Commercial Horticulture Farming and its Effect on Soil Fertility: A Case Study from Peri-urban Agriculture in the Kathmandu Valley

K. Sapkota[1] and P. Andersen[2]

[1]Department of Geography, Tri-chandra Multiple Campus, Tribhuvan University, Kathmandu, Nepal

[2]Department of Geography, University of Bergen, Norway

Abstract

The tremendous growth in commercial horticulture in peri-urban areas in the third world raises the question: does it deplete the soil or provide the incentive to balance soil fertility. This study from the Kathmandu Valley shows that when farmers switch to commercial horticulture, they improve their soil fertilisation practices through the use of chemical fertilisers, purchased chicken manure, compost, and compound micronutrient fertilisers which are available in the market. However, one important constraint is the lack of technical knowledge; both fertilisers and pesticides are applied haphazardly. Boron deficiency and soil acidification are particular problems in the area.

Introduction

Peri-urban agriculture provides a critical source of livelihood and food for many urban dwellers, particularly low income households in developing countries (ECOSOC 2000). In the peri-urban agricultural system in Kathmandu Valley, a wide spectrum of production systems can be found, ranging from household subsistence to large-scale commercial production. Growing of plants and trees in urban and peri-urban areas has occurred since the dawn of urbanisation in Nepal, but modernisation and commercialisation have increased urban demand for horticultural products. Traditional rotations of cereals with vegetables are being replaced by still more intensive horticulture. It is a very dynamic production sector; with rapid and frequent changes in crops and heavy use of agricultural inputs.

Knowledge and Technology Transfer

After the 1970s, the view of technology transfer has focussed consciously on agriculture as an active partnership between rural people and agricultural extensionists (Scoones and Thompson 1993). In this respect, outsiders play an important role in the transfer and exchange of knowledge and ideas between farmers and others. Technology transfer and progress can help to produce more, safer, and higher quality food and agricultural products, at low cost as well as with lower depletion of the natural resource base. There is a risk, however, that scientific technology or knowledge transfers – developed as they may have been in 'laboratories' or at least isolated from existing local knowledge – will fail to capture the unique relationship that farmers have with their own environmental and agricultural practices and the knowledge, and its framework, which is handed down through generations. In theoretical contexts of agriculture, Pretty and Chambers (1993) criticise science not as a body of knowledge, principles and methods, but on the basis of the beliefs, behaviour, and attitudes that accompany it. Similarly, in 1992 Marglin (quoted in Hogg 2000) went further suggesting that modern science, because it portrays itself as the totality of knowledge, cannot peacefully coexist with the tacit knowledge of farmers. Common to these perspectives is an appreciation, however varied, of the interplay between power and knowledge. There is a dialectical interplay between the two. For Howes and Chambers (quoted in Hogg 2000) the need of 'scientists' to lean on scientific knowledge to legitimise their superior status is at the root of a bias against polyculture systems.

However, knowledge is not evenly distributed throughout society. Different individuals are recognised as 'specialists' in particular fields and are key to the transmission of knowledge within a community or family. Knowledge transmission is not based on simple communication channels or linkages, but involves human agency and occurs within socially and politically constituted networks of different actors, organisations, and institutions (Scoones and Thompson 1993).

In contemporary agricultural development theory, farmers are no longer seen as ignorant and naive: they are experimenters, who dynamically interact with their environment and who do not passively adopt the extension's fixed packages of technology, but rather adapt them to their own circumstances. They maintain the diversity, create new farming systems, apply technologies appropriately to different environments, and design new machinery and new methods of pest control or fertiliser application (Rhoades 1989; Maurya 1989). However, there is still a long way to go in order to join scientific traditions with farmers' needs.

Blaikie and Sadeque (2000) criticise the agricultural research traditions in Nepal for being narrowly focused on biological, physical, and mechanical aspects, and neglecting for the most part the social, economic, and cultural context in which the technology is applied. Research is produced within the realms of NARC (Nepal Agricultural Research Council). In theory, NARC produces knowledge and the extension offices transfer the knowledge to the local farmers' level.

The extension system at local level consists of a network of junior technicians and junior technical assistants (JTs/JTAs). Different models for extension have passed through the system, but the low qualifications of the JT/JTAs and a lack of clear and coherent policies have restricted the achievements of agricultural extension goals (Ibid.).

The study area was very close to the city centre and had good access to extension officers, in spite of that it is still in a shadow in terms of agricultural extension. None of the farmers had regular contact with the extension offices, and no farmers had used the state-subsidised facilities for soil testing.

The farmers are constantly looking for affordable new technology and knowledge which is suitable for them. When they do have problems with production, they visit either agro vets or discuss their problems with other farmers. During the study period, we made contact with several farmers who were using chemical fertilisers and 'vitamins' on their land. They transfer their knowledge to each other verbally when they face problems and in this way receive new information regarding agricultural systems.

Generally, the knowledge and technology transfer is based on a market-oriented mechanism. Markets themselves do not develop new techniques or technologies, although they can help to transfer knowledge and technology among the farmers and from institutions to the farmers. Markets merely provide more or less good signposts or paths for new technological change in agriculture. In practice, many of the commercial farming inputs arrive at the local market with scanty or no declarations of content, not to mention user instructions.

Farmers tend to avoid risk and high investment, and mechanisation is absent. Technical modernisation is based on improved varieties of seeds, chemical fertilisers, pesticides, and micronutrients, in addition to some irrigation improvement.

Peri-urban farmers use different local techniques for sustainable agriculture which are mainly based on the characteristics of crops. The traditional practices that contributed to sustainability are the use of organic or farmyard manure (FYM), the use of riverbed sand, and cultivation of drought resistant crops. The local knowledge of farmers, their perceptions, attitudes, ideas, and behaviour in relation to methods of operation and ongoing changes is of great concern in the context of the peri-urban agricultural system.

Study Site

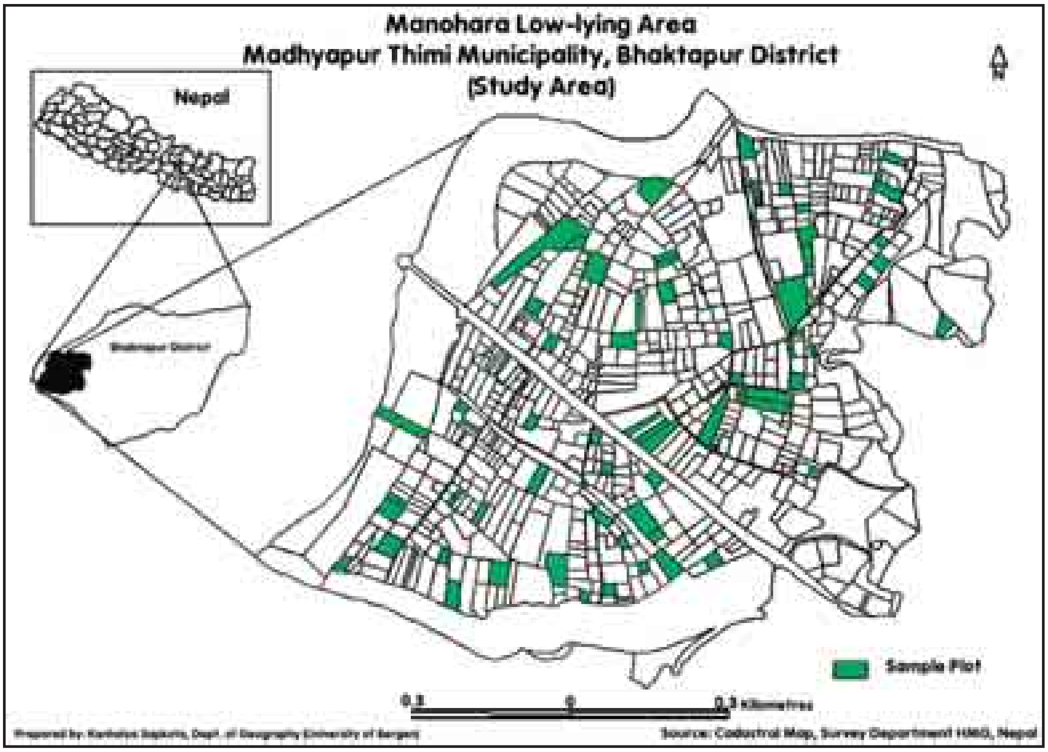
Manohara, a low-lying (phant) area of Bhaktapur district lying in the central part of the Kathmandu Valley, was selected for a variety of reasons. Firstly, it is typical of an area where agriculture has been practised intensively; in terms of production, this location is good and suitable for all seasonal crops. Secondly, the traditional irrigation system is still preserved, although not sufficient for rice production outside the monsoon season, and intensive horticultural practice is the main characteristic of the area. The area is near to major market centres, and it is a major producer of perishable vegetables for urban dwellers. Local farmers can easily transport farm inputs, i.e., agricultural tools, fertilisers, and pesticides. Good transportation facilities permit transport of perishable vegetable products to the urban centre and other areas by lorry, bus, motorcycle, or bicycle. The area is located at an elevation of about 1300m and falls within the warm temperate belt. During the winter season, night frost may occur, but the climate permits year-round cropping.

Horticulture is mainly a single-house enterprise, and it involves the whole process from the beginning to farm selection to harvesting. In this whole process, farmers use their own knowledge in the best way, intending to get a good harvest by selection of different crops for different plots. The rotation is important. There has been a great degree of specialisation in horticulture in the study area.

Basically, the climate is dominated by the south-eastern monsoon rains. These rains bring about 80% of the annual precipitation from June-September. The rainfall is heaviest from the second half of June to the first half of September, with considerable annual variation in the total number of rainy days.

The soil in general is medium to light textured with a strongly acidic reaction. The area is situated in an alluvial plain which has some undulating surfaces.

Intensive farms in peri-urban areas use a lot of inputs on a small area of land; however, good quality soil suitable for agriculture is relatively scarce. Thus, local indigenous farmers designed their crops to produce a maximum yield from rather small fields. Traditionally,



farmers use intercropping, with plantation of several kinds of vegetables mixed together in the same field (Table 1). Green vegetables and spices are the main crops planted by local farmers who rely on multiple cropping. There are several reasons why local farmers choose to undertake multiple cropping including yield, resources (soil nutrients, water, and sunlight), use efficiency, pest and disease reduction, weed suppression, and spreading labour costs.

On typical farmland, different vegetables are planted together, for example chamsur (cress), palungo (spinach), dhaniya (coriander), sounp (fennel), or methi (fenugreek) are planted together with khursani (chilli). Different types of vegetables grow row by row or in alternate strips, each consisting of several rows of the same crops, or they may be grown in more complicated spatial patterns, or, indeed, at random. Hedgerow planting of onions and garlic is used for biological pest control.

Almost all types of vegetables are cultivated intensively in this area. However, only a very few vegetables are specialised in which cannot grow in the off-season. Some farmers also grow paddy in the monsoon season in bagar khet (sandy/gravelly lowland) and sim khet (wet lowland). However, they are moving from a traditional paddy-based farming system to modern intensive horticulture. One step in this respect is the application of large amounts of river sand in order to make paddy soils looser and better drained.

Compost use and production

Most of the farmers studied practised intensive agriculture that had allowed them to produce food and vegetables and manage plant diseases for some decades with few outside inputs.

Table 1: **Types of crops grown**		
Main crop	**Crops planted together with the main crop**	**Months for sowing and harvesting**
khursani (chilli)	chamsur (cress), palungo (spinach), dhaniya (coriander), sounp (fennel) or methi (fenugreek)	Falgun/Chaitra (March) – Ashadh/Srawan (July)
lasun (garlic)	dhaniya (coriander), jiri ko sag (lettuce), celery	Mangsir (November/December) – Chaitra (March/April)
couli/ bandagovi (cauliflower/cabbage)	tori (indian rape), dhaniya (coriander), pyaj (onion)	Bhadra/Asoj (August/September) – Magh/Falgun (February/March)
pyaj (onion)	jiri ko sag (lettuce), mula (radish), couli (cauliflower)	Mangsir/Poush (December) – Chaitra/Baishakh (April)
gajar (carrot)	chamsur (cress), palungo (spinach), dhaniya (coriander)	Bhadra/Asoj (August/September) – Mangsir (November/December)
bhanta (brinjal/ aubergine)		Bhadra (August/September) – Mangsir/Push (December)
salegam (turnip)	chamsur (cress), palungo (spinach), dhaniya (coriander), sounp (fennel) or methi (fenugreek)	Asoj/Kartik (October) – Mangsir/Push (December)
mula (radish)	tori (indian rape), dhaniya (coriander)	Bhadra/Asoj (August) – Kartik/Mangsir (November)
dhan (paddy)		Jestha/Ashadh (June/July) – Kartik/Mangsir (November/December)
Some Off-season Vegetables		
couli (cauliflower)	dhaniya (coriander)	Ashadh/Srawan (July) – Asoj/Kartik (October)
rayo (broad leaf mustard)	lasun (garlic), mula (radish)	Srawan (July/August) – Bhadra (August/September)
chamsur (cress)	palungo (spinach)	Bhadra (July/August) - Srawan (July/August)
salegam (turnip)	chamsur (cress), palungo (spinach), dhaniya (coriander)	Mangsir/Push (December) – Asadh (May/June)
mula (radish)	tori (indian rape), dhaniya (coriander)	Mangsir (October/November) – Falgun (February)
pyaj (onion)	rayo (broad leaf mustard)	Chaitra/Baishakh (April) – Ashadh/Srawan (July)
gajar (carrot)	lasun (garlic)	Mangsir (October/November) – Falgun (February)
Source: Field Survey, 2002		

Many of their successful practices have been forgotten or abandoned, especially in the case of peri-urban farmers but also rural farmers, but some are still using traditional farming systems and management in this area. A traditional farming system is based usually on practices that have been passed down for many generations. In the region as a whole, most of the farmers are still using the traditional ways of farming, and the horticulture described here is a small, although growing activity.

Use of compost in peri-urban agriculture is a rather old concept, so the use of compost and manure were integral parts of this study. Organic waste can be re-used to make compost. Composting is an activity that helps to turn waste into a good soil conditioner which can be used for agricultural practices (Hart and Pluimers 2000). In this area, most of the farmers applied farmyard manure or compost manure combined with inorganic fertiliser for the improvement of and for sustaining soil quality.

Ten to 15 years ago, most of the local farmers applied night soil to maintain soil fertility. They believed that night soil is the main source of nutrients for vegetables. Now this practice has almost disappeared because of the availability of different industrial nutrients (i.e., chemical fertilisers and micronutrients). Another traditional practice is to dig up a fertile, clayey sediment layer, popularly known as *kalimati* (black soil), and use it to improve soil quality.

In general, direct application of manure is not recommended, because it can lead to problems of excess nitrates in the plant, and excessive raw manure can burn plants and lead to toxic levels of nitrates in leafy green. Some farmers in the past faced this problem when they used manure directly, but now they are more conscious and do not apply raw manure directly to plants.

According to the farmers, when they used only farm-yard manure (FYM), organic manure, and home-made pesticides and insecticides, the quality of land was very good and the soil was in good and fertile condition. After the haphazard use of chemical fertilisers, they complain that the quality of land has deteriorated and they face problems of damaged plants. They still prefer to apply organic manure to fields because of the high cost and the low quality of chemical fertilisers and other nutrients.

There are various options in the use of compost and urban waste, apart from for agriculture in peri-urban areas. Linking compost with urban agriculture seems to have the most potential because of low transportation costs and direct benefits to low-income earners. This reduces nutrient cycles, transport costs, the use of chemical fertilisers and available space, and labour intensive productivity. For agriculture, farmers mainly use compost, farm-yard manure directly derived from poultry and other livestock, and organic waste. They use compost to maintain and/or increase soil fertility for greater crop production. Due to the lack of scientific knowledge, most hill farmers do not have any real perception of the quality of compost. But in peri-urban areas, farmers might have different attitudes, knowledge, ideas, and practical experience of the quality of compost and other manures as well as their use to improve soil fertility.

Two basic types of soil fertility maintenance generally applied in this area are manuring and management. Crop residues are burned, and the ash added to the farmland; chicken and livestock manure are spread on fields; and leaf litter and night soil (in some cases) are also spread on agricultural land. These activities are practised widely on both khet (irrigated lowland) and bari (rain fed upland) land. On the basis of local knowledge, local farmers also use farmyard manure (FYM) for almost all vegetable plants. FYM is a mixture of straw, cow dung, urine, and other plant materials. According to the farmers, raw cow dung is not good for vegetable farming. They prefer FYM which regulates the supply of nitrogen and also changes the colour of the soil, an essential factor for absorbing sunlight.

Compost can serve as a soil amendment to improve the soil moisture and nutrient holding capacity, increase soil organic matter, and ultimately improve plant growth and yields. Composting can be used as an alternative form of weed control and to increase soil fertility in vegetable crop production systems. During the field study, we collected four different types of compost manure for laboratory analysis at NARC. All the compost manure we collected for laboratory analysis contained good amounts of primary nutrients (Table 2). Poultry manure, which is bought by farmers from outside, contains high levels of nitrogen (N), phosphorous (P), and potassium (K). Similarly, FYM has very good levels of phosphorous.

Table 2: **Analysis of Sample Manure**

Manure	Nitrogen %	Phosphorous %	Potassium %
Poultry + Mixed	0.58	1.74	3.78
Compost + FYM	0.73	1.90	4.76
Poultry	1.06	1.50	5.46
Compost + Mixed	0.88	1.31	3.78

Source: Field survey 2002

Use of fertilisers in horticulture

Although the main emphasis of this paper is on the use of nutrients/micronutrients in horticulture and the effects on soil fertility, some additional analyses of soils were carried out in order to obtain further information on factors affecting the behaviour of nutrients/micronutrients in soils. In general, most plants and vegetables grow by absorbing nutrients from the soil. Their ability to do this depends on the nature of the soil. Soils in the Manohara low-lying area generally had good qualities in terms of texture and nutrient content, which makes some soils more productive than others.

According to Chaudhary and Manandhar (1996), Nepal's per hectare nutrient consumption is not only the lowest in Asia but also highly unbalanced in terms of N, P, and K application. In the study area, N and P dominated the supply. Cropping patterns do not incorporate legumes and other crops having nitrogen-fixing ability, but are mostly focused on market-oriented crops which remove significant amounts of nutrients from the soil. Farmers have adopted improved varieties of seeds. Due to this fact, they began to give less attention and importance to the traditional nutrients (organic manures from various sources like FYM, green manure, crop residues) that improve chemical and physical properties of the soil. Farmers argued that even though the supply of chemical fertilisers is increasing, they are unable to maintain soil fertility and yields are declining.

For a long time in this area, cultivation of the same surface soil has led to it being slowly drained of nutrients. Most of the crops are grown on the same farmland and in the same few inches of soil; and this has been tilled, year in – year out, for decades. Farmers are facing the problem of soils drained of essential nutrients due to unnecessary and haphazard use of chemical fertilisers and pesticides. They say that when they sprayed pesticides on the soil, some vegetables and crops which they have cultivated all their lives reacted negatively. Some vegetables dried out and even died after the use of pesticides. This might be due to the loss of soil fauna that originally released locked-up minerals and helped to keep the soil fertile, but it may also be attributed to the toxic effects of the uncontrolled amounts of pesticides sprayed on crops – even a few days before harvest. The use of pesticides in Nepal is characterised by very weak regulations, little if any control, and lack of knowledge and awareness among farmers (Dahal 1994).

The use of chemical fertiliser has been increasing in the study area since its introduction in the 1960s. The study did not allow for a detailed quantitative analysis of the use of fertilisers, but, as indicated by the soil values below, the amount is high.

Despite the acidity of the soil, farmers have ceased using agricultural lime. A general explanation given in Nepal is that the bulkiness and cost involved in liming is rarely justified by the production benefits. Therefore, the farmers normally rely on the buffering effect of compost only.

Quality of chemical fertilisers

Chemical fertilisers attract farmers and they appreciate them for quick action, ease of handling, easy access and availability, and comparatively low cost per unit of plant nutrients. Moreover, in the beginning, they were relatively cheap and often produced dramatic increases in yields. Chemical fertilisers normally improve soil fertility and increase agricultural crop yields. Modern agriculture is dependent on chemical fertilisers that are manufactured or mined and chemically processed.

The increases in yields have been facilitated primarily by the introduction of improved varieties of seeds and the use of chemical fertilisers and pesticides. The consumption of fertilisers in Nepal has also escalated after market liberalisation. According to Basnyat (1999), consumption escalated from 37,522t in 1997/98 to 219,038t in 1998/99. Now, chemical fertilisers have become the major input for agriculture. Farmers use both the chemical fertiliser and compost manure on agricultural land. Some farmers claim that the chemical fertilisers that are available in the local market are not as good as previously (before market liberalisation). Basnyat (1999) collected 24 fertiliser samples for laboratory analysis (analyses in six different laboratories); his analyses indicated that urea of Indian origin had a low nitrogen content, almost all of the diammonium phosphates (DAPs) of Indian origin were either spurious or substandard, and that muriate of potash (MOP) of Indian origin had slightly low potassium content.

In contrast to the results of Basnyat, the samples that we collected contained satisfactory levels of nutrients (Table 3). However, some farmers still do not like chemical fertilisers for different reasons. They find that chemical fertilisers make the soil hard and difficult to plough. They accelerate decomposition of organic matter, leading to degradation of soil structure and increased vulnerability to drought because of the reduced water-holding capacity of the soil (Carson 1992). Acidifying fertilisers (DAP) decrease the soil pH, lower the availability of some plant nutrients, and increase vulnerability to some diseases. Likewise, they also argued, yields of some crops were now declining and, the most important point,

Table 3: **Analysis of fertilisers**							
Fertiliser	Origin	Total N (%)	Total	Total K	Formal content		
			P_2O_5 (%)	K_2O_0 (%)	N	P	K
Urea	India	45.9	-	-	46	0	0
DAP	India	16.90	46.04	-	18	46	0
Urea	Indonesia	46.01	-	-	46	0	0
Complex	India	11.62	20.11	-	20	20	0
Potash	India	-	-	57.67	0	0	60
Urea	Korea	46.0	-	-	46	0	0
Urea	UAE	46.0	-	-	46	0	0
Source: Field Survey, 2002							

farmers were increasingly at the mercy of fertiliser traders who were unable to deliver supplies to farmers in a timely or cost-effective manner. It does not mean that local farmers always avoid using chemical fertilisers. Some of them have very good things to say regarding the use of chemical fertiliser on their farmland. For example, some farmers said that chemical fertilisers make it possible to cultivate throughout the year, that crop and vegetable yields increased greatly, and that cash earned by selling more vegetables helped to improve their household economy.

Similarly, farmers from the study area have been using different types of micronutrients ('vitamins') for different vegetables. All the farmers were using some sort of micronutrients; for example, they use Vegimex, a compound micronutrient product containing nine different elements. In 2003, the local agro-vets, sold about six litres of Vegimex, indicating that each farmer used about 50 ml on average of Vegimex micronutrients and suggesting that the amount of micronutrients used is small and only determined by leaf colour. Farmers also use other micronutrient products for different vegetables, but the information available does not permit firm conclusions. Most farmers do not have any specific micronutrients for particular vegetables, because of their lack of knowledge about the availability of micronutrients. The knowledge gap includes traders, and it is having a negative impact on their sales because appropriate inputs would be more cost effective and increase farmers' willingness to use them. There are no government institutions facilitating the use of micronutrients in the area.

Methodology

Primary data were collected during the fieldwork which started in May 2002 and ended in September 2002. A survey of the area was undertaken using a checklist-questionnaire; the purpose was to gain information about the best general locations for the preferred cultivation sites identified by field work from surveys of seventy-five households.

The source of primary data was based on structured and semi-structured (content focused) interviews with sample households, preliminary or exploratory field observations, subjective assessment, and contacting of key informants and resource persons. In addition several discussions were held with local key informants, and relevant information collected through semi-structured interviewing techniques. This helped the study team establish a good relationship with the informants and other local people, and made it easy for us to obtain the relevant information.

To gain a better appreciation of the epistemologies and practice of peri-urban farming, we held detailed interviews (question focused) with selected local farmers. In addition to the farmer interviewees, numerous interviews were also held with local persons who seemed to have good knowledge about agricultural practices; for example, members of the elected administrative body and shopkeepers selling different chemical fertilisers and micronutrients ('vitamins'). Initially we asked them abstract questions and more general questions at the end. This is known as a pyramid-interviewing strategy (Hay 2000). This strategy helped build up rapport by starting with easy to answer questions about an informant's duties or responsibilities, or their involvement in an issue (Ibid).

To achieve the goal of this study, we collected different information for quantitative analysis. The nutrient contents of soil and compost are quite variable. They are affected greatly by the raw materials from which they are derived. For the analysis of nutrients in the soil and manure, soil samples from different plots of land and manure samples were taken to test for different minerals and properties (i.e., N, P, and K). We collected samples from those households where we had held interviews. This helped us analyse the level of nutrients in the fields, which is directly related to crop production and the socioeconomic status of particular landowners or tenants. In the meantime, the knowledge, attitudes, and behaviour of local farmers regarding nutrients were also explored in an effort to understand local knowledge about the use of manure and chemical fertilisers in agriculture.

For the selection of soil samples, the following procedures were followed.

- First, a cadastral map was obtained from the Department of Survey and the categories of land parcels in the study area were stratified.
- Sample plots were selected from each category.
- A quadrat was designated as a ten-metre square sampling site
- A geo-positioning system (GPS) meter was used to confirm the coordinates of the sample plot.
- On the quadrat, surface soil samples were collected from ten different areas, including from the four corners and from the centre.
- With the help of a soil auger, we dug a hole 12 cm deep.
- The soil samples were mixed thoroughly to obtain a composite soil sample.
- Samples of about 150-200g were collected in plastic bags, and each sample bag was tagged with a number.

Compost samples were collected from households for analysis of N, P, and K.

Seventy-five representative soil samples were collected for analysis at the SSD (Soil Science Division), NARC. The following methods were applied.

- pH analysis: using a pH meter (1:1 soil water ratio)
- Nitrogen analysis (N%): total nitrogen analysis by the Kjeldahl method
- Available phosphorous (P_2O_5): the Olsen method using Olsen extraction
- Available potassium (K_2O): 1N ammonium acetate at pH 7 was used in the lab test
- Organic matter: Walkey-Black titration method

- Available boron (ppm): hot water extraction (modified Berger and Trugo method)
- Available zinc (ppm): The method of extraction was AAAC-EDTA (acid ammonium acetate-ethylenediaminetetracetic acid) method, determination with an atomic absorption spectrophotometer (AAS)

Status of Soil

The most common views expressed were that, although the soils are of high quality, they are fragile and in need of careful management. Soil fertility and nutrient management influence agricultural productivity. Maintaining soil fertility is an important step in creating sustainable agriculture. In this area, farmers are practising different methods of soil fertility management, i.e., applying both organic and inorganic fertilisers. The benefits of chemical fertilisers are that they are low cost and ease to apply. But farmers claim that when chemical fertilisers and other pesticides were introduced, production increased and then problems occurred in terms of the loss of soil quality. According to them soil turned drier and harder and certain vegetables which they had cultivated traditionally did not grow properly. It seems that soil fertility is gradually declining due to inadequate and imbalanced nutrient application and improper farming practices.

Table 4 shows the status of soil nutrients in the study area. The overall findings indicate that the levels of nutrients are not much of a problem, except for boron. Most soil pH values fall within 3.5 to 5.4 (extremely acidic to moderately acidic), indicating pH problems to be more serious than reported from other middle hill areas, for instance the Jhiku Khola area (where the pH value was 4.94 in red soil and 4.78 in non-red soils). Reaction (pH) is probably the single most important parameter in predicting the fertility of soil. Correct management of soil pH is important for providing optimal growing conditions for specific crops; reducing potential for deficiency of certain nutrients; and efficient use of fertilisers. It has a significant influence on other soil chemical properties as well as on biological organisms. The effect of soil pH is high on the solubility of minerals or nutrients. Most minerals and nutrients are more soluble or available in acid soils. The availability of nitrogen is somewhat restricted at low pH values, whereas that of phosphorous is best at intermediate pH levels.

Table 4: **Soil property analysis**

Soil property	Mean (n = 75)	Rating	Standard deviation	Minimum	Maximum
pH	4.59	strongly acidic	0.35	3.5	5.4
Organic matter (%)	2.36	low	0.82	0.13	4.56
Total N (%)	0.16	medium	0.16	0.038	1.138
Available P*	1038.69	very high	381.55	90	2179
Exchangeable K	318.24	high	138.66	96	749
Boron	0.0051	very low	0.0053	0.0	0.02
Zinc (AAAC-EDTA)	3.8462	medium	2.0752	0.480	9.226

Source: Field Survey, 2002 * Possible laboratory error

About 12% of the samples were very low to low in total N, but the average was in the medium category. A large variation in available P levels is evident: the levels were high to very high. Although the farmers applied purchased chicken manure as well as DAP fertiliser, the P figures are suspiciously high, and it is probable that a laboratory error has occurred. About 55% of exchangeable K values were in the range of high to very high.

Boron is highly deficient, which agrees well with findings from elsewhere in the region (Andersen 2000 and this volume). Zn, normally a widespread deficiency problem in the hills, does not seem to be a problem, probably due to the use of chicken manure and compost/FYM.

Relationship of organic matter (OM) to other nutrients

Organic matter influences the physical and chemical properties of soils far beyond the proportion of the small quantities present (Brady 2002). The main source of organic matter is plant tissues. In general, the tops and roots of trees, shrubs, grasses, and other native plants supply large quantities of organic residue.

Soil organic matter contains about 50% carbon, 40% oxygen, 5% hydrogen, 4% nitrogen, and 1% sulphur (Brady 2002). Most of the other nutrients are also associated in some way with organic matter, which affects the availability of nutrients for plant growth. Addition of organic matter to the soil increases its ability to hold nutrients. The relationship between organic matter and other nutrients is highly significant in this area (Table 5). Soil organic matter correlates extremely well with a number of important soil physical, chemical, and microbiological properties. As soil nutrients such as available nitrogen, phosphorous, and sulphur increase, other nutrients like potassium , boron, and zinc also increase. However, one thing this study suggests about boron is that FYM alone is not enough to redress the deficiency.

Table 5: **Correlation between organic matter and different soil nutrients**

Properties	r – value
OM – pH	- 0.03132
OM – N	0.122909
OM – P	0.224612
OM – K	0.228343
OM – Zn	0.481858
OM – B	-0.07806

Source: Field Survey, 2002 (Note: soil analysis at the Soil Science Division, NARC, Nepal)

Some of the farmers use cover crops of different vegetables and grasses that can gradually add organic matter to the soil and help retain nutrients from one season to the next. Cover crops contribute to soil organic matter and fertility; for example, legumes decay quickly because their residues have a high nitrogen content thus they are more valuable as sources of nitrogen than as sources of organic matter. Farmers used different cover crops on their farmland for this.

The relationship of organic matter with nitrogen is correlated in this area, because organic matter is also one of the major components in fixation of nitrogen in the soils. It means that when organic matter increases in the soil, the level of nitrogen also increases. None of the relationships of organic matter with other nutrients except boron was statistically significant.

Conclusions

When farmers move from traditional cereal and vegetable production to commercial horticulture, they improve their soil management by using a combination of compost/FYM, purchased chicken manure, chemical fertilisers, and micronutrient fertilisers. However, their access to scientific knowledge is restricted by the limitations of their own knowledge, in addition to limitations in the national extension system and in the market. There is an information gap, and this means that farmers have problems maintaining soil quality. As a result, soil nutrient values in the area studied were reasonably good for most nutrients, but fertiliser-induced acidity and boron deficiency remained problems. Still, the soil management was better than that of non-commercial agriculture, and intensification and commercialisation may be among the keys to more balanced soil nutrition.

Bibliography

Andersen, P. (2000) *Beyond local knowledge and institutional reach: micronutrient disorders in hill agriculture*. Paper presented at a regional conference on 'Physical Mobility and Development in the Mountains', 15-17 March, 2000, Kathmandu, Nepal

Basnyat, B.B. (1999) *Meeting the fertilizer challenge: a study on Nepal's fertilizer trade liberalization programme,* Winrock International, Policy Analysis in Agriculture Resource Management, Research Report No. 41. Kathmandu: Winrock International

Blaikie, P.M. ; Sadeque, S.Z. (2000) *Policy in high places: environment and development in the Himalayan region*. Kathmandu: ICIMOD

Brady, N.C. (2002) *The nature and properties of soils*. New Delhi: Prentice-Hall of India

Carson, B. (1992) *The land, the farmer and the future: a soil fertility management strategy for Nepal*, ICIMOD Occasional Paper No. 21. Kathmandu: ICIMOD

Chaudhary, S.L.; Manandhar R. (1996) 'Extension of soil fertility and plant nutrition management: DOA's experience'. Paper presented at the National Workshop on 'Soil Fertility and Plant Nutrition Management, 19-20 December 1996, Soil Science Division, Nepal Agricultural Research Council (NARC), Kathmandu, Nepal

Dahal, L. (1994) *A study on pesticide pollution in Nepal.* Kathmandu: IUCN and National Planning Commission

ECOSOC (2000) *Sustainable agriculture and rural development*, United Nations Economic and Social Council Commission on Sustainable Development, Eighth Session, 24 April - 5 May, 2000

Hart, D.'t; Pluimers, J. (2000) *Wasted agriculture: the use of compost in urban agriculture, urban waste expertise programme, composting of organic household waste*. Working Document 1 of the Urban Waste Expertise Programme (UWEP), The Netherlands

Hay, I. (ed) (2000) *Qualitative research methods in human geography*. Australia:Oxford University Press

Hogg, D. (2000) *Technological change in agriculture: locking in to genetic uniformity*. Basingstoke (UK): MacMillan Press

Maurya, D.M. (1989) 'The innovation approach of Indian farmers'. In Chambers, R.; Pacey, A.; Thrupp, L.A. (eds) *Farmer first – farmer innovation and agricultural research,* pp 9-14. London: Intermediate Technology Publications

Pretty, J.; Chambers, R. (1993) *Towards a learning paradigm: new professionalism and institutions for agriculture*, IDS Discussion Paper DP 334. Brighton: Institute of Development Studies

Rhoades, R. (1989) 'The role of farmers in the creation of agricultural technology.' In Chambers, R.; Pacey, A.; Thrupp, L.A., (eds) *Farmer first-farmer innovation and agricultural research*, pp. 3-9. London: Intermediate Technology Publications

Scoones, I.; Thompson, J. (1993) *Challenging the populist perspective: rural people's knowledge, agricultural research and extension practice,* IDS Discussion Paper No. 332. Brighton: Institute of Development Studies, IIED

Shah, P.B. (2000) 'Indigenous agricultural land and soil classifications'. In *Components of integrated plant nutrient management for Nepal*, proceedings of workshop, February 2000. Kathmandu: Ministry of Agriculture and Co-operatives, Department of Agriculture, Crop Development Directorate, STSS