 The trees you can plant in your agroforestry cropping system

The traditional tree species shown to be successful at Tutu and throughout the Pacific Islands region are:

- *Glyricidia Sepium (*Bai ni cagi*)*
- *Caliandra*
- *Erythrina (*Drala*)*
- *Leucana (*Vaivai ni valagi*)*

Yaqona being planted between alleys of Bai ni cagi with vanilla planted on the Bai ni cagi in this alley cropping system (photo: Andrew McGregor)

Drala (photo: Lex Thomson)

Calliandra.(photo Lex Thomson)

Vaivai ni valagi (Leucana) (photo Lex Thomson)

What benefits do these trees bring to your farm?

They are:

- Easy to propagate
- Fix N and produce high biomass which will improve soil fertility
- Restore the fertility of the soil when planted on degraded soil
- Grow rapidly, which enables them to quickly regenerate the soil
- Conserve soil moisture because they are deep rooting, which draws water and nutrients from below the top soil

Pruning the trees in your agroforestry system

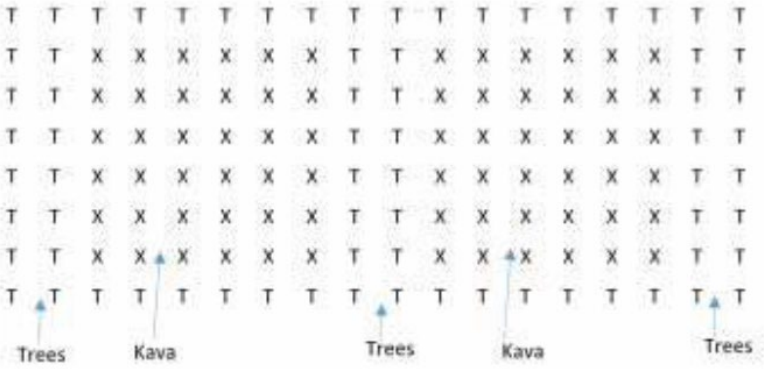
It is important that the trees in your system are pruned regularly to avoid excessive overgrowth – which will crowd out your yaqona and other income earning crops. Pruning and leaving the branches on the ground enhances the nitrogen fixing and nutrient enhancing contribution of these trees.

Overgrown Calliandra at TRTC - these trees need to be pruned fairly regularly (photo: Rohit Lal)

2.1.4 The different types of agroforestry systems that you can use depending on your situation

Alley cropping: an appropriate system where cleared land that was previously farmed is to be replanted

Alley cropping is defined as the planting of rows of nitrogen fixing trees between the crops you are growing. Alley cropping is a particularly good system for growing vegetable crops, root crops and yaqona. Trees such as *Calliandra, Glyricidia,* or *Leucaena* should be planted at a spacing of 2 m x 4 m in distinct rows as shown below. Approximately two to four months later, when they have formed a canopy, yaqona can be planted in between the trees at a spacing of 1.5 m x 1.5 m. After a year of growth, the trees are pruned back to allow for more sunlight to reach the now well-established yaqona plants. Chopped leaves and branches should be placed to provide mulch around the yaqona plants for weed suppression and moisture conservation.



Isolation/hedge row planting an appropriate system when new land is being cleared for planting

Soil must be fertile with high organic matter and well drained when selecting new sites to plant yaqona. New land clearing should be well planned as shown below. Your plantation should be divided into approximately 1 acre plots where the trees along the edges should be maintained. These trees will form permanent boundaries and should be maintained throughout the farming cycle.

Planting of root crops between alleys of Gliricidia (Bai ni cagi) photo Vincent Lebot)

Yaqona planting protected from pest and diseases by hedge row of trees (Fr. Isaia)

They will act as barriers against strong winds and will prevent disease, such as kava dieback, from moving from one plantation to another. Trees inside the plot should only be chopped if the conditions are too shady. However, after yaqona is harvested, agroforestry trees should be planted to replace the chopped trees. Trees on the edges of the farm should be maintained as permanent boarders

Mixed inter cropping

If you are clearing forest areas for the new planting of yaqona some of the taller native trees with smaller canopies should be retained. To these could be added nitrogen fixing agroforestry trees (such as Calliandra, Leucaena and Glyricidia) together with fruit trees (such banana, citrus and mango) and timber trees (such as sandalwood (yasi) and flueggea (pou)). Most of these trees are maintained throughout the entire yaqona production cycle and are retained during the fallow period before yaqona is planted again. Such mixed cropping systems maintain soil fertility, increase crop diversity and reduce the incidence of kava dieback. This cropping system, based on traditional knowledge, will be the one you will utilize in adopting a **'going back to the future'** approach. For more detailed guidance on the implementation of agroforestry see Agroforestry Guidelines for the Pacific islands https://agroforestry.org/free-publications/agroforestry-guides

Father Isaia Wairairoga demonstrates agroforestry practices currently in use at Tutu in his Fiji TV "Green Pillars" presentation here

Further discussion by Nicholas about his agroforestry farming system in a Fiji TV Green Pillars presentation here, here and here.

TRTC Young Farmer graduate with his high yielding yaqona crop grown as part of an agroforestry system (photo: Fr. Isaia)

3 A 'FOOD FOREST' IN THE MIDDLE OF DEGRADED SUGAR CANE LAND: A DEMONSTRATION FOR FARMERS THROUGHOUT WESTERN VITI LEVU

Creating a 'food forest' is essentially an effort to model the diversity of a natural forest where a variety of plants grow together as an ecosystem. The focus is on producing food for sustainable food and income generation. By modelling this concept on your land, plants grouped together complement each other, taking advantage of niches and microclimates, resulting in increased biodiversity and ensuring healthy soil and plants.

In the middle of degraded sugar cane land outside Lautoka, a farmer, Prakash, has defied the expectations of surrounding farmers and transformed typical low productivity sugar cane land into a productive and remunerative 'food forest'. For an aerial view of Prakash's 'food forest' by Moko Productions here

Prakash's breadfruit orchard intercropped with pineapples (photo Moko Productions)

The lessons learnt and strategies adopted show how a skilled and committed farmer, with the right information, can successfully make the necessary changes for the benefit for their family and future generations

Nearby degraded and now obsolete farming land (photo Moko Productions)

3.1 Background to Prakash's 'food forest'

Shania Singh of Fiji TV's Green Pillars introduces Prakash here

Prakash farmed sugar cane most of his life on land that he inherited from his father. After years of toiling to make ends meet, he ventured into a successful nursery business. The business produced vegetable seedlings, fruit tree seedlings, spices and herbs. Prakash then started planting out surplus trees from the nursery onto his farm which was eventually converted into a 'food forest'. To do this he received technical advice from the Australian Centre for International Agricultural Research (ACIAR)'s Pacific Breadfruit Project that was implemented by Nature's Way Cooperative (NWC) [9]. His food forest has been built around establishing a breadfruit orchard utilizing both alley cropping and intercropping. Supplementary irrigation, mulching and composting was also used.

Prakash with a marcotted breadfruit (photo Moko Productions)

Vegetables intercropped with fruit trees (photo Moko Productions)

9 Harrison and Karim (Eds). 2016. Promoting sustainable agriculture and agroforestry to replace unproductive land use in Fiji and Vanuatu. Australian Centre for International Agricultural Research : https://www.aciar.gov.au/publication/books-and-manuals/promoting-sustainable-agriculture-and-agroforestry-replace-unproductive-land-use-fiji

3.2 What has been planted, how and at what cost?

The first step for Prakash was to invest in a commercial breadfruit orchard (50 trees) which set the basis for his 'food forest'. The 'bale kana' breadfruit variety planting material was supplied by NWC´s Pacific Breadfruit Project. Once these trees were established along the periphery of the property, he began to replace much of his sugar cane farm with a 'food forest'. This involved establishing alleys of breadfruit trees and other assorted fruit trees and long-term native trees, intercropped with root crops, vegetables (eggplant, beans, chillies etc.) and pineapples. All of these nutritious food crops are in high demand on local markets and are consumed by the farm household.

By using the standard spacing of 9 m x 9 m between the trees Prakash had space for his medium- and short-term crop seedlings which he sourced from his nursery. The main capital cost has been an investment in supplementary irrigation (which is an essential requirement in this dry area). The start-up cost of this irrigation system was around FJD 5,000.

In a Fiji TV "Green Pillars" video Livai Tora talks about the benefits that Prakash has acquired from having a food forest as opposed to when he was sugar cane farmer. He goes on to discuss here how Prakash and his son provide sufficient labour to efficiently operate the farm.

3.2.1 The benefits from Prakash's investment in a 'food forest'

For Prakash and his family

Prakash identified the benefits from converting his low yield sugar cane farm into a food forest to be :

- **Financial stability throughout the year**. The regular income derived from farm sales was sufficient to meet the daily financial needs of the family
- **Food security for the family** even during off season. This means no shortage of fresh fruit and vegetables on the table for daily consumption
- **Less stressed lifestyle.** This contrast with sugar cane farming which is stressful especially during harvesting season when the there was always a labour shortage. Now, he and his son provide sufficient labour for the farm year-round
- **Spreading the risk of crop loss** during natural disasters. He now has a wide range of crops that are fruiting and being harvested at different times of the year.
- **Long term sustainability and productivity for their soil.** This will be passed to the next generation farming the land.

For the wider community in the cane belt and elsewhere

- **A demonstration farm** for surrounding sugar sugarcane farmers wanting to diversify into a more remunerative sustainable crop production system than monoculture sugar cane.
- **A breakaway from the prevailing mono cropping production system** to a much more sustainable and climate resilient approach that is economically viable.

For the environment and climate change adaption

- **Less damage from tillage in land preparation** by using mulch, compost, and shredded debri**s**
- **Establishment of a microclimate suitable for viable vegetable production** which was not available with monoculture sugar cane production
- **The different tree crop combinations compliment and supplement each other for nutritious food** production now and into future
- **Shade trees which have encouraged more bird life activity** helping to minimize damaging pests
- **The reintroduction of vetiver grass ('going back to future')** which has helped to minimize soil erosion and restore soil fertility in an area where the soil has been badly degraded due to the previously adopted sugar cane production system.
- **A cropping system that will enable farmers to better adapt to climate change.** With climate change, the weather pattern for any one season cannot be accurately predicted - one year could be very dry and the next, very wet, and so on. Therefore you can't just grow one crop, one variety - a mix of crops and varieties is needed to reduce the risk of losses from climate variability. It is this 'no regrets' approach that Prakash has adopted, with his 'food forest', which will be an insurance against the climate-induced risks in the future.

4 PLANTING GREEN MANURE COVER CROPS – MUCUNA BEAN CROPPING SYSTEMS FOR SUSTAINABLE DALO AND YAQONA PRODUCTION ON TAVEUNI

4.1 What are green manure cover crops?

Green manure is a crop that is mixed into the soil to improve the health of the soil and the nutritional contribution it provides for the crops. A green manure crop can also help to retain moisture, suppress weeds and slow the spread of pests and diseases. One such green manure cover crop is mucuna beans *(Mucuna pruriens)*. This tropical legume is native to Africa and tropical Asia and was first introduced into Fiji by the Colonial Sugar Refinery (CSR) in the 1950s. The sugar industry extension service, at the time, required contracted cane farmers to leave their land fallow after a limited number of ratoons. This fallow land would often be planted with mucuna bean before replanting again with cane. Unfortunately, the practice has long since been abandoned by Fiji's farmers and replaced by exceptionally long ratoon cycles – often extending beyond a decade and thus yields steadily fell.

Vegetables planted in slashed mucuna beans at the Tutu Rural Training Centre (photo Fr. Isaia)

4.2 Declining commercial crop yields on Taveuni: the dalo export boom

As discussed in Module 2 (2.1) Taveuni experienced a boom in dalo exports to New Zealand for more than a decade, commencing in the mid-1990s. During this period, considerable areas of land were cleared to plant dalo as a monocrop – departing from the traditional shifting cultivation system involving extended fallow periods. Initially high yields were obtainable because of the high organic matter content in Taveuni soils (as a result of the traditional cropping system previously practiced). As organic matter was depleted yields began to fall and farmers found they had to increase their usage of chemical fertilizer in an effort to try and maintain yields.

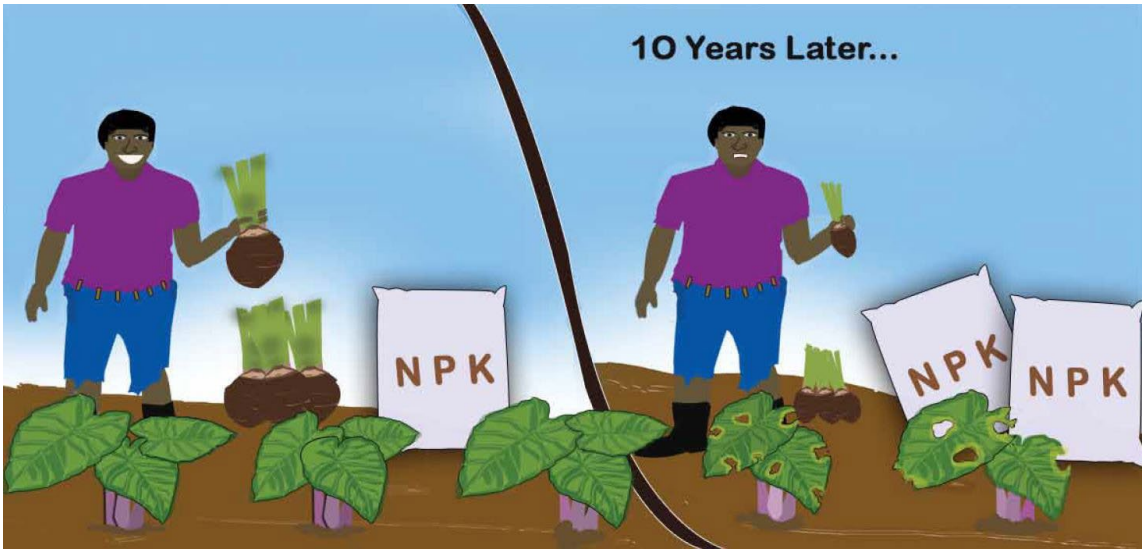


Fig 3: *The situation in Taveuni after 10 years monoculture dalo production*[10]

4.3 'Going back to the future' and introducing mucuna bean cropping systems for dalo and yaqona production on Taveuni.

Traditionally farmers maintained the organic matter in their soil, and thus their crop yields, though a combination of shifting cultivation and prolonged fallow periods. Today, with increasing population, the demand for land and the more immediate need for cash income, shifting cultivation and prolonged fallow periods are no longer viable and acceptable for many farmers. Much can be learned from traditional cropping systems which can be successfully applied by farmers today, particularly as they can help to mitigate the challenges of climate change – the agroforestry cropping systems presented above provide good examples of the systems available for farmers to use.

The use of green cover crops is another important example of the benefits of traditional cropping practices. Fast-growing leguminous cover crops, such as mucuna beans, can make a significant contribution to achieving sustainability without the need for shifting cultivation and prolonged fallow periods. This benefit was demonstrated in the past by Fiji sugar farmers and is now being adopted by root crop farmers on Taveuni and through the TRTC outreach program. Supported by the Ministry of Agriculture, this outreach program, is starting to be extended to farmers on Vanua Levu [11].

Dr Rohit Lal has been working with TRTC to sustainably address the problem of declining dalo and yaqona yields through a 'going back to the future' and working with nature approach, which has largely involved introducing a mucuna bean green manure cropping system. The mucuna bean cropping system is mainly being introduced in areas that had been previously cleared and over-cropped. Mucuna beans, where possible, have also been integrated into alley cropping systems where dalo and yaqona are planted between rows of appropriate agroforestry trees.

10 McGregor and Stice, 2014, Agricultural Value Chain Guide for Pacific Islands CTA, SPC, and KSP

11 https://www.fiji.gov.fj/Media-Centre/News/MUCUNA-BEANS-LAUNCHED-IN-NADOGO

Dalo thriving growing with mucuna bean ground cover (photo Rohit Lal)

Earth worms thriving in a fallow field that had been planted with mucuna beans (photo Rohit Lal)

Dalo planted with a mucuna bean cover crop ready for harvesting (photo Andrew McGregor)

Premium quality dalo harvested from a mucuna bean cropping system ready for sale (photo Andrew McGregor)

Increasing numbers of farmers on Taveuni are now integrating mucuna beans into their crop rotations. The sustainable increase in income which they have been able to achieve has been of considerable benefit to their families, the wider community and Taveuni's environment.

Planting mucuna bean on fallow land has been shown to produce high amounts of organic matter (biomass) as well as fixing large quantities of nitrogen (N) in the soil over six to twelve months [12]. The TRTC Young Farmers, assisting Dr Rohit Lal, dug the top 30 cm x 30 cm soil on fallow blocks with and without mucuna bean green manure and counted the number of earthworms. The large increase in earthworms is an indication of how soil organic matter had been restored by the introduction of the mucuna bean cropping system. Research carried out by ACIAR found that mucuna beans used as a fallow and cover crop has the potential to reduce nematode numbers in the soil [13].

Another major benefit of planting mucuna bean on your fallow land before planting your dalo or yaqona is weed control. A traditional fallow plot will be heavily covered in grass and weeds that would require considerable weeding (either manually or in recent times with weedicides) prior to planting and during the early growth phase. In contrast, the ground cover provided by mucuna beans is very effective in controlling weeds – particularly if mucuna beans are cut prior to planting the dalo[14] or yaqona. The substantial reduction in the need for weeding means a large cost saving for the farmer. The research carried out by ACIAR also proved that mucuna beans suppressed 18 types of weeds

12 Lal, R. 2013. Influence of Mucuna (Mucuna pruriens) fallow crop on selected soil properties and taro yields in Taveuni, Fiji. http://digilib.library.usp.ac.fj/gsdl/collect/usplibr1/index/assoc/HASH421b.dir/doc.pdf

13 See https://www.aciar.gov.au/sites/default/files/project-page-docs/final_report_hort.2007.118.pdf

14 Lal et al. 2016 Influence of mucuna fallow crop on selected soil properties, weed suppression and taro yields in Taveuni, Fiji Acta Horticulturae 1118(1118):89-94 DOI:10.17660/ActaHortic.2016.1118.13

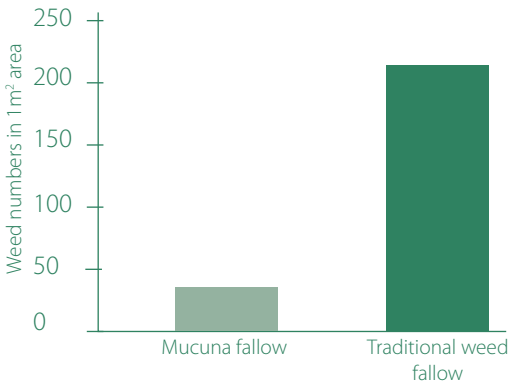


Fig 4: *Weed numbers after mucuna and the traditional fallow system*[15]

Weed numbers substantially reduced by planting mucuna beans 6 to 9 months before planting (photo Rohit Lal)

4.3.1 My mucuna bean cropping system: how should I do it?

What do I need to plant to grow mucuna beans?

Mucuna bean is a legume crop and when planted in the field as a green manure crop it dies off once it has produced beans. Thus, it needs to be planted using seed – it can't be planted using seedlings and cuttings. Remember once the seeds are taken out of the pod, they are only viable for two months at most.

When should I plant my mucuna bean seed?

Mucuna bean is a seven to eight month crop that can be planted at any time of the year. However, with the climatic conditions that prevail on Taveuni, mucuna is best planted in January (seed harvested in December) or July (seed harvested in June). This timing is best for your dalo or yaqona - which require fertile soil, high rainfall and sunshine for maximum growth.

Where should I source my mucuna beans for planting?

Currently most of the mucuna beans that are being planted are sourced from Taveuni through the MoA. Check with your local MoA extension officer as to where you can source your mucuna beans for planting. The Teitei Taveuni Office at Waiyaevo also has seed available, as does the TRTC. Taveuni farmers may also be able to supply you with mucuna beans – but remember they must be fresh.

How long before planting dalo or yaqona do I need to plant my mucuna beans?

It takes around seven to eight months for mucuna beans to flower. However, after about six months the plant has been growing for a sufficient time to have had its beneficial biological impact on your soil. Any time after six months, the mucuna bean can be chopped at its base, and left on the ground to compost and add further organic matter to the soil. Two weeks after the mucuna beans have been cut, you can proceed with the planting of your dalo or yaqona.

15 Lal, 2013, Influence of Mucuna (Mucuna pruriens) fallow crop on selected soil properties and taro yields in Taveuni, Fiji Is

Do I need to clear my mucuna beans before planting dalo or yaqona?

No need to clear – mucuna bean will die off and provide beneficial ground cover. Don't remove the trash - it should be left to provide compost for the soil which will benefit your crops. This period takes around two weeks for the mucuna trash to die down and be easier to cultivate.

Do not plant your dalo or yaqona before the mucuna bean has died off or has been chopped after 6 months' growth. If you do plant your dalo or yaqona before this period you will not get the full soil health benefit from your cover crop. Also, the mucuna beans will grow up and damage the surrounding plants.

Should I be worried that mucuna bean is an invasive species?

There is no need to worry – mucuna is not an invasive species. After they flower the mucuna plant dies. The only way it will grow again is if the seeds are replanted – which you need to do as a farmer. In the days of the CSR, mucuna beans were common place around Nadi, Ba and Rakiraki. This is because cane farmers planted mucuna beans as part of their crop rotation system. Today mucuna beans can rarely be found in these areas and only when the MoA has supplied farmers beans sourced from Taveuni. Farmer Nicholas Naceba talks to Fiji TV 'Green Pillars' about the benefits of 'going back to the future' and adopting an agroforestry cropping system here

Mucuna bean growing up and damaging bananas (photo Rohit Lal)