Managing water and nutrients in sandy soils for tree crop production in Central Coastal Vietnam

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Abstract
Increasing the agricultural productivity of arenosols in hot dry tropical climates is a significant challenge for farmers and applied R&D agencies in many countries. Central Vietnam has extensive areas of sandy soils which are used for mixed farming systems. This paper reviews soil and water constraints to tree crop production by farmers in central coastal Vietnam and outlines strategies that are being evaluated to reduce them. The application of improved irrigation and nutrient management practices is impeded by inadequate farmer knowledge, labour shortages and very little capital for on farm investment. Field trials are in progress to evaluate potential changes to existing irrigation practices with the aim of improving water use efficiency, crop productivity and raising farm net income. The irrigation trials integrate nutrient management strategies. Specifically, rice husk biochar amendments applied to sandy soils are being investigated with the aim of improving soil nutrient retention. The trials also have institutional capacity building, research and extension objectives.

Introduction

Arenosols occupy 900 million ha or 7% of the earths land area (FAO 2001). These sandy soils pose many constraints to agriculture, particularly when they occur where there are seasonal hot dry climates. Arenosols in the warm climates usually have low water and nutrient holding capacity due to their low organic matter content and cation exchange capacity. Their plant available water is typically only 50-110 mm per metre of soil (Allen *et al.* 1998). Soil organic carbon is rapidly lost due to the high soil temperatures in the tropics (Jabbagy and Jackson 2000). The storage capacity for carbon of sandy soils is typically less than 1% because of the low potential to protect carbon from microbial activity (Hassink 1997; Six 2002; Mtambanengwe *et al.* 2004). The actual soil carbon contents are often much lower than this due to low plant productivity and hence low carbon input rates. Farmers reliant on sandy soils need carefully designed and well integrated water and nutrient management systems to increase their productivity and reduce adverse effects on groundwater and soil acidity.

In central coastal Vietnam there are more than 500,000 ha of sandy soils which are derived from granite weathering, alluvial deposition and windblown coastal dune systems. The region has a 6-8 month dry season which is also hot and humid. The coastal river floodplains are prone to flooding during the monsoonal wet season and are used mainly for rice production. The coastal zone and lower foothills of the river valleys are used for mixed farming using a combination of groundwater and surface water for irrigation. Upland soils are subject to erosion in the wet season and many also have acidic sub-soils. Farm incomes in the region are low and constrained by low soil fertility. This paper reviews the water and nutrient management practices used by poor small farmers in the coastal zone and lower foothills and outlines management options being evaluated to increase incomes and reduce environmental degradation.

Farmer's water and nutrient management practices

A survey of 150 farms was conducted in Ninh Thuan and Binh Dinh in 2007 to assess practices used by farmers, particularly for water and nutrient management. Whilst the landscapes and farming systems of the two provinces are similar, the rainfall is higher and water resources are more available in Binh Dinh. The survey found that;

- Seventy three percent of the farms had areas less than 2.5 ha. Most farms were mixed farms with tree, crop, vegetables and livestock components.
- Ninety five percent of farms used groundwater accessed through open wells for irrigation. Irrigation water is applied almost entirely using hand held hoses or surface flood irrigation techniques. Irrigation is labour intensive and labour is in short supply.
- All farmers indicated they had water shortages in the dry season which reduced the area of land they could grow crops on.

- Groundwater salinity was reducing the productivity of farms developed on sandy soils stretching 1 km or so inland along the coastal fringe.
- Nearly all farmers surveyed used manure for soil improvement, usually in combination with inorganic fertilisers. Livestock owners may also sell manure . Applications of manure vary from 40 t/ha on grapes to 6 t/ha on cashews.
- The application rates of mineral fertilisers vary widely and tend to be higher on the most profitable crops. Application rates are not guided by nutrient budgets.

Water and nutrient management strategies for main tree crops.
The survey was followed by 15 farm case studies to further describe the range of farm management practices for the major tree crops grown in the region i.e. cashews, mango and table grapes (Figure 1). These studies found that productivity of cashews varied from 0.4 to 2.5 t/ha depending on variety, irrigation and nutrient inputs. Many cashews receive no inputs. Farmers who irrigate cashews apply water from hand held hoses starting at flowering. This is a labourious operation so farmers tend to apply a large volume of water infrequently (e.g. every 15 days) and production remains low, typically less than 1 t/ha nut in shell.

Figure 1. Cashews, mangos and grape production on sandy soils in central coastal Vietnam.

Table grapes are a significant and expanding crop in Ninh Thuan. They are high yielding and profitable and so receive high rates of inputs. They are typically surface flood irrigated every 2-4 days. Manure and mineral fertilisers are distributed in the irrigation water. Manure rates vary from 20 to 80 t/ha. We have estimated that annual N application rates may be as high as 1500 kg total N/ha. Nitrate levels >50mg/L have been measured in groundwater sampled from adjacent to table grape farms in the area.

Mangos are a higher value expanding crop in Binh Dinh and are mainly irrigated from flowering with groundwater applied via hand pulled hoses. Irrigation intervals are highly variable between farmers, ranging between 5 to 20 days. Binh Dinh groundwater levels fluctuate from ground level in the wet season to 6 m below ground level in the dry season.

Some of the major constraints facing farmers growing tree crops are outlined in Table 1 along with management strategies that we are currently evaluating to address them. We are testing components of an integrated water and nutrient management system for tree crops on sandy soils which builds on, but modifies, existing farmer water and nutrient management practices. Poor farmers are most likely to be driven to adopt new practices that save labour and increase incomes. The effects of elements of the proposed management system (Table 2) on these drivers are being evaluated with collaborating farmer's in both provinces.

There are also micro- nutrient, agronomic, animal production and marketing constraints to farm incomes in the region. These components, together with the soil and water strategies identified above, are being evaluated as parts of an integrated project supported by the Australian Centre for International Agricultural Research (ACIAR). The collaborative project is also assisting to build institutional research and extension capacity in the southern central coastal region of Vietnam.

Table 3. Constraints to tree crop production on sandy soils in central coastal Vietnam.

Main constraints to food production in upland farms	Management strategy being evaluated
1. Soil and water constraints	
Water scarcity in dry season	Improved water management practices and irrigation systems. • Reducing plant water stress only during critical phenological stages (e.g. flowering to nut set in cashews) using on-farm evaporation pans to guide when and how much to irrigate. • Deficit irrigation technologies eg partial rootzone wetting
Low water and nutrient holding capacity of sandy soils	• Incorporation of biochar from rice husk • Use of surface mulches • Use of organic (manure and biochar) and inorganic fertiliser amendments as per recommended production guidelines.
Acidic sub-soils	Manures, lime, controlled irrigation and fertilizer practices.
Salinisation of coastal aquifers and soils	Improved irrigation water management and irrigation systems.
2. Environmental constraints	
Groundwater contamination with nitrates	Improved irrigation water and nutrient management practices and irrigation systems. Drip irrigation systems for table grapes
3. Socio-economic constraints	
Low capacity for investment	Demonstrating conservative return on investment.
Labour scarcity	Evaluating labour efficiency through improved irrigation systems.

Table 4. Current and proposed practices used by small farmers in central coastal Vietnam.

Current farmer practice	Proposed practice
Uncontrolled irrigation volumes and frequency	Water application frequency controlled using on-farm mini-pans
Uncontrolled volumes of water applied to variable sized circular bunds around each tree using hand held hose. Labour intensive.	Standardising bund to canopy edge and applying guideline water volumes using partial irrigation strategies e.g. to half of the circular bund area, alternating i.e. Alternating rootzone wetting.
Highly variable application rates of manure and inorganic fertilisers before and after wet season.	Application of manure and inorganic fertilisers applied at guideline rates based on tree size. Manure and fertiliser are applied to biochar (Figure 2) amended soil ring within irrigation bund before and after wet season and for inter-row crops e.g. peanuts.

Figure 2. Rice husk biochar amended sandy soil used for tree crops and inter-row crops.

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