THE ROLE OF IMPROVED CASSAVA CULTIVARS IN GENERATING INCOME FOR BETTER FARM MANAGEMENT

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ABSTRACT

Cassava has been changing its role from a traditional fresh human food to an efficient crop for animal feed and starch production. Nearly all cassava is grown by small farmers. Harvested roots are sold to animal feed or starch factories, or are used for on-farm feeding of pigs to be sold at the market. Thus, cassava is an important source of cash income to small farmers in many parts of Asia.

International breeding efforts for higher root yield and starch content have been successful and the total area planted with the improved cultivars is now reaching one million ha in six countries in Asia. A substantial portion of economic gain generated by the improved cultivars is entering the household income of small farmers. However, cassava production often causes soil degradation when proper agronomic practices are not followed. Soil conservation is the prime issue in sustainable cassava production. While individual agronomic practices are important and indispensable components of soil management, a more fundamental requirement is to first upgrade the economic situation of farmers, in order to cut the vicious cycle of poverty and environmental mismanagement. Improved cassava cultivars is one of the most readily adoptable components for inducing better farm management by increasing feed or starch production leading to increased farm income.

INTRODUCTION

Cassava (*Manihot esculenta* Crantz) is one of the most important calorie-producing crops in the tropics. It is efficient in carbohydrate production, adapted to a wide range of environments and tolerant to drought and acid soils (Jones, 1959; Rogers and Appan, 1970; Kawano *et al*., 1978; Cock, 1985). The major portion of the economic product, the root, is consumed as human food after varying degrees of processing. An estimated 70 million people obtain more than 2100 kj/d(500 kcal/d) from cassava, and more than 500 million people consume more than 420 kj/d(100 kcal/d) in various forms of cassava throughout the tropics (Cock, 1985).

In many parts of Asia cassava's traditional role as a fresh human food is rapidly changing to being an efficient industrial crop for factory processing. In Thailand, cassava for fresh human consumption has been completely replaced in the past three decades by cassava production for animal feed and starch processing. In Indonesia, Vietnam, China and the Philippines, while a considerable amount of cassava production is consumed as fresh human food or is used for the on-farm feeding of farm animals, the proportion used in producing value-added food, feed and industrial products is increasing. Thus, in this rapidly developing part of tropical Asia, cassava production for fresh human consumption is decreasing while its use for feed and industrial processing is rapidly increasing (Bottema and Henry, 1992; Kawano, 1995a).

Cassava as Animal Feed

In tropical America, the center of origin and diversification of cassava, cassava roots have been traditionally used as an energy source for humans as well as for farm animals. Research has shown that dried cassava can be added upto a certain proportion of

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the feed rations of broilers (Montilla, 1977), layers (Omole, 1977), swine (Khajarern *et al*., 1977), and ruminants (Devendra, 1977). A life-cycle swine feeding study indicated that fresh cassava roots of a so-called "sweet cultivar" were an excellent source of energy for swine feeding if properly supplemented with protein, vitamins and minerals, and it was concluded that a life-cycle feeding of pigs could be based on a high level (60-70%) use of cassava meal (Gomez, 1977). Bitter cassava roots in fresh form are not usually consumed by pigs because of their high content of cyanide.

In Vietnam and China, dried cassava roots are widely used for swine feeding. The remarkable increase of cassava production from the 1960s to the 1980s in Thailand was almost entirely based on the export of dried cassava chips and pellets (some 6-8 million t/year in peak years) mainly for swine feeding to the European Community. Now that the cassava pellet exports to the EU have diminished, the cassava harvest is effectively diverted to the domestic feed market and to starch production. Since the consumption of animal protein in Asian diets is expected to rise very significantly, increased production of energy sources for livestock feed is much needed. Cassava is a strong candidate for answering to this need.

Cassava Toxicity

Toxicity of cassava is caused by the presence of the cyanogenic glycoside linamarin, together with much smaller amounts of the closely related lotaustralin. These substances hydrolyze under the influence of the endogenous enzyme linamarase to liberate hydrogen cyanide (HCN). The quantities of toxic principle vary greatly between cultivars. Although so-called sweet cultivars are generally of lower toxicity than the bitter ones, the correlation is not exact. Variation in cyanogen content with ecological conditions during plant growth also occurs (Coursey, 1973).

A wide variety of traditional food preparation techniques are used for processing cassava in different parts of the world, and an important element in all of these is an attempt to reduce the cyanide content by liberation of the HCN, either by volatilization or dissolution in water. These processes involve drying, maceration, soaking, boiling, roasting, or fermentation of the cassava roots, or a combination of these processes (Coursey, 1973).

A series of studies in Africa revealed that while all toxic effects from cassava can be effectively avoided by sufficient processing, short-cuts in established processing methods are the underlying cause of cyanide exposure from cassava that can cause acute intoxications and chronic aggravations of goitre (Rosling *et al*., 1993).

There is a long list of insects that attack cassava plants (Bellotti and Kawano, 1980). Many of these are specialists (feeding only on cassava or closely related species) and are considered to have co-evolved with cassava since a long time ago. On the other hand, there are also generalist enemies, such as the cassava burrowing bug (*Cytomenus bergi* Froeschner, Cydnidae, Hemiptera), for which the high HCN content in cassava roots appears to function as a strong defense (Bellotti and Arias, 1993; Riis *et al*., 1995). This group of generalists includes rodents, wild boars, human thieves, and even elephants. They are considered to be newcomers to the evolution of cassava. Some practicing agronomists consider that the advantages of HCN in cassava outweigh the potential disadvantages.

It is the general understanding that for animal feeding cassava is an excellent energy source as long as it is properly processed (chipped and dried). Since the production of starch from cassava roots, no matter how crude it may be, includes the basic detoxification processes, such as maceration, soaking and drying, HCN toxicity from consumption of food products made of cassava starch is not heard of.

Yield Improvement Opportunities

A comprehensive cassava breeding endeavor, initiated by CIAT (Centro Internacional de Agricultura Tropical, with headquarters in Colombia) in 1973, and later involving a network of national breeding programs, is now witnessing the economic effects generated by the adoption of new cultivars (CIAT, 1995; Kawano, 1995b; 1998).

There have been three phases in the successful varietal improvement. The first phase corresponds to the evaluation of cassava germplasm and the generation of advanced breeding materials conducted at CIAT headquarters from 1973 to 1982. We attained in this phase a significant upgrading (90%) of physiological yield potential of the breeding population (calculated as the mean fresh root yield of selected clones to be used as cross parents for recycling in the hybridization program, in each year relative to the control) compared with the starting population which consisted of mostly traditional land races (**Figure 1A**). Of this process, enhanced (55%) harvest index (proportion of root weight in the total biomass) was the major factor (**Figure 1B**) (CIAT, 1976; 1983; Kawano *et al*., 1978).

The second phase corresponds to the Thai-CIAT collaborative cassava improvement program, conducted at the Department of Agriculture and Kasetsart University from 1983 onward. In this phase we accomplished, using the local materials and the advanced materials from CIAT/Colombia, a significant upgrading (50%) of dry root yield of the breeding population (**Figure 2A**). Of this process, enhanced biomass (25%, **Figure 2B**) and root dry matter content (15%, **Figure 2C**) were the major factors (CIAT, 1993; 1995; Kawano, 1998; Kawano *et al*., 1987; 1998)

The third phase corresponds to the selection of new cultivars, their release and dissemination by national programs. While Thailand naturally attains the largest acreage planted with new cultivars, Vietnam shows this varietal development success more dramatically than any other country. For the most part of the 1970s and 1980s, agricultural research in Vietnam was isolated from progress made outside the country. During this period, cassava varietal improvement in Vietnam was not much more than the maintenance and evaluation of local cultivars. The introduction into Vietnam of the best cassava clones from the Thai-CIAT collaborative breeding program started in 1989. This led to an immediate improvement (more than 100% eventually) of yield levels in the breeders' trials at the research stations (**Figure 3**), and similar improvements soon followed in farmers' fields.

The number of CIAT-related cassava cultivars officially released in Asian national programs has passed 35 in 1997 (Kawano,1998; and other unpublished communications). In Thailand, where hard data are available on the area planted with each cultivar from statistics of the Department of Agricultural Extension, the total area planted with five new cultivars was 376,250 and 622,000 ha in the 1995/96 and 1996/97 planting seasons, respectively (Rojanaridpiched *et al*., 1998). In Indonesia, new cultivars were planted in more than 110,000 and 136,000 ha in 1995/96 and 1996/97, respectively (Puspitorini *et al*.,

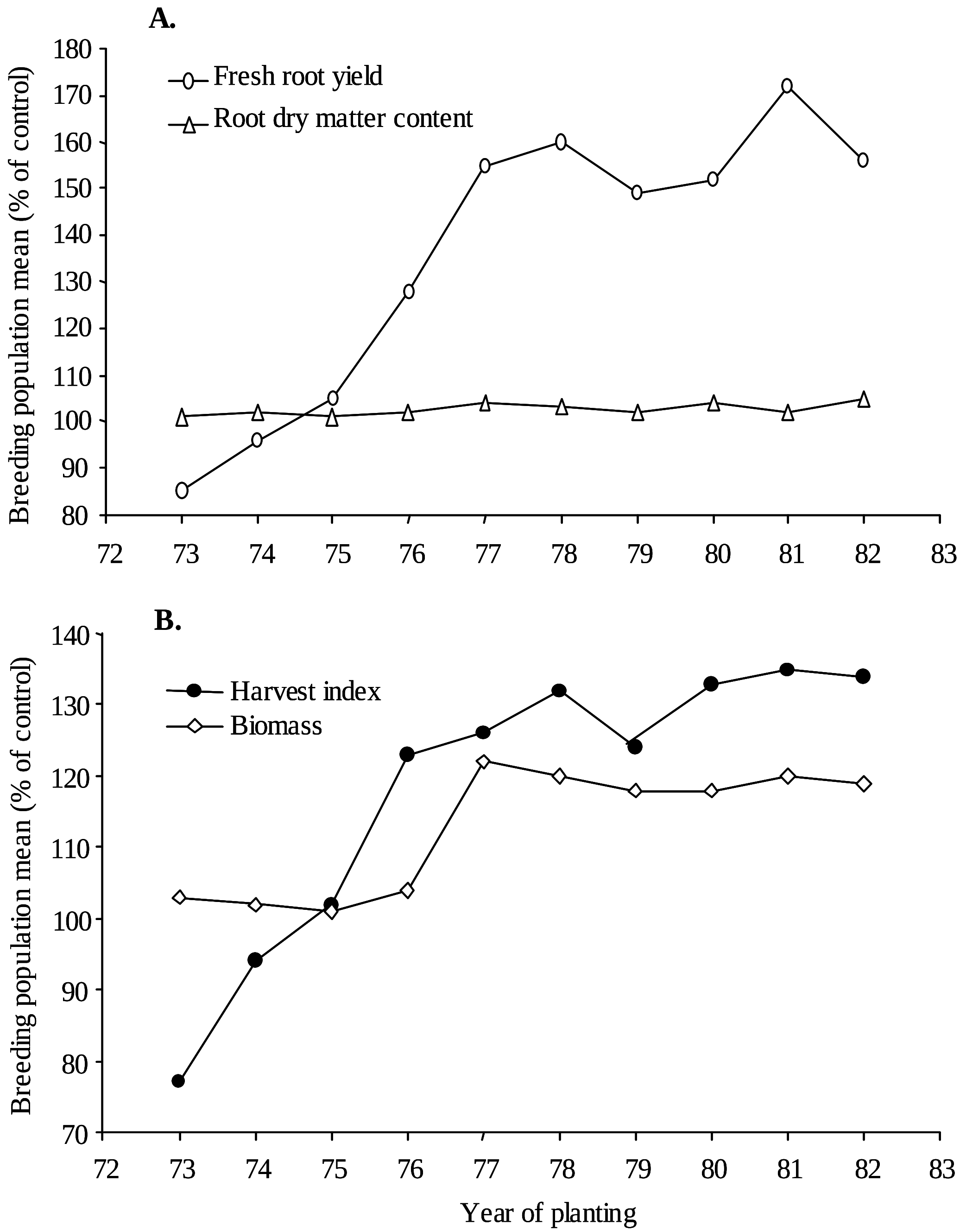

Figure 1. Change in yielding capacity (A) and harvest index and biomass (B) of the breeding population, given as the means of all entries in a yield trial for advanced clones to be used as cross parents for recycling in the hybridization program at CIAT Headquarters from 1973 to 1982.

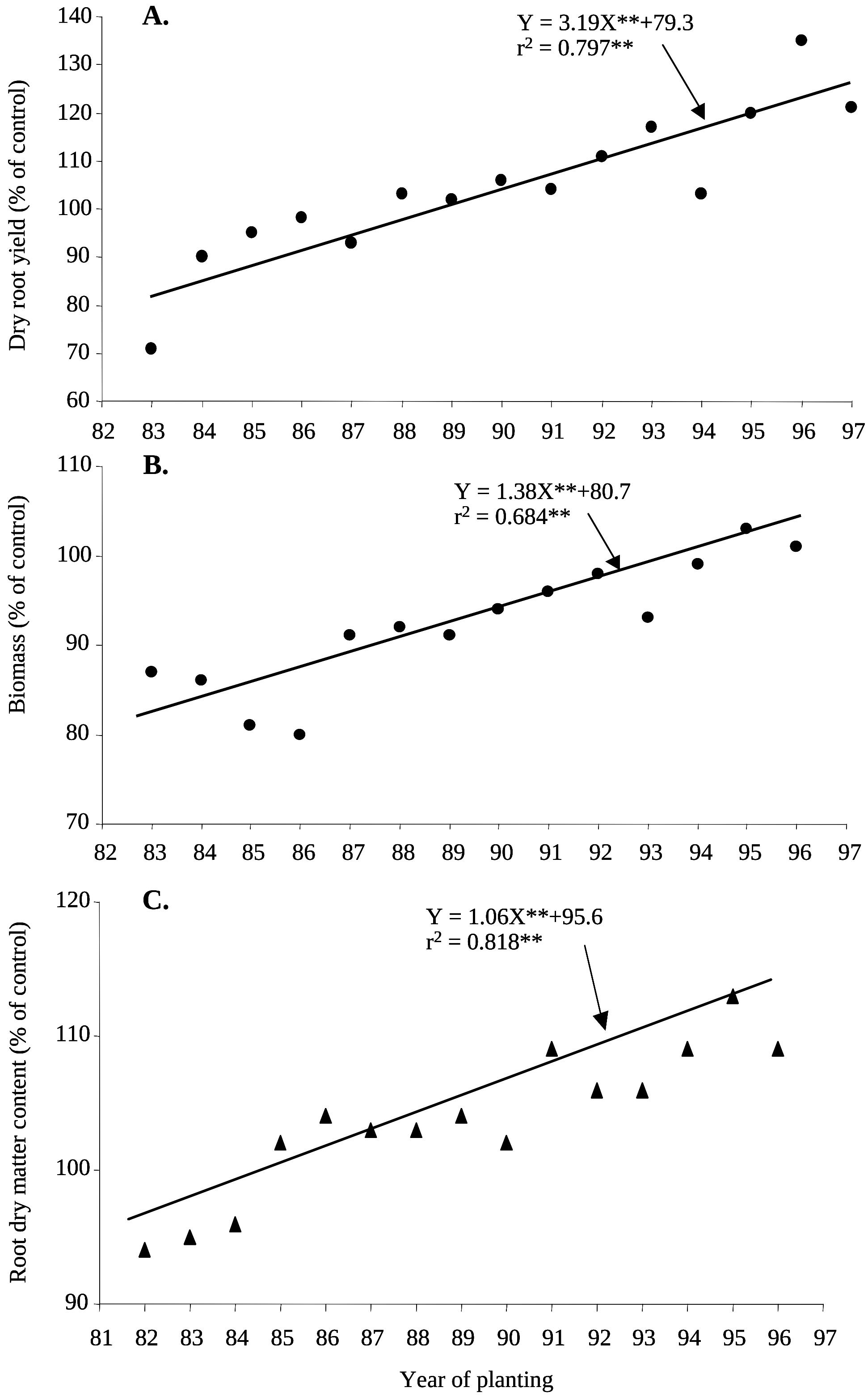

Figure 2. Yearly change in dry root yield (A), biomass (B) and root dry matter content (C) of the breeding population, given as the means of all entries in six regional yield trials for clones of official release condidates relative to control varieties in Thailand from 1982 to 1997.

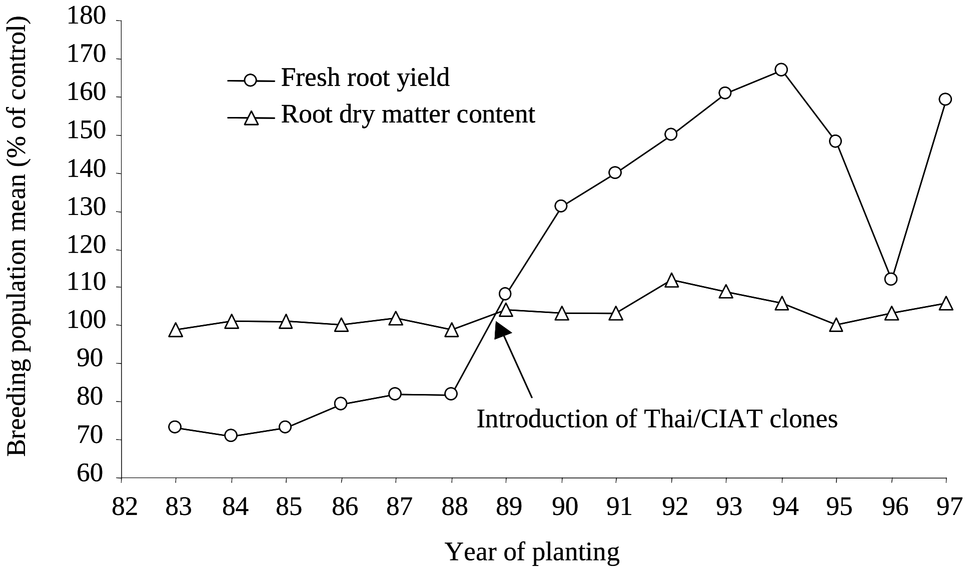

Figure 3. Change in yielding capacity and root dry matter content of breeding population, expressed as mean of all entries of yield trials for selected clones at Hung Loc Agric. Research Center, Vietnam.

1998). In Vietnam where the CIAT collabolation started much later but the progress is the fastest, the area planted with new cultivars is estimated to have passed 15,000 ha in the 1996 planting season (Kim *et al*., 1998). The adoption of new cultivars is also starting in the Philippines (Mariscal and Bergantin, 1998), China (Tian and Lee, 1998), and Myanmar (personal communication). Thus, the total acreage of CIAT-related improved cultivars in Asia is passing the one million ha this year.

Economic Effects Caused by the Adoption of Improved Cultivars

The results of hundreds of on-farm varietal trials indicate that in general farmers are getting 5 to 10 t/ha additional fresh root yield and the factories are enjoying an additional 3% (actual value) of root starch content by the adoption of the newest cultivars (Kawano, 1998; Kim *et al*., 1998). The additional economic effects caused by the higher starch content of the new cultivars in Thailand is estimated to be 87.6 million US dollars, and that caused by the higher fresh yield to be 42.4 million dollars for the 1996/97 season (Kawano, 1998; Rojanaridpiched *et al*., 1998). In Sumatra, Indonesia, the additional fresh root yield in the fields and the additional starch production in the factories caused by the new cultivars are estimated to have generated the economic gains of 32.6 and 44.7 million US dollars, respectively, for 1996/97 (Puspitorini *et al*., 1998). In South Vietnam, more money had been made by the sale of planting stakes of new cultivars than by the sale of fresh roots with higher starch content in the early years, but the benefits caused by the additional fresh root production and the additional starch production will probably surpass that from the sale of stakes from the 1996/97 season onward (Kim *et al*., 1998). The total economic effects due to the superior yield and quality of new cassava cultivars accumulated in the past ten years upto 1997 is estimated to be 693 million US dollars in Asia.

Benefits to Small Farmers

In Thailand virtually all the cassava production takes place in small farmers' fields and all the harvested roots are sold to processors. In Vietnam also, all the cassava is produced by small farmers and at present those advanced farmers who adopted the new cultivars sell all their harvested roots to processors (South Vietnam), or use them for feeding pigs to be sold at the market (North Vietnam). In Indonesia and the Philippines, some cassava production occurs in large plantations; yet, the majority of production takes place in small farmers' fields. Thus, we can assume that virtually all the additional economic effects generated by the higher fresh root yield of new cultivars are going directly to the pockets of small farmers.

How much of the additional profit generated by the higher starch content of new cultivars is shared by the farmers depends on what differential prices starch factories (or chipping plants) pay to the farmers. Large factories in Thailand, Indonesia and Vietnam are returning 55 to 100% of the value of additional starch production caused by the higher starch content of the raw material to the farmers. All in all, the scheme is not outrightly unfair to the farmers. We can safely assume that a substantial portion of the 693 million US dollars so far generated by the adoption of new cultivars has entered the household income of small cassava farmers.

The recent varietal dissemination in North Vietnam revealed that thousands of small farmers are adopting new cassava cultivars in their small plots (360-5000 m^2). Virtually all of them use the additional cassava production for on-farm pig feeding, which results in 50-600 kg additional pig sale (US$ 45-545) per family per year. The whole scheme is not as spectacular as the rapid varietal dissemination in South Vietnam or in other countries; yet, here is a scheme where a new technology is spreading thin and wide equitably, creating economic opportunities for overcoming rural poverty.

Is Cassava an Indefensible Villain?

Cassava is often considered as a crop that is conducive to soil degradation. Intensive research on cassava management and its effect on soil productivity (Howeler, 1991) revealed that:

1. Soil nutritional requirements of cassava per unit of dry matter yield are much lower than of most other crops, except for potassium. Actually, cassava is a very efficient user of soil nutrients (Howeler, 1991; 1995; 2001; Howeler *et al*., 2000).
2. The high nutrient absorption by cassava, especially of potassium, is a result of the crop's high productivity under sub-optimal conditions.
3. Continuous cassava production without fertilizer application inevitably induces soil nutrient depletion, but this can be prevented by appropriate fertilizer application (Howeler, 1991; 1995; 2001).
4. The slow rate of canopy formation and soil cover by cassava is due to the crop's low planting density, which in turn causes soil erosion; this may not only physically damage part of the cassava plantation but will also remove the most fertile part of the soil, including the nutrients contained in the eroded soil and in applied fertilizers (Howeler, 1995;1998; Howeler *et al*., 2000).
5. Contour ridging, closer spacing and appropriate fertilization are generally recommendable practices for preventing soil erosion (Howeler, 1995;1998).

Thus, cassava can be a very problematic crop if the cultural practices used are not appropriate, while it can be grown successfully, like any other well-managed upland crop, if the farmers adopt proper soil management procedures (Howeler, 1998; Kawano and Howeler, 1998).

Cassava Farm Management in Micro- and Macro-contexts

My recent experiences in North Vietnam, where thousands of farm families make their living on equally divided small farms, which typically comprise of 0.1-0.3 ha of paddy rice and 0.1-0.4 ha of upland cassava, offer a good opportunity for seeing soil management from many angles. We naturally start our sustainability concern by looking into soil management, for which we already have a comprehensive list of recommendable cultural practices. For any good method to give a result, it has to be adopted by the farmers. For this, farmers must be motivated and have extra cash for investment. Thus, soil management can not be separated from the more general development in farm management and farm income generation, which can not be sustained without a favorable market environment, which in turn is much dependent on the whole country's economic situation (**Figure 4**). After all, farmers' immediate interest is extra cash for tomorrow. Any technology that can not satisfy farmers' immediate needs has very little chance of being adopted.

In North Vietnam, pig production with new cassava cultivars is now well recognized as a new economic opportunity. Innovative farmers who plant new cultivars in larger plots and convert the extra production into more value-added products, such as piglets, can attain a US$ 500 level of additional income per year. As a consequence, many farmers are giving extra care to their upland cassava fields by applying more farm-yard manure and potassium fertilizer. Some are also making hedgerow plantings of *Tephrosia candida* or pineapple.

It is logical to start looking at the sustainability issue by defining each soil management component, but it is equally logical to handle this in terms of increased farmers' alternatives. Cutting the vicious cycle of poverty and environmental mismanagement is the most crucial factor. Among many technical components that constitute good farm management, improved cultivars may be the most readily adoptable component to induce good resource management.

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Soil management	*Farm management*	*Income increase*	*Socio-economic situation*
Contour ridging	Fresh cassava	Bicycle	Soil management
Intercropping	On-farm pig feeding	Color TV	Family economy
Farm-yard manure	Pig and poultry sales	2nd-hand motorcycle	Processing/mardetting
Chemical fertilizers	Cash for investment	New house	National economy
Hedgerows		New motorcycle	Sustainability across generations

Figure 4. Factors surrounding small cassava farms in North Vietnam.

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