PUTTING NUTRITIOUS YAMS BACK ON THE MENU

Efforts are being made to resolve some of the agronomic and economic constraints that are holding back the production of yams in Pacific Ocean communities, reports Janet Lawrence

PHILIP HOLZKNECHT

A traditional yam storage house on Kiriwina Island in Papua New Guinea's Trobriand group. Yams are the only root crop that can be stored for long periods; they must be stored in a well-ventilated space away from sunlight and vermin to provide food over many months.

While yams – numbering about 500 species of the genus *Dioscorea* – have dietary and cultural significance in many Pacific nations, production is falling in the face of soil fertility issues and less nutritious, but cheaper, imported foods.

Dioscorea yams are climbing, perennial vines that produce underground tubers that weigh anywhere between one and 25 kilograms. They are abundant in tropical and subtropical regions and certain species are staple foods in many developing countries.

However, among the tropical root crops yams are the most demanding in terms of soil fertility, which has been declining in many areas and needs a concerted soil improvement program to restore yields.

Cheaper but less nutritious imported foodstuffs have started replacing yams, leading to serious health implications for Pacific populations. And although islanders prefer yams, they find prices too high when compared with imported foodstuffs. Farmers are disinclined to grow more than they require for their own needs because they make so little from what is a labour-intensive crop.

A new ACIAR project is looking at the extent to which soil nutrient deficiencies could be to blame for reduced growth and tuber production. The project will determine whether yields can be economically elevated using soil fertility management techniques to diagnose and correct nutritional disorders.

Involving institutions in Queensland, Papua New Guinea (PNG), Tonga and Vanuatu, the project has had formidable obstacles of distance, environmental stresses such as drought, crop diseases and nematodes and technical challenges to surmount. Many findings were inconclusive and some results differed substantially from year to year. Yet an improved knowledge of soil and nutrient levels was obtained in all regions.

To determine the impacts of different nutrients, scientists employed solution culture where different nutrients are progressively excluded to define specific symptoms of each deficiency. In glasshouse trials at the University of Queensland (UQ) researchers adapted techniques already developed and successfully applied to sweet potato in another ACIAR project. They produced deficiency symptoms of all of the nutrient elements of interest and established critical concentration values for most nutrients in leaf tissue of *Dioscorea alata*, and to a more limited extent for *Dioscorea esculenta* and *Dioscorea rotundata*.

This work was an essential prerequisite to the study of deficiencies in the field. Under the direction of the project leader, UQ's Dr Jane O'Sullivan, project team members located throughout the partner countries began to undertake pot experiments to characterise yam nutrient requirements at their selected sites, trying to discover what nutrients were lacking for optimal yam growth in particular soils. Their results suggested that nitrogen, phosphorus and potassium (and sulphur in some places) were major limiting nutrients – findings that agreed with previous data for sweet potato and taro.

The next big question was how to alleviate the deficiencies. Through field trials in Tonga and PNG, yield responses of yams to inorganic and organic soil treatments were tested. In particular, the team tested a range of legumes to see if they could improve yams' nitrogen nutrition levels. Many trials focused on using legumes as green manures, or growing a legume crop as fallow to increase the nitrogen supply in the soil and to recycle phosphorus and potassium.

Good research results were recorded for Tonga, especially for

NEW SKILLS GAINED AT UQ

Marie-Vianney Melteras is a scientist based at VARTC in Vanuatu. As a project research assistant she carried out the Vanuatu trials looking for plant responses to nutrients in selected soils. Her work continued in Brisbane as she undertook a Masters degree based on the research of the Vanuatu program. She was granted an ACIAR John Allwright Fellowship to support her study. Project leader Jane O'Sullivan reports that Marie gained many competencies during her intensive year of study at the University of Queensland. She also contributed to the 4th International Crop Science Congress held in Brisbane in September 2004.

Farmers harvest a yam crop under the shade of *Gliricidia* trees, Bogia District, PNG. The trees have been allowed to grow unpruned since the yam vines began to die off.

PHOTOS: JAMES ERNEST

Gliricidia prunings are used as mulch, providing nutrients as well as holding in moisture and suppressing weeds.

PARTNER COUNTRIES: Papua New Guinea, Tonga and Vanuatu
PROJECT: Nutritional Disorders of Yams
DESCRIPTION: Research into soil nutrient deficiencies will determine whether yields can be economically elevated using soil fertility management techniques to diagnose and correct nutritional disorders
CONTACT: Dr Jane O'Sullivan, j.o'sullivan@uq.edu.au

phosphorus fertiliser field trials and legume fallow rotated with yams. Green manure trials found that mucuna (velvet bean) was able to improve phosphorus nutrition, as well as provide nitrogen through biological nitrogen fixation. Tongan soils, like all volcanic soils throughout the Pacific, bind phosphorus tightly, which is a problem for crops. However, the velvet bean proved efficient at extracting phosphorus and as a green manure alleviated phosphorus deficiency in subsequent crops.

In PNG, research revealed a growing tension between shorter fallows and/or competition for fertile land for cash crops, along with a general decline in soil fertility and resultant decline in yam production.

Another widespread impact of reduced fallows was a shortage of pole timber for staking yams. To address this, the team introduced a novel agroforestry system, using the leguminous tree *Gliricidia sepium* to improve the fallow and as a live stake for yams. The trees are established from pole cuttings planted directly into degraded grasslands eight to 12 months before planting yam. Planted in a grid pattern, each tree supports four yam vines. However, data from four trial sites harvested in 2003 showed no difference in yield could be attributed to the staking system.

The hoped-for cumulative effect of nutrient addition over successive seasons was not realised due to nematode damage. Nevertheless, preliminary results indicate that when regularly pruned, the trees do not compete to the detriment of the crop and can reduce management inputs for weeding and staking. The system may alleviate many of the problems associated with shortened fallows, including weed intensity, decline in soil nutrient availability and organic matter content and shortage of staking materials. Further benefits to farmers include softer soil texture, enabling the yams to be harvested more easily, and shading of workers at planting and harvest.

In Vanuatu, research at the Vanuatu Agricultural Research and Training Centre (VARTC) initially revealed little response by yams to fertiliser in many of the field trials. Therefore, scientists decided to study more closely the growth and development of *D. esculenta* by investigating its rooting structures.

Destructive harvests each month involved careful excavation of the roots and recording of root length and depth. Roots were observed to remain very shallow (less than 10 centimetres) while extending out from the plant for more than two metres and ultimately growing down to about 30cm depth. Feeder roots were not concentrated in or under the mound except for those growing from developing tubers.

These results called into question the efficacy of placing fertiliser in the mound and the distance required to separate fertiliser treatments in the field. Field trial designs adopted from other crop species appeared to be inappropriate for yam as the roots may travel into adjacent treatments. This was a likely cause of the inconclusive results of earlier trials.

To explore these issues further, Dr O'Sullivan established a small trial in Brisbane applying strontium, a non-toxic element of low abundance in nature, which plants take up in a similar way to calcium. By 'spiking' specific locations in the soil with strontium she could trace root activity and determine the ability of roots to reach a certain location based on the level of strontium in the leaves.

Her experiment showed that yam roots may reach horizontally for at least 5.5 metres and go to depths exceeding 40cm. Fertiliser placed in the planting hole under the seed tuber was rapidly accessed by the plant, but that uptake was greater when fertiliser was placed in a ring around the set within the mound. Fertiliser placed between the rows was accessed more slowly but resulted in similar or greater uptake over the growing season. These findings have great promise for future trials.

Meanwhile in Vanuatu, the Development of Sustainable Agriculture for the Pacific (a program funded by the European Union and managed through the Secretariat of the Pacific Community) has now adopted the project-developed facilities and techniques for pot experiments to determine soil nutrient requirements. Support from this program is a resounding vote of confidence for the project team.