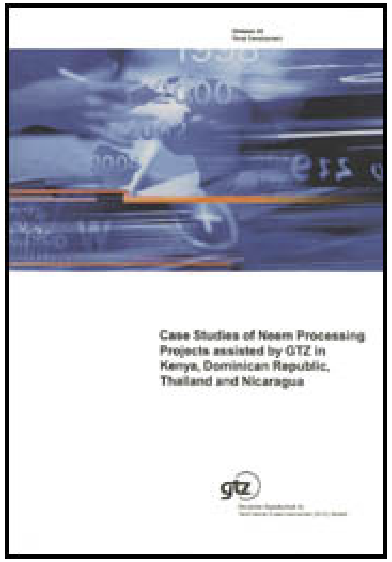

Case Studies of Neem Processing Projects Assisted by GTZ in Kenya, Dominican Republic, Thailand and Nicaragua (GTZ, 2000, 152 p.)

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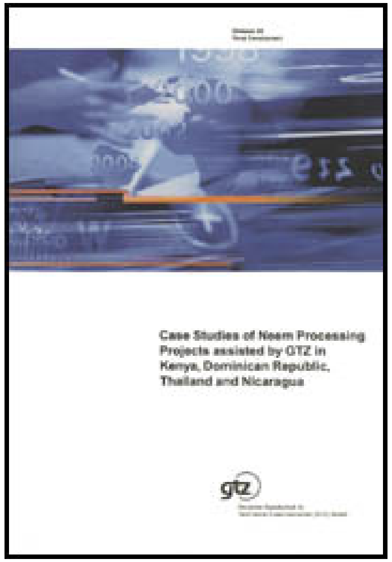

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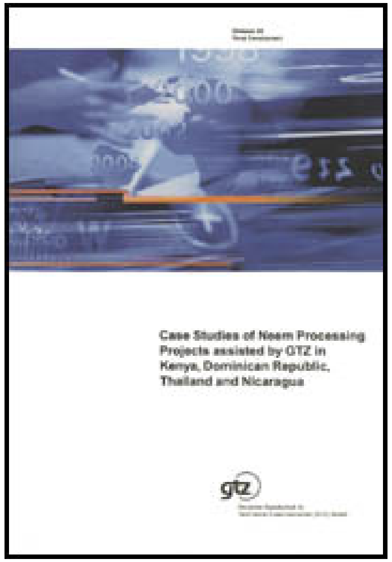

Case Studies of Neem Processing Projects Assisted by GTZ in Kenya, Dominican Republic, Thailand and Nicaragua (GTZ, 2000, 152 p.)

1. Introduction

1.1 Survey of the GTZ's neem activities

Over the past 25 years the Deutsche Gesellschaft fr Technische Zusammenarbeit (German Technical Cooperation, GTZ) has supported research, dissemination and use of agricultural applications of neem and neem products, particularly with regard to environmentally sound forms of plant protection and pest control (Schmutterer & Ascher 1980, 1984, 1987, Brechelt & Hellpap 1994, Foerster et al 1999) on behalf of the German Federal Ministry for Economic Cooperation and Development (BMZ).

In most cases, neem-related activities have been only a sideline of bilateral GTZ projects, e.g. those working on Integrated Pest Management (IPM). The only exception was the former supra-regional "Production of Natural Pesticides from Tropical Plants", often called simply the "Neem Project" in cooperation with the University of Giessen, with a field station in the Dominican Republic (1977-1995).

The objective of the project was to introduce the use of seed extracts and seed oil produced from the neem tree as insecticides for pest control for use by farmers in pilot regions. To achieve this aim, the supply to farmers of neem seeds as raw material was improved, methods for the production and application of simple neem products were developed and their socio-economic acceptance was investigated. In addition, information about the appropriate use of neem was

spread among farmers and interested institutions and neem programmes and projects of NGOs were promoted. In cooperation with the University of Giessen, the project carried out in-depth investigation of the neem tree. Cooperation was also established with a range of NGOs in Sri Lanka, Thailand, Nepal, Niger, Haiti, Ecuador and the Dominican Republic.

The project has built the base for a wide range of neem projects operating within development cooperation world-wide, both at governmental and at non-governmental level. Today, five years after termination of the Neem Project, NGOs in Sri Lanka, Thailand, Ecuador and the Dominican Republic are still manufacturing and selling neem products.

When the Neem Project was due to be phased out in 1994/95, the GTZ's "Supra-regional Pesticide Service Project" took over the task of promoting the use of non-synthetic, and in particular neem-based, pesticides and other pertinent objectives until 1999, when it was succeeded by the project "Improving the Quality of Agricultural Produce" from 2000 onwards. Supra-regional activities concerning neem are also offered by GATE within their NGO-promoting programmes (ongoing) and for east Africa by the IPM Horticulture Project in Kenya (until 2000).

The following table gives an overview of the supra-regional GTZ projects working on neem:

Table 1: Supra-regional GTZ projects with a neem component:

- "Production of Natural Pesticides from Tropical Plants" in cooperation with the University of Giessen, with a field station in the Dominican Republic (1977-1995): basic research, appropriate technologies for small farmers to produce neem pesticides, NGO support.

- "Biological-Integrated Locust Control" (1989-1999): has for 10 years investigated the effects of neem used for locust control.

- "German Appropriate Technology Exchange - ISAT/KPF/GATE" (ongoing): neem is one appropriate technology among others; target group NGOs, knowledge transfer, technical advice, limited assistance possible via "Small Scale Fund" - KPF e.g. in the Dominican Republic, Ecuador and Cuba.

- "Pesticide Service Project"/" Improving the Quality of Agricultural Produce" (1994-2000): both based at the GTZ Head Office in Eschborn, promoting neem as an alternative pesticide since 1994: technical advice, fact-finding and feasibility studies, socio-economic analysis of neem processing; conducting fact-finding (baseline) studies, seminars and workshops, planning neem projects.

- The IPM Horticulture Project, located in Nairobi, Kenya, at ICIPE and focusing on east African countries (1996-2000): this project aims to develop integrated concepts for producing high quality vegetables, fruits and ornamental flowers for export and local consumption. Target groups are the producers of fruit and vegetables in eastern and southern Africa, and small farmers as well as plantation farmers. A small project was elaborated and set up jointly in cooperation with the Pesticide Service Project, ICIPE and an entrepreneur, aiming to produce and register affordable neem-based pesticides in Kenya. The production unit was set up at Technopark ICIPE.

Bilateral projects:

Within the bilateral IPM projects (initiated at the request of our partner countries), the activities on neem are usually only one component among several, but their relative importance is steadily increasing. An overview of the projects is provided in Foerster (2000, 1999).

The expectations regarding the use of neem as a pesticide were that small farmers would adopt the technology of preparing and applying simple aqueous extracts of neem and that toxic broad spectrum synthetic pesticides would be replaced by neem extracts, beside the further merits and benefits listed in Table 2:

Table 2: Merits and benefits of neem:

Merits and benefits of neem (part I)
Environmental advantages: • suitable for afforestation of wasteland, soil improvement • rapid growth even on marginal sites • attractive tree providing welcome shade in private and public places and in agriculture • pesticides with low toxicity to mammals and birds • rapid decomposition in the environment and therefore no contamination of water, soil or air • pesticides largely benign to beneficial insects • little likelihood of resistance developing

- better use of nitrogen

During the project planning phases some experts argued that the effect of promoting crude water extracts would be limited and that it would be better to develop ready-to-use products. This strategy has been pursued in a bilateral IPM project in Myanmar, where an extraction plant was established as early as 1986, which is producing standardised neem-based pesticides. The market conditions in Myanmar are, however, artificial and cannot be compared to those of other countries.

As well as the merits and benefits of neem listed above, neem processing and the manufacture of commercial products have the following advantages:

Table 3: Advantages for the national economy:

Merits and benefits of neem (part II)

Advantages for the national economy:

- added value within the country
- reduces foreign currency spending
- pesticides are also available on the spot in remote regions, therefore enhanced added value in agriculture
- avoids extra costs incurred by the use of synthetic pesticides (poisoning, accidents during transport, contamination of drinking water, etc.)

- pharmaceutical usage
- potentially an additional cash crop
- resulting possible sources of income also in disadvantaged (dry) rural regions
- job creation

- a national insecticide - an additional export product

In the mid-1990s the GTZ evaluated the potential of the neem tree. Its potential is not exploited to a great extent considering the strikingly long list of merits and benefits presented above. To identify the main constraints which hamper the use of neem pesticides in agriculture, a questionnaire was carried out (Moser 1996, Foerster & Moser 2000).

It turned out that the main limitations on the wider use of neem were:

- **lack of knowledge about neem**
- **poor access to neem raw material and neem-based pesticides**
- **doubts about its efficacy which could also be due to a lack of knowledge about neem and lack of standardisation**
- **labour constraints on preparing neem water extracts**

- difficulties in handling

- the few available commercial neem-based pesticides were often too expensive, making the application of neem-based pesticides uneconomical.

These findings led to the conclusion that if the above-mentioned benefits were exploited to a greater extent, to increase the wealth of the people in developing countries, it would be essential to continue to:

- spread information on neem and raise awareness

- intensify the training with neem products,

- and also

- to come up with a competitive ready-to-use formulation which is easy for small farmers in developing countries to handle.

This was the aim of the three small projects presented here in Thailand, the Dominican Republic and Kenya, which were assisted in various ways by the GTZ (see below).

A great deal of the data and results presented here are based on an evaluation carried out by Dr W. Leupolz, CiM, H. Quentin, Consultant and Dr S. Praneetvatakul and her team, Kasetsart University, Bangkok, at the end of 1999 according to our Terms of Reference.

The evaluation aims to answer the following key questions:

- **Is neem processing profitable for small entrepreneurs in developing countries?**

- **What are the key factors determining whether neem processing is profitable?**

- **To what extent can neem pesticides substitute synthetic pesticides?**

- **What are the "bottlenecks" hindering neem products from gaining a greater market share?**

- **Are the constraints caused by the internal factors of neem processing or by the frame conditions?**

- **What factors determine the price of neem products?**

- **What is the potential market share for neem products?**

- **What recommendations can be given, and what strategies pursued to promote neem in the future?**

The objective of the case studies presented here is to document and evaluate the neem activities assisted by the GTZ in Kenya, Thailand, the Dominican Republic and Nicaragua, as examples of developing small-scale industrialisation of neem-based insecticides in developing countries from three continents.

The backgrounds of all these projects vary, not only due to the different ethno-social environment, and size and market conditions, but also due to the political

and economic frame conditions in the individual countries. Surprisingly, however, there are a lot of similarities among the three projects and the problems they have encountered. The fact that there are many similarities despite the different frame conditions emphasises the importance of such a supra-regional project in the steering and back-stopping of such activities.

Over the last 25 years considerable progress has been made in raising awareness of the potentials of neem and to a certain extent of neem products, too.

However, more emphasis is needed on demonstration and training with neem products, and particularly on how to identify and implement efficient marketing and distribution channels for reliable standardised neem products manufactured by small-scale enterprises.

Given their properties and price, the existing (available) neem pesticides are a viable alternative for niche markets where they have the potential to gain a considerable market share.

If the expectation that neem pesticides can replace standard broad-spectrum pesticides to a considerable extent is to be fulfilled, a change of frame conditions is required, such as integration into IPM research, training and promotion concepts, a reduction of the retail price for neem pesticides by 25-40%, tax exemption, efficient marketing and distribution channels and integration in credit packages, amongst other items.

Hopefully further organisations will in future assist neem-manufacturing companies, NGOs and government organisations in training. This training should

be directed at how to use neem, and at setting up distribution channels. These organisations should also advise local and/or national authorities on how to create favourable frame conditions for manufacturing, applying and selling neem-based products to take advantage of local resources and reduce the environmental and health effects caused by synthetic pesticides.

1.2 General introduction to neem products

The neem tree is a hardy, multipurpose tree, well known for its medicinal properties, and also as a source of timber and of materials for producing cosmetics, toiletries and pharmaceuticals. The tree is often planted to give shade, as a windbreak and for reforestation.

Neem-based water extracts, neem oil, leaves and cake have been used traditionally for thousands of years on the Indian subcontinent - in particular in India against various insect pests, although the knowledge was often lost during the time of the "green revolution". There is a growing interest in the potential of the neem tree as a source of natural pesticides.

Intensive research and screening of plants with insecticidal properties, e.g. by the GTZ Neem Project and biocontrol projects (Schmutterer & Ascher 1980, 1984, 1987; Brechelt & Hellpap 1994, Grainge & Ahmed 1988) have shown neem extracts to be the most promising plant extracts for insect control, especially in integrated pest management (Hellpap 1996).

Neem's unique properties as a pesticide, namely non-toxicity to warm-blooded organisms, potential to control a wide range of pests, relatively low toxicity or

non-toxicity to beneficial organisms, and low persistence in the environment, make neem-based products a better alternative to synthetic chemicals, particularly in the context of sound plant protection.

1.2.1 Need for neem products for pest management

In many developing countries, it is often felt that the pressure to increase agricultural production in order to cope with the growing population has promoted the use of pesticides to protect crops from pests and diseases. The careless and indiscriminate use of synthetic pesticides has led to well known problems such as environmental contamination, toxic residues, side-effects on non-target organisms, increasing pest resistance to pesticides and pest resurgence, the so-called "pesticide treadmill". The growing awareness of consumers and producers about these problems has prompted a search for a more ecologically rational approach to pest management. Thus the EU and other industrialised countries have set maximum pesticide residue limits (MRLs) for fruit and vegetable products. This has put pressure on agricultural producers to look for alternatives to synthetic pesticides, such as neem-based pesticides.

1.2.2 Efficacy of neem-based pesticides

Comprehensive research on the effects of neem has been carried out around the world, mainly in India, Germany and the US, and in many other countries, often assisted by GTZ projects.

There is no doubt any more that neem extracts and products are effective in controlling a wide range of pests (Schmutterer 1995).

According to Schmutterer (1995, 1998) the neem-based extracts display an array of effects on insects, such as:

- **antifeedancy**
- **reduction/prevention of settling and oviposition**
- **disturbance of metamorphosis**
- **sterilisation**
- **reduction of activity (fitness)**
- **effects on cell level (molecular level)**

Despite the fact that neem is effective against a wide range of pests, it is much more selective than standard broad-spectrum pesticides in the pests and beneficial organisms it effects. Therefore it must be quite clear which pest is to be controlled in which crop, and sometimes even at which stage of the crop. Otherwise the application of neem will fail and the farmers will disappointedly turn away from this environmentally sound alternative.

One reason for some disappointment lies in the fact that "neem" does not always mean the same thing. To date more than 145 active ingredients have been identified (Morgan 1999), of which 40 are assumed or proven to have insecticidal properties.

- **Azadirachtin ($C_{35}H_{44}O_{16}$), the most active insecticidal substance in neem seed, disrupts growth, prevents moulting, causes sterility of eggs, and other effects.**

- **Nimbin is a feeding repellent.**

- **Salannin inhibits feeding.**

It is not known exactly which synergistic or additional effects the other ingredients or metabolites have. Even if pesticides are standardised, the quality parameter refers to the azadirachtin content only, despite the fact that the other active ingredients (AIs) are as important or even more important against many pests. Therefore the need to select further AIs for quality parameters is occasionally discussed (Foerster 1998). This, on the other hand, would increase the costs of quality control considerably.

The potential of the neem tree as a source of natural pesticides has been exploited in the production of neem-based pesticides in several countries, often at cottage or small-scale level.

The following table (Table 4) lists possible neem products for agricultural usage:

Table 4: Overview of various neem products and target pests:

Product	Remarks	Application areas
Alcoholic extracts	Mostly ethanol, methanol, based on cake or kernels	Leaf chewing insects such as Lepidoptera
Raw, formulated or enriched neem oil	Cold pressed, problem: aflatoxin contamination	Sucking insects such as whitefly, aphids Refined oil as fungicide
Neem cake	Quality depends i.a. on pressing	Nematodes, systemic effects if

	method (temperature); Ground and mixed with shells or directly applied	applied in nurseries and to young or green (not woody) plants, As powder or extracts against biting pests De-nitrogenic bacteria suppressed
Remains (cake of alcoholic extraction)	Fertiliser	Effect not properly investigated
Azadirachtin-enriched extracts	Require additional extraction (two-step extraction) which produce azadirachtin powder	Same pests as above but more stable
Neem powder	Made of high quality dry neem kernels, sold in sealed vacuum-tight, polyethylene bags ("tea bags"), etc.	Wide spectrum of pests

1.2.3 Comparison between home-made products and commercial products

Home-made extracts and cold pressed oil based on high quality seed kernels possess excellent pesticidal properties but have the disadvantage that they are unstable and therefore cannot be stored. In addition they are laborious to prepare and are therefore only applicable and accepted by small farmers whose farms do not exceed 1-2 ha in size. Therefore there is a need for commercial neem products which have a longer shelf-life and are more stable in the field.

However, any extraction process required in the production of commercial pesticides will select some of the many active ingredients in neem, and will consequently disturb the synergistic and additive effects.

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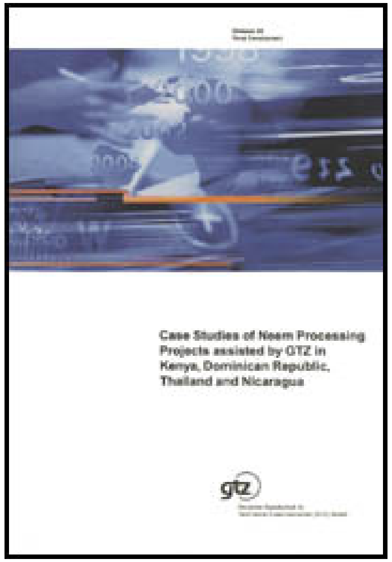

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2. Survey of neem-processing methods

In principle the following product lines can be characterised:

2.1 Home-made products

To prepare a simple extract from 1 kg of crushed neem seed or fruits, these are soaked and stirred in 20 litres of water and left for 5 to 8 hours, preferably during the daytime (Dreyer & Hellpap 1992, Hellpap 1989, Schmutterer 1995). The neem extract can be filtered and directly sprayed on the target crops, preferably in the evening to avoid UV light (which destroys the active ingredients) as long as possible.

This method is also known as the "tea bag method".

There are some examples reported from Thailand, where this method is even used for larger areas of vegetables. Farmers have developed simple technologies, putting 50 kg bags of crushed neem fruits into iron drums and spraying the water extracts on a large scale with motor driven pumps.

The neem remains or marc can be dried and packed or applied to the soil as a soil additive or to control soil insect pests and nematodes.

In addition, the neem seeds or neem cake from oil pressing may be ground to produce powder. This powder can be used to produce water extracts or can be directly applied to the soil or to plants themselves (e.g. funnels of maize).

Neem seeds can also be processed into oil which, mixed with soap (or better, an emulsifier) can be applied by spraying.

2.2 Commercial products

The following steps are required for the commercialisation of neem products:

- **Harvest: hand picking (for best quality) or collecting (sweeping up) fruits and kernels which have been depulped by bats and birds**
- **Cleaning with water/sand**
- **De-pulping: by hand or modified coffee depulper**
- **Drying: controlled exposure to sunlight/drying device**
- **Disinfection with calcium hypochlorite**
- **Storage in a dry, shady and well ventilated place, preferably at 20 C**
- **Extraction:**

- **alcoholic batch extraction (one-step extraction)**

- **methods for obtaining an azadirachtin-enriched extract: two-step extraction, supercritical CO_2,**

- **Formulation: increases stability but emulsifiers often also have synergistic or additive effects (e.g. sesame, soya or castor oil, piperonyl butoxide etc.).**

2.2.1 Collection systems

The commercialisation of neem products requires an effective and reliable collection system for neem seeds, which does not exist in most countries. It turns out that reliable collection and preparation of neem kernels of good quality for a reasonable price is one of highest hurdles in setting up neem processing in developing countries. On the one hand, in participatory training communities have to be persuaded to collect neem seeds during the one or two local harvesting seasons and to accept neem as an additional cash crop; on the other hand there has to be a commitment on the part of the entrepreneurs to buy a certain amount of the collected seeds frequently, even if they cannot process them all due to marketing problems. Moreover, the kernels may be of inferior quality in the early stages or due to extraordinary weather conditions, e.g. contaminated with fungi *(Aspergillus spp.).* The entrepreneurs, however, should keep the collectors motivated by continuing to buy at least some of the seeds. It is helpful to intensify the training and pay a premium for better quality.

2.2.2 Harvesting methods

There exist two ways to obtain neem seeds:

- **birds and/or bats feed on the pulp of the ripe neem fruits and drop the seeds underneath or near the trees (which happens in some places in Asia and Africa);**

or

- **the fruits are picked from the tree (in areas where the neem tree has been introduced only recently such as central and south America). The seeds are then collected from the ground.**

In the former case the seeds can be collected (swept up) more cheaply but further cleaning from debris is still required, as is depulping sometimes.

There are different harvesting techniques applied in other regions; the best one was developed in Nicaragua.

Pruning takes place during harvesting time, so a good proportion of the seeds can be picked directly from the chopped branches on the ground. Leupolz (1995) found that the average harvesting capacity is 30 kg fruits during 6 working hours (5 kg fruits/h).

During picking of the neem fruits the workers do not differentiate between ripe and unripe fruits for reasons of efficiency. Unripe fruits are stored in the shade at the processing site.

The average harvest in neem plantations is approx. 5 kg fruits/tree.

2.2.3 Processing technology seeds

Neem fruits can be processed in two different ways:

a) Wet processing on a small scale:

The fruit is depulped by hand, by rubbing and squeezing the pulp in water using sieves or hand-driven modified coffee depulpers. Modified coffee depulpers, however, have turned out to cause too much loss (damaged kernels and subsequent fungal infection).

The unripe fruits can be depulped after being stored for 4 - 5 days in the shade. After depulping, the seeds have to be washed in water, dried for 4 - 5 hours in the sun and then moved to the shade, if the sun is strong enough to risk lowering the azadirachtin content of the kernels. The time required for drying depends on the climatic conditions. The seeds should have a moisture content of less than 7%. A higher moisture content will lead to fungal contamination and subsequently to a reduced azadirachtin content.

b) Wet processing in a depulping plant:

Here the fruits are delivered to a processing plant. The process is more or less the same as on a small scale. The fruits are sorted into ripe and unripe ones. The ripe ones are depulped in depulping rollers (cylinders) with a capacity of 300-500 fruits/hour.

The depulped seeds will be either washed manually or by mill

electric washing machines to be eventually dried on drying sieves.

Usually the limiting factor for wet processing units is the lack of sites covered by a roof for ripening the unripe fruits and for drying the seeds. A problem encountered by both small-scale and semi-industrial processing is the lack of adequate drying units for the seeds, to avoid fungal contamination and reduce the moisture content.

In arid areas without water the seeds are cleaned by rubbing them in sand.

For storage, the seeds should be disinfected by some means, e.g. calcium hypochlorite, and dried in the sun or by heating devices to achieve a moisture content lower than 7%. The seeds should be stored in a shady and airy place. This is one of the main problems, especially on village level, due the lack of space in the huts of the poor collectors.

There has been good experience with entrepreneurs sponsoring drying and storing facilities to gain better quality seeds and build a close relationship between the collectors and themselves. This includes receiving credit to process the inferior quality seeds into neem oil for the village.

Extraction technologies

Neem seeds are a valuable raw material. They contain not only insecticidal and fungicidal ingredients, but also up to 48% oil. Even the extracted neem cake can be used as fertiliser and might have effects on soil pests. There are various

technologies available to extract the active ingredients of neem. Which technique should be used depends mainly on the quality required (content of AIs) for the final product.

The costs of the extraction plants vary accordingly: the higher the level of azadirachtin required, the more expensive are the plants. Considering the solubility of the leading component azadirachtin, it is clear that only polar solvents should be used for extraction. Still, the cold pressed neem oil could contain up to 0.6% azadirachtin A.

Water and alcohol are the best solvents. Often methanol is the preferred alcohol because of the availability and price.

Four different types of technologies are available, the types first described being the most commonly used ones:

A) EXTRACTION with alcohol (also called one-step extraction)
B) AZADIRACHTIN-ENRICHED EXTRACTS (also called two-step extraction)
C) EXTRACTION USING CENTRIFUGES
D) EXTRACTION WITH SUPRACRITICAL CO_2

A) Extraction with alcohol (also called one-step extraction)

Advantages:

- **relatively simple technology**
- **lower investment required**
- **makes use of all products, therefore no waste**

- **possible use of the extraction plant for other products**

Disadvantages:

- **quality of the final product is greatly dependent on the quality of the raw material**
- **often low stability/short shelf-life of the products**

The neem seeds are crushed into crude powder and extracted with ethanol or methanol by maceration or percolation. The alcohol should have only a low water content, and its quality (purity) is also important.

The alcoholic extracts contain the active ingredients. Using the moving-bed contacting method, the kernels will be stirred for 3-4 hours by an overhead stirrer in a mixing-settling tank. After decantation of the crude cake, the neem solution is drained out, filtered and passed to the next procedure. The dilute neem solution will be further evaporated until a specific volume - called the "concentrated extract" (CE) has been achieved, and the solvents are recycled.

Neem kernels contain a large percentage of oil (up to 48%, average 40%), which is of considerable value on its own. The oil disturbs the extraction of the active ingredients. Therefore it would be best to remove the oil with solvents such as hexane or by cold pressing with an oil expeller. It is also possible to remove the oil content from the extract by cooling or freezing to separate the oil. The de-oiled neem cake could be further extracted with methanol to gain the azadirachtin. The oil component of neem is currently used in formulating a pet shampoo, e.g. in Thailand, or as an acaricide.

The sticky CE is dressed with carriers which will form an eventually an emulsified extract (EC) formulation

Finally the solution obtained can be bottled and supplied to the consumer.

This sort of technology is used in the smaller neem-processing plants (100 - 500 t of kernels annually) such as those in Myanmar, Thailand and Kenya. The products contain between 0.3 and 1% azadirachtin A as well as many teranortriterpenoides and other substances (residual fat, sugar etc.).

Furthermore, some of the products are formulated for a specific purpose. However, the information about formulation technology of neem pesticides is a commercial secret and often patented.

Figure 1 is a schematic diagram of a production line using a single-step extraction method for producing commercial neem-based formulations. This technology is used in Thailand, Myanmar and Kenya:

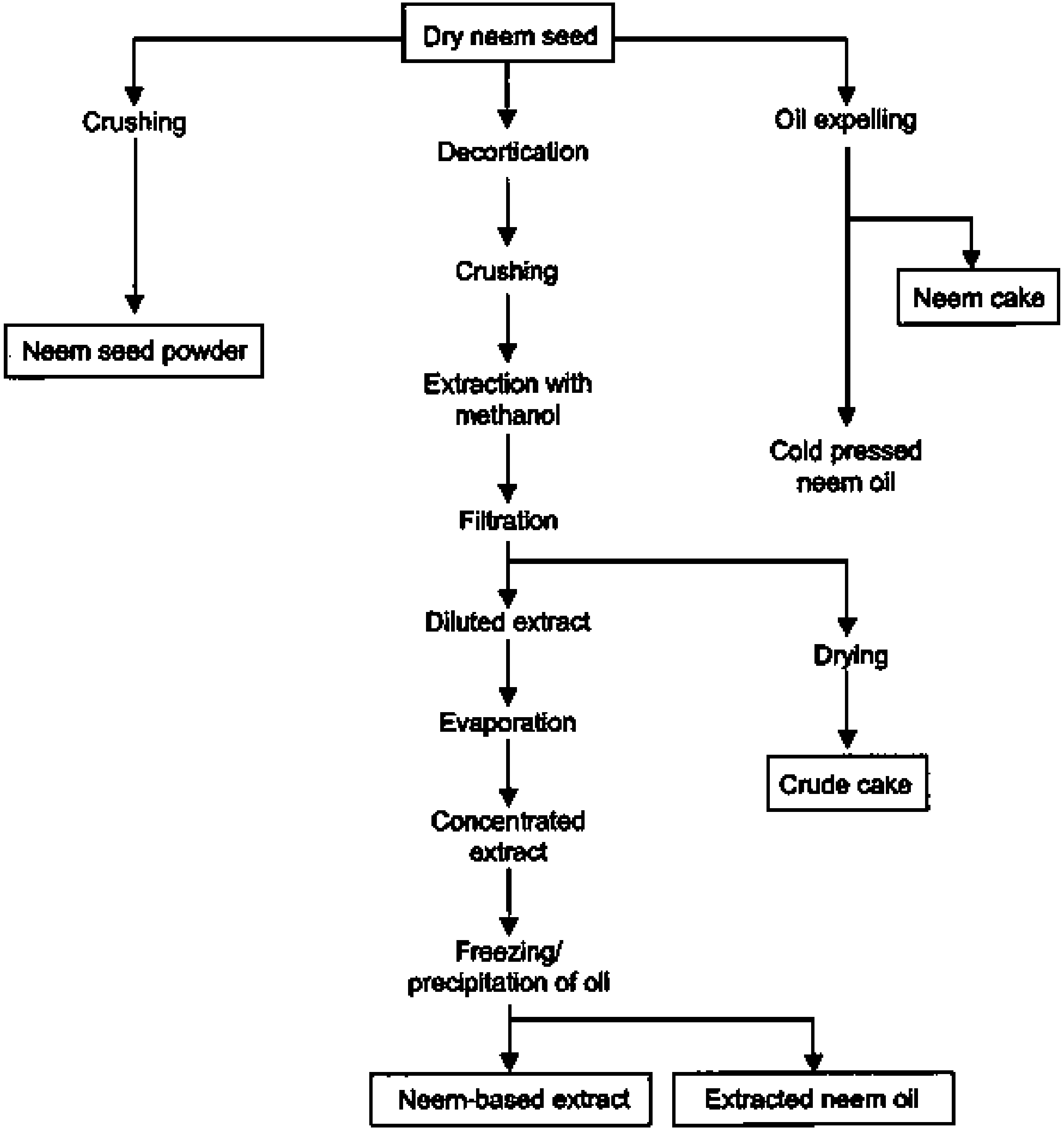


Figure 1: Example of batch extraction (from Thailand)

Machinery required for one-step neem extraction:

- **Dryer for the seeds (solar dryer), thresher, oil press or hexane extraction plant, hammer mill, percolators and solvent tanks, pumps**
- **Evaporator, cooling tower, boiler (steamer)**
- **Dryer for recycling the solvents from the extracted cake, desolventiser, filling and packing equipment, cooling room, laboratory for quality control**

The costs of such extraction plants (of 2000 t capacity) are approx. US$ 500 000 - 750 000 $ (CIF), without a laboratory for quality control.

The processing of neem involves many operations, as shown in Figure 2 and requires a certain mount of equipment. Figure 2 shows the equipment for commercial neem processing in Thailand.

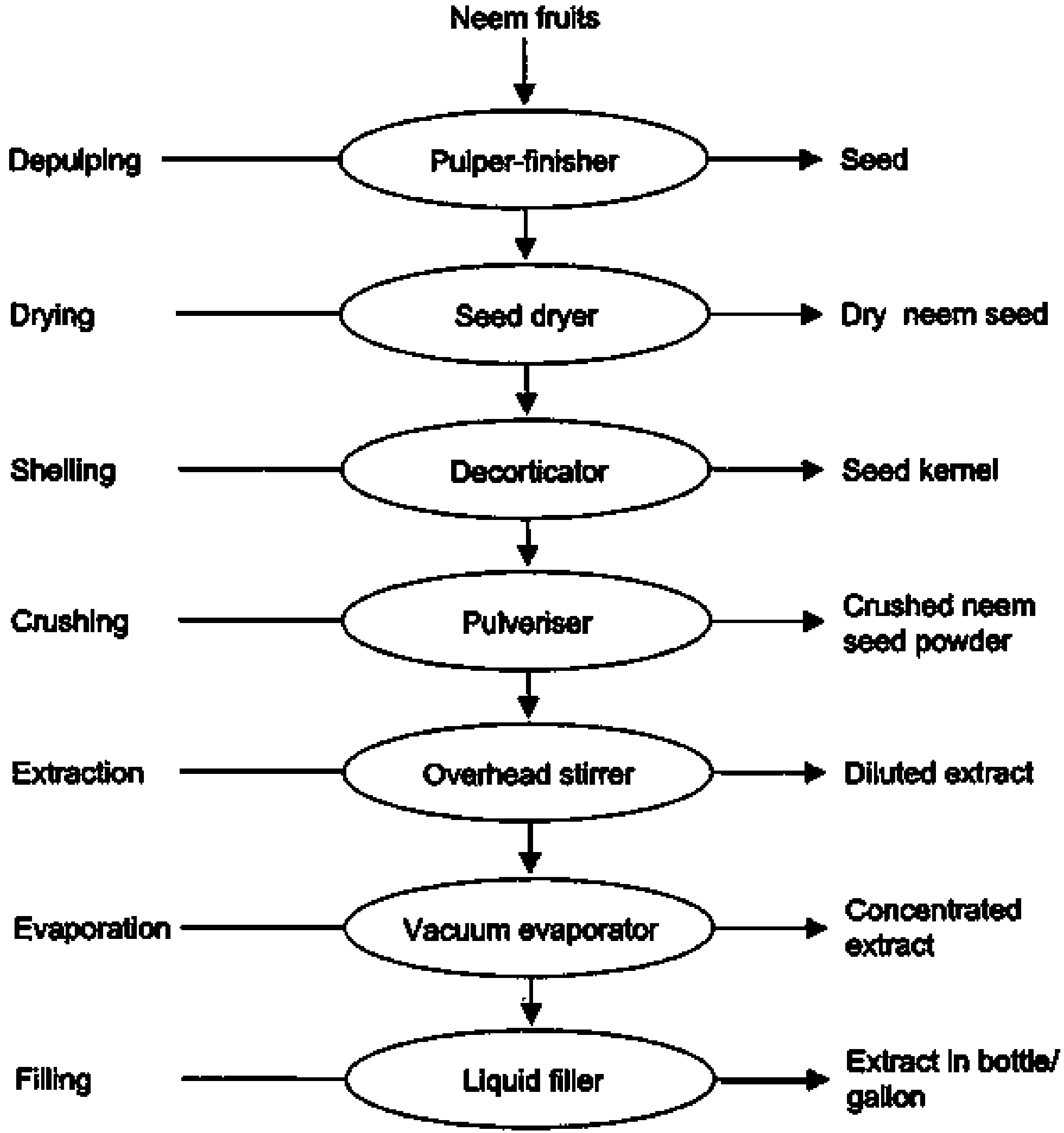


Figure 2: Equipment required for commercial neem processing

B) Refined neem extracts - AZADIRACHTIN-ENRICHED EXTRACTS (also called two-step extraction plant)

Advantages (according to Ermel, personal communication):

- **products can be easily stored (less volume) and have a longer shelf-life**
- **better quality in terms of azadirachtin content**
- **easier to fulfil the registration requirements since they contain no oil or additional substances**
- **easier to formulate**
- **homogenous quality (do not vary much from batch to batch)**
- **higher concentration of azadirachtin, which is required to control certain pests**
- **less phytotoxicity by eliminating undesirable by-products such as wax**
- **possible use of the extraction plant for other products**

Disadvantages:

- **higher investment required**
- **more sophisticated technology**
- **technology protected by patents and therefore often not available to small entrepreneurs**

By applying special extraction procedures or further enrichment steps for alcoholic extracts, e.g. by fluid/fluid extraction, unwanted substances (such as residual oil, sugar, etc.) are separated and azadirachtin(s) and other tetranortriterpenoides are converted in an organic phase which is easy to vaporise. After recovery of the solvents a powder extract remains with an azadirachtin content of up to 20%. The powder can be stored and used on demand to formulate an emulsified extract (EC) with 3 - 5% azadirachtin A.

This sort of production technology is used by most plants processing commercial neem products on a large scale (1000 - 3000 t of neem kernels). In India these plants are often set up in joint ventures with partners of companies offering neem products in industrial countries such as the US.

The company Trifolio has developed a procedure starting from simple water extracts, but continuing with a fluid/fluid extraction with a special combined solvent and formulation liquid, which concentrates the AIs of the non-water phase and formulates them for application in the field (Kleeberg 1996).

Other technologies

There are two further technologies which are of importance in relation to neem extraction:

C) Extraction using centrifuges

This technology is used to produce high quality oils. In a further extraction step it can be used to gain azadirachtin. In a pilot plant a powder containing 15% azadirachtin has been gained from the cake.

Investment costs: approx. US$ 3.5 - 5 million for a complete plant with an annual capacity of more than 2000 t of neem kernels.

Advantages:

- **efficient exploitation of azadirachtin**
- **stable powder product**
- **neem oil, free of bitter principles**
- **technology can be used for other oils (e.g. castor oil, etc.)**

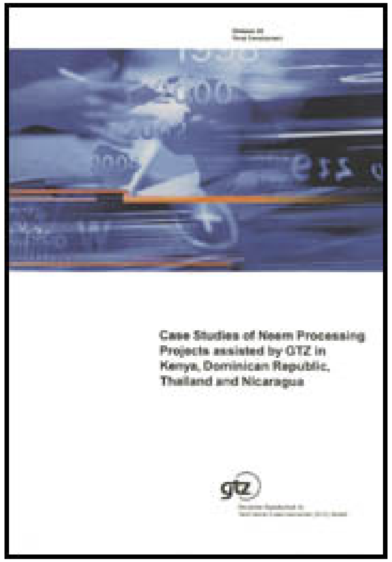
Disadvantages:

- **very high investment costs**
- **only profitable on a large scale**
- **complicated technology**
- **no experience concerning scaling with neem**
- **additional solvents are required.**

D) Extraction with Supracritical CO2

This technology has recently been used in India in a joint venture with a German company and is considered a very "elegant" technology from the technical point of view.

The technology is relatively environmentally friendly, using CO_2 under high pressure and a transport carrier. The investment costs are quite high, at approx. US$ 3.5 million. Very little is known about experience with this technology so far.



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3. Investment costs of setting up a neem-processing plant

The details below provide a rough idea of the investment costs required to set up production plants. The costs depend greatly on the local market conditions and are presented in more detail in the case studies from the different countries.

Seed processing:

Depulping manually US$ 5 - 20/farmer

Or:

Semi-industrial wet depulping under shelter and drying on sieves, optional drying device

Building	US$	20,000 - 40,000
Land purchase	US$	5,000 - 10,000
Infrastructure		
(power, water supply, roads, etc.)	US$	2,000 - 5,000
Machinery (depulping, washing)	US$	2,000 - 10,000
Drying device	US$	3,000 - 5,000
Sieves	US$	1,000 - 4,000
Other	US$	1,000
	US$	34,000 - 85,000

Dry processing:
Manufacturing of ground neem seeds or neem cake

Hammer mill	US$ 2,000 - 5,000

Manufacture of ground neem kernels:	
Thresher/decorticator	US$ 3,000 -15,000
Hammer mill, see above	
Production of neem oil:	
Thresher/decorticator	see above

Oil expeller,	US$ 5,000 - 50,000
Hammer mill, see above	
Manufacture of formulated oil:	
Sealed stirring unit	US$ 1,000 - 3,000
Water bath	US$ 400 - 800

Small one-step extracting plants for 100 - 200 t of neem seed capacity require an investment for the machinery of US$ 30,000 - 100,000.

For decentralised oil production various manufacturers are offering different screw expellers. It is however important that the oil is cold-pressed, meaning not more than 70 C for a longer time period, and that the screw does not wear out too fast due to the hard neem shell.

A survey of different oil expellers is given in the following table (Table 5):

Table 5: Price and characteristic data of different oil expellers

Type	Manufacturer	Capacity (kg seed/h)	Power supply (kW)	Price (US$)	Remarks
AP VII	Reinartz (Germany)	70	9	16,000	
DD 85	IBG Monforts (Germany)	47	3	12,000	including 2 snail screws
OP 100	Heger (Germany)	100	4	18,200	including spares
PO 101	Keller (Germany)	100	7.5	13,000	

FO 101	Keller (Germany)	100	7.5	15,000	
Multipress 80	Bauss (Germany)	80	5.5	15,000	
Multipress 60	Baus (Germany)	60	4	10,000	
Type 52	CeCoCo (Japan)	40	2.2	11,000	
H 54	CeCoCo (Japan)	90	7.5	21,000	
Mini 40	Rosedown (GB)	40	4	6,500	
16" × 4"	Tinytech (India)	90	5.6	1,500	
6 bolt 24" × 4"	Rajalaxmi Eng. (India)	65	7.5	1,000	
4 bolt 18" × 3"	Rajalaxmi Eng. (India)	35	5.5	500	
Sundhara 3,4	DCS Butwal (Nepal)	60	3	1,500	

Source: FAKT 1996

Further investment required:

Scales:	US$ 200 - 500
Bottling equipment:	US$ 400
Glassware and small equipment:	US$ 1,000
Storage room:	US$ 500 - 1,000
Sealing unit for plastic bags:	US$ 300 - 1,000

Costs of building, including the land area and infrastructure: US$ 50,000 - 100,000

The extraction plant set up with GTZ assistance in Myanmar in 1985 cost about US$ 270000. The capacity was about 300 kg of neem cake. An extract of 2 - 2.5% azadirachtin was produced.

The extraction plant of the Trifolio company required an investment of US$ 100 000 - 200 000 for the machinery and equipment. Daily about 0.4 to 1 tonne of neem was produced (an annual capacity of 2.5 - 7 t Neemazal F). The costs of the building were between US$ 25 000 and US$ 50 000, and of the installation another US$ 120 000 - 25 000. A larger plant with the same technology but a daily capacity of 3600 kg neem kernels and a production of 60 - 159 l Neemazal F requires an investment of US$ 550 000 to US$ 1.35 million (Kleeberg 1996).

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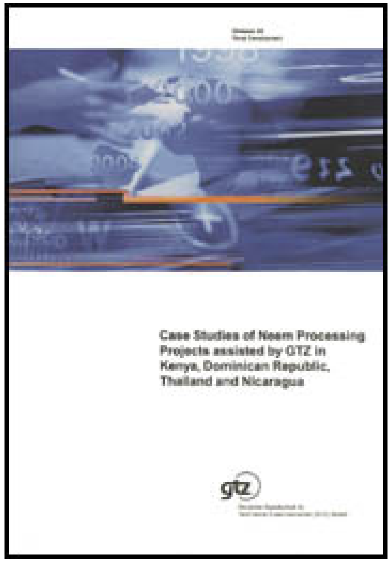

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4. Case studies of small-scale semi-industrial neem processing in Kenya, Thailand,

the Dominican Republic and Nicaragua

Comparison of selected countries

For this study we selected four countries representing the conditions for neem processing on each of the continents considered. It is, however, difficult to find a representative country in Asia; the situation of Thailand for example is very different to that of India or Indonesia.

Nicaragua has been added although no assistance in the strict sense has been given directly to the neem manufacturer, but traditionally good working relations exist.

The backgrounds of all these projects vary, not only due to the varying abundance of the neem tree, the ethno-social environment and size of the pesticide market, but also due to political and economic frame conditions in the individual countries. Some characteristics are presented in Table 6.

Table 6: Characteristics of the agricultural sector in Thailand, Kenya, the Dominican Republic and Nicaragua

	Thailand	Kenya	Dominican Republic	Nicaragua
Population	54.5 million	21.5 million	7.9 million	4.5 million
GNP/capita	US$ 2960	US$ 320	US$ 1600	US$ 380
Agric. production as a % of GNP	11%	29%	13%	35%

% of population working in agricultural sector	57%	78%	15%	22.4%
Insecticide market	12 800 t (1998) imported + 6500 t local products	1 800 t insecticide 22% = US$ 9.7 million	1000 t, value US$ 6.8 million	US$ 8.2 million
Share of insecticide market covered by neem products (value)	?	0.24%	0.25%	?

The data indicate quite clearly that Thailand has the largest pesticide market in terms of quantities and value.

While in Thailand the government is strongly supporting and promoting the use of low-residue locally produced alternative pesticide products, the policies in the Dominican Republic, Nicaragua and Kenya favour high-input agriculture based on agro-chemicals. Only recently has there has been a slight policy change due to pressure from the World Bank and other donors.

Thailand on the other hand also has considerable local pesticide production, while no such production exists in the Dominican Republic, and only a small *Pyrethrum* industry exists in Kenya, amounting to about US$ 1 million annually.

Compared to the three other countries the contribution of the GTZ to the neem processing activities in Nicaragua is marginal and consists mainly of testing neem products within IPM concepts.

Nonetheless there are quite a number of similarities between the other three

countries:

- **All of them export considerable quantities of agricultural produce to industrialised countries.**
- **In all three countries the pesticide market can be classified as "liberal".**
- **A small number of (international) agro-chemical companies share most of the market.**
- **Pesticide use has increased considerably in recent years, driven by population increase and subsequent shortage of land.**
- **In all three countries agricultural production is relatively intense, which also means that all three countries have the same problems such as resistant pests, contaminated resources and intoxicated labourers, and problems with high levels of pesticide residues on crops.**

Table 7 indicates the formal structure of the partners, the availability of the raw material and the form of GTZ assistance.

Table 7: Partners, source of neem, form of assistance provided by GTZ

Country	Partners	Source of neem raw material	Assistance
Thailand	Entrepreneur Thai Neem Products Ltd	Thai-Neem, *A. indica* and imports	CiM/DoA
Kenya	Entrepreneur Saroneem	Locally available	GTZ/ICIPE

	Biopesticides Ltd		
Dominican Republic	NGO FAMA	Locally available and imported	GTZ/CIM/Deutsche Welthungerhilfe
Nicaragua	NGO Copinim, DoA	Locally available	NGO "Stiftung Umverteilen", other NGOs, GTZ

Our partners are in Thailand a small-scale family manufacturing firm, exclusively engaged in neem processing; in Kenya a company previously in the conventional agricultural supply business for about 40 years, but now putting emphasis on bio-pesticides; and in the Dominican Republic an NGO whose pesticide activities are focused on neem. However, the latter also conducts some activities in the field of sustainable agricultural training.

All neem-processing units investigated are relatively small, often family-run ventures. There are further firms (in addition to the one mentioned offering neem products in Thailand) which also offer locally produced neem pesticides, but these have no standardised azadirachtin content.

The following table shows some characteristic data of the plants:

Table 8: Description of the potential capacities of the processing units in Thailand, Kenya, the Dominican Republic and Nicaragua

	Thailand	Kenya	Dominican Rep.	Nicaragua
Staff (1998)	5+4 labourers	2+3 labourers	2.5 + 4 labourers + 1-2 technicians	2 + labourers on demand

Potential:				75 t
Neem cake	59 t	42 t	12.5 t	
Alcoholic extract	44 t	Combined oil + alcoholic extract 42 t		25 t
Formulated neem oil	4.4 t		12.5 t	75 t

We still hope that some general principles, difficulties and constraints - but also solutions -are illuminated by these case studies which may help to avoid mistakes in other countries if similar projects are going to be started (either by private entrepreneurs or technical cooperation organisations) and that these studies help others to learn from our experience.

4.1 Kenya

Documentation of neem activities in Kenya with special reference to "SMALL-SCALE INDUSTRIAL PRODUCTION OF NEEM-BASED PESTICIDES IN KENYA" compiled by A. M. Varela, H. Quentin and P. Foerster with the assistance of D. Rocco.

4.1.1 Introduction, previous activities and other projects in Kenya in relation to neem

Neem was introduced into Kenya, in eastern Africa, during the 19th century by East Indian immigrants, who propagated the tree essentially for its medicinal properties. Until recently, local knowledge about the tree's uses was still limited to traditional beliefs in curative properties, in particular for the treatment of

malaria, stomach problems, fever, colds, chest complaints and skin disorders. The leaves and/or bark and roots are boiled and used as tea or applied directly to the affected area. Neem twigs are also used as toothbrushes.

Currently the tree is grown in large numbers along the coast, where it is locally known as "Mwarobaini" the tree of forty cures. In addition to its medicinal properties, it is used as a mosquito repellent, firewood, shade, windbreaks, boundary delineation and reforestation. The timber is used primarily for making furniture. People have gradually learned about neem's potential for reforestation, timber, firewood and as an insect repellent, and more recently as a pesticide as research and awareness campaigns on the potential of neem are being conducted in Kenya. The results are disseminated through agricultural extension services and organisations such as the Deutsche Gesellschaft fr Technische Zusammenarbeit (German Technical Cooperation, GTZ), the International Centre of Insect Physiology and Ecology (ICIPE), and several non-governmental organisations (NGOs) (see also Foerster & Moser 2000).

In Kenya, some people use a concoction of leaves for spraying their vegetables and ornamental gardens. A large farm, Baobab, located near Mombasa, has been experimenting with neem for more than twenty years. Leaves are used as protective mulch for vegetable plants as well as to control weevils in maize storage. A mixture of neem oil and water is sprayed onto the plants. The cake is mixed directly into the soil as protection against nematodes (DM 1994).

Research on the use of neem was limited before the 1990s. In 1991 ICIPE started trials on the use of extracts of neem bark, seeds and leaves for controlling ticks and tick-borne diseases. Ticks, as disease vectors, are a serious threat to livestock

in Africa. These extracts showed potential for controlling the juvenile stages of the major tick species.

Major activities on neem started in August 1994, when ICIPE received funding from the government of Finland and the United Nations Environment Programme (UNEP) to start a project on neem. The project objective was building awareness of the potential uses of the neem tree among agricultural and forestry trainers, extension personnel, health workers, and representatives of NGOs.

Training courses and seminars to create awareness about uses of neem were held at Mbita Point, an ICIPE field station on the shores of Lake Victoria. The courses covered possibilities for production, application and commercialisation of neem products in Africa. This project trained over 650 people, and demonstrated the "standard" technology, using a cold-press oil expeller for the production of neem cake and oil. In addition research has been supported to investigate the effect of neem against pests of banana, maize and cowpea (Saxena 1997, Musbyimana & Saxena 1999).

Trials to determine the efficacy of neem-based products and their performance compared to commercial insecticides for the management of agricultural pests, have been conducted in collaboration with the Kenya Agricultural Research Institute (KARI). For example, trials on cowpeas were carried out at the KARI station at the coast (Mtwapa). Furthermore, there have been studies on neem products for management of ticks.

In September 1995, the GTZ Pesticide Service Project offered a training course for technicians in extraction and bioassays of biologically active plant products. The

course was held in Nairobi with participants from several countries in the region.

4.1.2 Situation found prior to the project for neem industrialisation

Abundance of neem trees

Kenya has good potential for growing neem. Based on a conservative GIS analysis with rainfall, altitude and soil characteristics as parameters it is estimated that over 25% of the land area in Kenya is suitable for growing neem (DM 1995). The tree is currently found across Lamu, Taita Taveta, Kilifi and Mombasa Districts in the Coast Province. About 30-year-old stands of neem trees are present in Wajir, Mandera and Garissa in the North Eastern Province. Neem trees are also found around Lake Magadi.

There is no available information on the exact number of trees growing in Kenya; however, it can be estimated that several million stems are fruiting in the country. In a preliminary survey done by DM (1995), neem trees were found to be common along the coast. In Lamu District, most trees were found bordering plots of land, around schools and along roads. In Taita Taveta District trees were widely dispersed throughout the district. It was estimated that an average of one to two trees could be found on most homesteads in Mwatate Division. In Kilifi District, hundreds of mature neem trees can be seen on either side of the main road all the way to Malindi. In Mombasa District neem was present within Mombasa City centre, around government offices and in residential areas. Large numbers of neem trees are also found along the main road to Mtwapa. In North Eastern Province, the tree is confined to settlements. So far the tree has not been planted on plantations.

Neem seeds

Several organisations have been purchasing seeds for propagation and processing. For example, the Kenya Forestry Research Institute (KEFRI) is active in the collection and dissemination of neem seeds to farmers. Collection and germination of seeds is organised by the KEFRI research station at the Coast. The KEFRI headquarters in Muguga sells the seeds to farmers. The Kenya Forestry Seed Center has distributed neem seeds to farmers in the dry areas of Western Kenya. The ICIPE Awareness Project has also purchased seeds for propagation and for processing in order to produce material to be used in trials. Seeds and seedlings are being sold at Mbita Point, ICIPE's field station on Lake Victoria.

The Kenya Institute of Organic Farming (KIOF), a member of the International Federation of Organic Agriculture Movements (IFOAM), is promoting the dissemination of the existing local knowledge of the potential use of neem leaves, seeds and bark for plant protection, and conducting demonstration trials.

Processing activities

As stated earlier, the neem tree has been mainly used for shade and for its curative properties, using the leaves and the bark. Seeds have been occasionally collected for sale, mainly for propagation purposes and not for processing. As a result, no machinery has been developed specifically for neem processing. Baobab Farm uses a locally available hand press to extract neem oil from entire seeds, extracting about 2 l of oil per 100 kg of clean seeds (DM 1995). The ICIPE Awareness Project at Mbita Point uses an imported "Comet" oil expeller (manufactured by Monforts, Germany), which, although locally available, is costly.

More affordable Indian-made oil mills are locally available; however, the quality of the steel would have to be taken into consideration to determine their suitability for neem processing because the neem seeds/kernels are quite abrasive. For instance, even the spindle of the Comet oil expellers, although made of a special steel, has to be replaced after processing about 10 tonnes of neem seed/kernel (D. Rocco, personal communication).

Need for neem products to manage pests in Kenya

Although the issue of pesticide residues is not considered in the Plant Protection Act of Kenya, and no regular control of residues is carried out on horticultural produce for the internal market, concerns about the levels of pesticide residues is increasing. KARI, through the Pesticide Chemistry Laboratory, has lately conducted studies on pesticide residues on crops such as tomatoes (Ngatia et al. 1996). The pesticide Chemistry Laboratory, formerly under the Kenya Agricultural Research Institute (KARI), and now under the Kenya Plant Health Inspection Service (KEPHIS), is also a pesticide residue level testing facility, used mainly for the horticultural export market.

The production of simple, home-made pest control products from the neem tree has been considered an attractive option for the resource-poor farmer in developing countries such as the majority of the Kenyan farmers. However, as in other countries the Kenyan farmers mentioned the various shortcomings (Moser 1996, Foerster & Moser 2000) listed in Chapter I and the majority of the farmers prefer ready-to-use pesticides.

Apart form this local commercial production and marketing of neem-based

pesticides were expected to show the merits and benefits listed in Chapter I.

4.1.3 The beginning of small-scale commercial neem production

In 1994, the GTZ-IPM Horticulture Project (GTZ-IPMH) in Kenya directed its attention towards neem as an alternative to synthetic pesticides, in the context of integrated pest management programmes (IPM), to increase production of horticultural crops for export and local consumption in an environmentally sound and economically viable manner (Loehr et al 1997).

Based on experience from other countries, GTZ-IPMH focused its efforts on establishing a small-scale industry for producing simple, ready-to-use neem-based pesticides.

As a first step the GTZ IPMH project funded two feasibility studies, which were conducted in the coastal area in Kenya during 1994 -1995. The aim of these studies was to determine the economical and technical feasibility of producing neem-based pesticides. In January 1996, a local agrochemical company called Saroc Ltd (today: Saroneem Biopesticides Ltd) was contracted to organise the first commercial seed collection and to establish a pilot processing unit for extraction of oil from neem seeds. When these studies showed that Kenya had good potential for growing neem and first experiences were gained with processing and seed collection, measures were taken by IPMH and the Pesticide Service Project to initiate a separate project. This was started in mid-1996, as a two-year project called "Small scale industrialisation of neem-based insecticides in Kenya", funded by the GTZ and set up at ICIPE. The aim of this project was to produce simple, standardised, neem-based pesticides which could be purchased on the market at

competitive prices.

ICIPE contracted Saroc Ltd to organise collection of seeds, to develop neem-based pesticides and to coordinate marketing of the products. A part-time scientist was contracted by ICIPE to coordinate research on the efficacy of the developed products and to generate the necessary information for registration of the developed products.

The main activities and business of Saroc are confined to the formulation of imported pesticides, mainly fungicides based on copper, and importing fertiliser for the east African market. At the end of 1999 the conventional agricultural supply wing was separated off and sold, while the neem-processing wing continued to operate under the name of Saroneem Biopesticides Ltd (for more data see: "description of the plant", below).

Development of neem products

- **Seed collection:**

The peak fruiting season in coastal Kenya and Tanzania is from March to May, which coincides with the rainy season. It was found feasible to organise collection of seeds through existing organised groups, especially women's groups, which expressed interest in a collection scheme. However, the feasibility studies concluded that the success of seed collection depended on several factors, such as:

  - **educating and familiarising local residents with neem and its use as an insecticide well in advance of the fruiting season;**

- **training on collection, cleaning and drying of neem seeds;**

- **setting the prices to take into account factors such as seed availability, wage levels for casual workers, the amount of time required, and opportunities of alternative sources of income. This should involve discussion with other organisations collecting seeds (DM 1994, 1995).**

Collection started in 1996, when Saroneem Biopesticides Ltd staff met with representatives of the local authorities and rural farmers' organisations, women's groups and pupils from primary and secondary schools. The aim was to identify, motivate and train potential collectors. It turned out that schoolchildren made excellent multipliers, since they pass on their knowledge and information to their families.

During the first collection it was found that a further factor was crucial to seed collection, namely creation of confidence between the collecting communities and the purchaser. Due to bad experiences in the past, villagers were extremely cautious and were not prepared to work if they were not fully assured of payment. Nevertheless, almost 7000 kg of seeds were collected by women's groups, schools, and local farmers. The seeds were then transported to Nairobi for processing (Rocco 1996).

Saroneem Biopesticides Ltd organised meetings in the coastal area and in the north-eastern region to inform the local population of the possibilities of earning money through seed collection, and to train them in harvesting, cleaning and drying the neem seeds. However, no collections were made in the north-eastern region due to the high costs of transporting the seeds to Nairobi. Thus, seed

collection was concentrated along the coastal region in Kenya (Kilifi and Malindi Districts) and Tanzania. The average distance to the neem processing plant is about 730 km.

A series of local organisations, women's groups, farmers and their families as well as inmates of prisons were involved in seed collection. Since the harvest period coincides with the period of heaviest rains along the coast, special attention had to be given to the proper storage and drying of seeds to avoid fungal contamination and degradation of the seeds due to the high humidity.

Luckily, at the coast the harvest of seeds is facilitated by large colonies of fruit bats and birds, which pluck the ripe fruit off the tree, feed on the sweet pulp and then spit out the seed, which can be found lying under the tree. This saves depulping, which is a labour-intensive step in processing.

The following table (9) indicates the amount of neem seeds purchased in the last four years (since the beginning of the neem-processing activities).

Table 9: Neem kernels purchased by Saroneem Biopesticides Ltd

Year	Neem seeds purchased (kg)
1996	6,700
1997	16,755
1998	13,474
1999	31,148
Total	68,077

In each season Saroneem Biopesticides Ltd purchased the total amount of collected and usable seeds to create confidence in its collection system and motivate the farmers to collect seeds in the forthcoming seasons.

About 17 tonnes of neem seeds were collected and delivered to Nairobi in 1997. The collection in 1998 was hampered by the onset of unusually heavy and long rains at the end of 1997. Many of the flowers aborted, limiting the amount of fruit produced. Moreover, the seed quality was affected by the prolonged moisture conditions. About 14 tonnes were collected in 1998. In 1999 in total 2000 people were involved in collecting the 31 t of neem seeds. These are individuals and groups, mainly women and children, who see the collection of neem seeds as an additional source of income.

Seeds were delivered to collection points and transported to Nairobi. In 1999 the collections were organised by four agents situated in the coastal region, which purchased the collected neem seeds on behalf of Saroneem Biopesticides Ltd.

During the harvesting season the collected neem seeds are checked at the collection point, and the deliverers paid promptly. There the seeds are packed, and they are collected and transported to Nairobi twice a week.

The collectors receive 20 KSH (70 KSH = US$ 1) for 1 kg of usable neem seeds from the agents, or 5 KSH for lower quality seeds. The agents in their turn get 25 KSH for 1 kg of good quality seeds and 5 KSH as lump sum for packing and transport. The azadirachtin content was about 0.3 or 0.4% in 1999. The seeds are graded (and paid for) according to following quality criteria: contamination by

fungi, cleanliness and moisture content. Oil and azadirachtin content are not considered because they cannot be checked on the spot.

It is difficult to obtain reliable figures on the yield per tree due to the heterogeneous growing conditions. According to rough estimates, about 30 kg of neem seeds are produced by a 12-15 year old tree, and about 12 kg per tree are gathered by the collectors. The yields, however, vary from year to year according to climatic conditions. Considering younger neem trees as resource trees, about 3500 to 4500 neem trees are required to obtain 31 t of seeds.

Seeds are transported from the collection area to the district capital by private pick-ups, and from there to Nairobi by frequent buses. Transport costs for the neem manufacturing plant are 30 000 KSH/t.

For the year 2000 Saroneem Biopesticides Ltd intends to purchase 50 t neem seeds, provided sales are according to the expectations. It is considered that it is feasible to extend and intensify the collection of seeds if more seeds are required.

- **Processing**

In order to overcome the difficulties of storing seeds under the climatic coastal conditions it was decided to undertake post-harvest development in Nairobi. For this purpose a pilot unit was established.

Description of the pilot plant

The machinery used was developed and manufactured by testing and adapting local machinery for groundnut processing, with the exception of a "Comet" oil

expeller manufactured in Germany. The machinery included:

- **a groundnut sheller, modified to cope with the much smaller neem seeds, for breaking the shell to liberate the seed kernel,**
- **a winnower to separate the kernels from the shell,**
- **an oil expeller to extract the oil from the kernels (later a double spindle oil expeller with a higher processing capacity was added),**
- **a hammer mill to crush the neem cake,**
- **an automatic packing machine.**

The main problems faced during processing were:

1. **Drying of seeds was difficult under the prevailing weather conditions and in the limited space available at Saroc Ltd in Nairobi. It was found that oil extraction was very limited unless the kernels were properly dried.**

2. **Crushing neem kernel cake alone was not easy as it jammed the hammer mill. This problem was solved by mixing the neem kernel cake with neem shells.**

3. **Contamination of neem products was possible since the company was producing agro-chemicals under the same roof.**

4. **The lack of equipment for analysis of azadirachtin hampered the**

formulation of standard products.

After these initial experiences the pilot unit developed by Saroc was moved to ICIPE headquarters in Nairobi. A section of the former livestock centre was made available for the processing unit. It consisted of a large covered shed of about 600 sq m, a large enclosed room, an office and a laboratory block. The covered shed was suitable for drying and shelling the seeds, whilst processing, formulation and packing could be restricted to the enclosed area, thus minimising the risk of contamination.

The processing capacity was later increased (see above).

Formulation of neem products

Pesticides for seed treatment, soil treatment and foliar spray were developed based on neem kernel cake powder and neem oil. Processing of neem seeds into pesticides includes the following steps:

1. Disinfecting and drying the seeds: the seeds are treated with a solution of calcium hypochlorite to prevent fungal growth and subsequent aflatoxin contamination.

2. Drying the seeds: the seeds are spread in thin layers and exposed to the sunshine. During the evening the seeds are covered with polyethylene sheets.

3. Threshing the seeds: 50% of the seeds are passed through a modified groundnut sheller to liberate the kernel from the seed shell.

4. Winnowing: a fan blowing through a constricted space is used to separate shells from kernels.

5. Extraction of oil: a mixture of kernels and seeds is passed through the mill. Trials on the most effective ways of extracting oil from the seeds showed that a mixture of 2/3 kernels to 1/3 shells maximised the extraction of oil.

6. Filtering the oil produces the pharmaceutical by-product "Neemsar "O" "The neem cake can be either used to produce neem powder or for alcoholic extraction. The quantity depends on the demands for the specific product lines.

7. The azadirachtin content in neem cake is quantified using high performance liquid chromatography (HPLC) at the chemistry department of ICIPE. Standardisation of azadirachtin A content in neem cake powder is achieved by reconstituting the neem cake with neem seed shell in appropriate proportions. A hammer mill and mixer are used to grind and mix neem kernel cake and shells. The final product is a neem powder of 0.5% azadirachtin, called "Neemros 0.5% Powder".

8. For alcoholic extraction the neem cake stays in an alcoholic extractor for 8 h. 100 l of alcohol is required for 130 kg cake. The alcohol percolates continuously through the cake, extracting part of the remaining neem oil and other active ingredients. The plant in Kenya has been using isopropanol (isopropyl alcohol), due to its easy availability and cheap price (but it is now using ethanol).

9. The neem oil (32%) is combined with alcohol (63%) and an emulsifier (5%). This marketable product, an emulsifiable concentrate, is sold under the trade name "Neemroc EC 0.03% W/W".

10. The extracted cake mixed with neem shells in a ratio of 1:1 is milled with a hammer mill and can be sold as organic fertiliser. To date Saroneem Biopesticides has not traded this product.

11. Formulation of neem products: pesticides for seed treatment, soil treatment and foliar sprays were developed based on neem kernel cake powder and neem oil. Two formulations were developed:

A) Neemros: Neem cake powder (NCP) standardised at 0.5% azadirachtin and

B) Neemroc EC oil: a water-miscible oil with 0.03% azadirachtin. For clarification the processing of neem cake is explained below:

The shells are removed from 1 t of neem seeds. The shells make up about 25% of the seeds' weight, coming to 250 kg. From the remaining 750 kg kernels 120 kg cold neem oil is pressed (16%). This leaves 630 kg neem cake which is mixed with 100 kg neem shells for technical reasons. Together the neem cake and seed shells amount to 730 kg of neem powder.

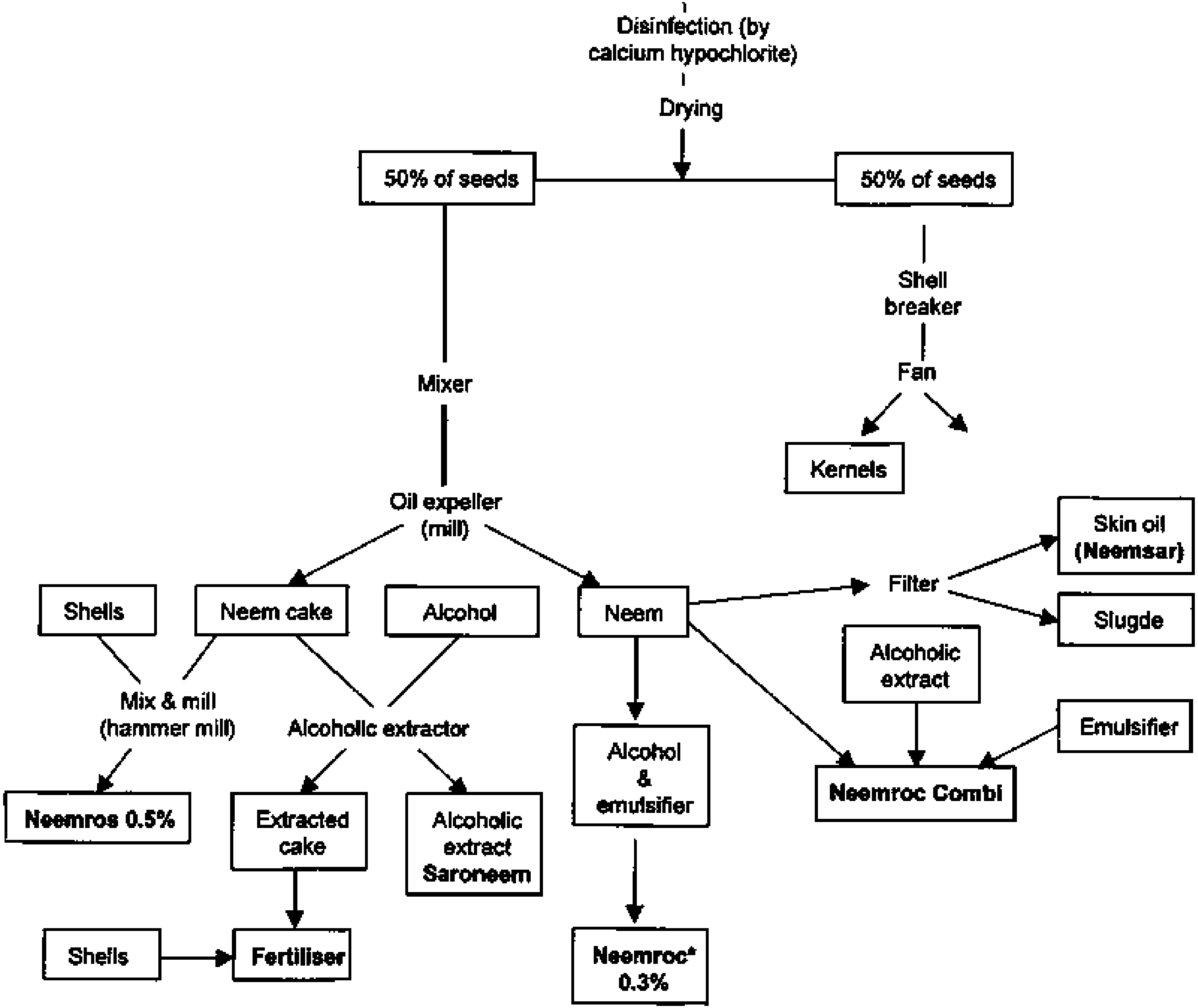

Disinfection (by calcium hypochlorite)
Drying
50% of seeds
50% of seeds
Shell breaker
Fan
Kernels
Mixer
Oil expeller (mill)
Skin oil (Neemsar)
Filter
Slugde
Shells
Neem cake
Alcohol
Neem
Alcoholic extract
Mix & mill (hammer mill)
Alcoholic extractor
Emulsifier
Neemros 0.5%
Extracted cake
Alcoholic extract Saroneem
Alcohol & emulsifier
Neemroc Combi
Shells
Fertiliser
Neemroc* 0.3%

Figure 3: Processing of neem seeds into pesticides includes the following steps:

***Officially Neemroc has a minimum azadirachtin content of 0.03%, although it is usually higher than this.**

In 1999 Saroneem Biopesticides Ltd purchased 31 t of neem seeds and from this manufactured the following quantities of marketable products:

Table 10: Expected output of marketable neem products

Raw material: 31 t neem seeds	
Product	**Output**
Neemroc	10,000 l
Neemros	10,000 kg
Neemsar "O"	60 l
Organic fertiliser	10,000 kg

The above data concerning marketable products could vary according to the demand. The figures are estimates based on the experience gained in previous years.

Quality Control

Quality control takes place with regard to the following components: aflatoxin (not desired) and azadirachtin content (desired, should be as high as possible).

The seeds are checked for contamination with the storage fungus *Aspergillus spp.* The absence of aflatoxin in the seeds and in the finished products (neem oil, neem cake and neem powder) is regularly monitored (twice a month) at the chemistry department at ICIPE. The technician in charge of the analysis at ICIPE took part in a training course in extraction and bioassays of biologically active plant products, offered by the GTZ Pesticide Service Project in 1995. During 1996-1997 duplicates of some samples were sent for analysis to Trifolio-M GmbH in Germany for the sake of comparison.

The shelf-life of the products was determined by monthly HPLC azadirachtin A analysis of stored products and seeds. The changes in content of azadirachtin A in neem cake powder, stored at room temperature, during a ten-month period ranged from 0 to 30% reduction. The analyses showed that azadirachtin A was better conserved when the seeds were stored and then processed as needed.

The following table (11) provides data on azadirachtin and aflatoxin content according to the quality control laboratory at ICIPE in the latest analysis of products from Saroneem Biopesticides Ltd:

Table 11: Results of the quality analysis of Saroneem Biopesticides Ltd products in October 1999:

Product/material	Azadirachtin	Aflatoxin (mg per g)
Neem cake	5	below the limit of determination
Neem powder	3.9	below the limit of determination
Neem oil	0.2	not detectable

Filtered neem oil	0.2	not detectable
Neem seeds	3.2	below the limit of determination

The quality criteria for marketable neem-based pesticides are defined as follows:

- **constant azadirachtin content**
- **constant consistency**
- **reliable efficacy against pests**
- **aflatoxin content below defined limit**

- **Registration of neem-based pesticides in Kenya**

All pesticides to be used in the Kenya have to be approved by the Pest Control Products Board (PCPB), the authority established by the government of Kenya to take care of pesticide regulation. The requirements for registration of plant derivatives are the same as for synthetic chemicals. Information on chemical composition, toxicity and efficacy is required. Efficacy trials can only be conducted by institutions recognised by the PCPB. The costs of efficacy trials conducted by governmental institutions such as the Kenya Agricultural Research Institute (KARI) have to be covered by the company making the application. Other institutions charge a fixed fee for conducting efficacy trials. Once all requirements are met, a fee of KSh 10,000 (about US$ 140) per product has to be paid for provisional registration and 30000 KSh (ca. US$ 400) in order to apply for permanent registration.

Applications for the registration of the two products, Neemros® and Neemroc® were presented to the PCPB in 1996. Information on the chemical composition and

toxicology of neem and neem products was gathered from the literature and from information provided by the GTZ Pesticide Service Project.

Field and laboratory trials of the efficacy of the two products for the control of key pests of several crops were conducted. These trials were also intended to determine the frequency of application and effective rates of application that are economically competitive with other available pesticides. The trials on horticultural crops were carried out in collaboration with the GTZ-IPMH Project, the ICIPE-USAID Export Vegetable IPM Project, and the Kenya Agricultural Research Institute (KARI), as well as fruit, vegetable and cut-flower growers. Trials on maize and banana were conducted by the ICIPE Neem Awareness Project. Some of these studies were done as MSc theses by students from local and German universities under the supervision of scientists from ICIPE and the respective university.

A temporary Certificate of Registration for Neemroc® and Neemros® for use on horticultural crops was issued by the PCPB in March 1998. Further information on efficacy of the products in the field and effects on non-target organisms might be required in order to get a permanent certificate of registration.

At the end of 1999 Neemroc and Neemros were provisionally registered for horticultural crops.

These products are being tested, but are not yet registered in Kenya for potatoes/tobacco.

- **Vegetables and fruits**

- **Flowers and ornamentals**
- **Potatoes**
- **Tobacco**

- **Results of the efficacy trials**

Pests of brassica crops

Foliar applications with Neemros® water extracts at concentrations of 25 and 50 g/l, and Neemroc® at 1 - 3% have compared favourably with the *Bacillus thuringiensis* products Florbac and Dipel, for control of the diamond-back moth, and with Karate for control of aphids on kale and cabbage in greenhouse and field experiments (Ksters 1998, Okoth 1998).

Pests of French beans

Foliar applications with Neemroc® at concentrations of 1 - 3% provided very good control of *A. fabae* on French beans in greenhouse trials. This aphid was also satisfactorily controlled by foliar applications of Neemros® water extracts at a concentration of 50g/l (Maundu 1997).

Pests and diseases of tomato

Foliar sprays of Neemros® of 10 - 50 g per litre of water controlled dipteran leaf miners *Lyriomyza spp.* on tomato in field experiments (Pacho, in preparation).

Aqueous Neemros® extracts at concentrations of 5 - 50 g/l inhibited mycelial growth, sporulation and germination of *Fusarium oxysporum* fsc *lycopersici.* These

applications reduced the pathogenicity of the fungus (Stanley 1998).

Dipping bare-root tomato seedlings into aqueous Neemros® extracts (50g/l) protected the seedlings when planted in soil inoculated with mycelium of *F. oxysporum* fsc *lycopersici* compared with plants dipped in water. The reduction in the severity of the disease increased as the duration of dipping increased (Stanley 1998).

Soil additives with Neemros® have proven to be promising for controlling root-knot nematodes on tomatoes. Unfortunately, conclusive data could not be obtained since the field experiments were hampered by diseases which wiped out the experimental plants.

Pests of cut flowers

In a commercial-scale trial, foliar sprays containing Neemros® at 10 - 25 g/l of water applied in combination with Trigard (whose AI is cyromazine) controlled leaf miners on *Carthamus* in a flower farm in Naivasha. A significant increase in levels of the leaf miner parasitoid *Diglyphus isaea* Walker was observed after synthetic pesticides were replaced by Neemros® in the spraying programme. Application of chemicals was reduced by 80%. Rejection of flowers due to leaf miner damage was reduced from 70% to 6%.

Management of stemborers

Products based on neem powder have proved to effectively control stemborers on maize and sorghum. This has been demonstrated in trials with neem seed powder conducted by the Neem Awareness Project. The trials were conducted at Mbita

Point and at the ICIPE field station at the coast. These results were reconfirmed in trials carried out with Neemros®. Results of trials with neem cake (NC) showed that damage and stemborer infestations on plants treated with NC were similar to those on plants treated with Dipterex and much lower than on untreated plants. Grain yields of NC-treated plants were also comparable to yields from plants treated with Dipeterx and much higher than in control plants (Anon. 1996/97).

Other potential uses of neem-based pesticides

Neem products, particularly neem-seed kernel extract and neem oil, have proved to effectively control nematodes and the banana weevil, serious pests of banana in Kenya (Musabyimana & Saxena 1999).

Trials on tobacco are being conducted by the British American Tobacco Company Group (BAT), Kenya Ltd. Trials on cotton are being conducted by an organic cotton project in Lamu District, Kenya and by the Namulonge Research Institute in Uganda.

In addition, neem-based products have shown potential for the management of ticks and tick-borne diseases on livestock in Kenya. Neem kernel extracts and neem oil are being further tested (Kaaya 1997).

Further opportunities are discussed in section IV 1.5.4 below.

4.1.4 Economic assessment of the neem processing plant in Kenya

4.1.4.1 Technical and economic description of Saroneem Biopesticides Ltd

There is only one manufacturer of neem-based pesticides in Kenya, Saroneem Biopesticides Ltd (formerly Saroc Ltd). The company is processing neem pesticides in a one-step extraction plant (see section II.2.3).

The following provides key data on the neem-processing plant in Kenya:

Location of the plant: on the outskirts of Nairobi at Technoparc of the "Centre of Insect Physiology and Ecology (ICIPE)".

Owner: Saroneem Biopesticides Ltd is owned by Mr Dorian M. Rocco, Nairobi. The building and land at ICIPE are leased from ICIPE.

For a description of the location and list of machinery see above.

Capital invested:	US$	43,500.
Detailed breakdown:		
• Machinery & equipment:	US$	32,500
• Oil expeller:	US$	6,000
• Electric installation:	US$	500
• Raw materials:	US$	4,500

Staff:

- Number of full-time employees: 2
- Number of part-time workers: 3

The full-time staff are working in production, distribution and sales. The part-time

workers only work in production and are requested on demand, according to the orders received. Over the period from 1 October 1998 to 30 September 1999 they were employed for eight months.

It has to be taken into consideration that some of the work of packing, bottling labelling, sales and administration for the fluid neem pesticides is carried out by the non-neem-processing wing of the former Saroc Ltd.

Period of Operation:	entire year
Operating days per year:	300 days.

Production capacity per day:

potential:	440 kg neem seeds[2]
in 1999:	86 kg neem seeds[3]
per year:	150 t neem seeds

[2] Based on 360 production days per year and 24 production hours per day.
[3] Calculated average daily production for 300 days of production per year.

Based on a production capacity of 360 days annually and 24 h/day, it appears that only 20% of the potential capacity is used.

The following products can be manufactured per day, using the amount of neem seeds mentioned above:

Potential:	142 l Neemroc (see below)
and:	140 kg Neemros (see below)
or:	308 kg Neemros (see below)
actual:	33 l Neemroc (see below)
and:	32 kg Neemros (see below)
or:	51 l Neemroc (see below)
or:	72 kg Neemros (see below)

The following table (12) provides a list of the neem products of Saroneem Biopesticides Ltd. and their prices.

Table 12: Prices and neem products offered by Saroneem Biopesticides Ltd.

Product	Retail price KSH per kg or l	Wholesale price KSH per kg or l
Neemroc EC 0.03% W/W	400	330
Neemros 0.5% powder	200	160
Alcoholic extract (1.0% azadirachtin)	500	410
Unfiltered oil	300	250
Neemsar "O"	600	500
ULV formulated oil		

<u>Product description:</u>

- **Neemroc EC 0.03% W/W: for product description see page 39 above.**

- **Neemros 0.5% powder: for product description see page 39 above.**

- **Alcoholic extract Saroneem "M" 1% EC (1% azadirachtin): the alcoholic extract is used for the production of Neemros. It is sold for research purposes only and has not been registered. The product has hardly any significance at all for the profit of the company.**

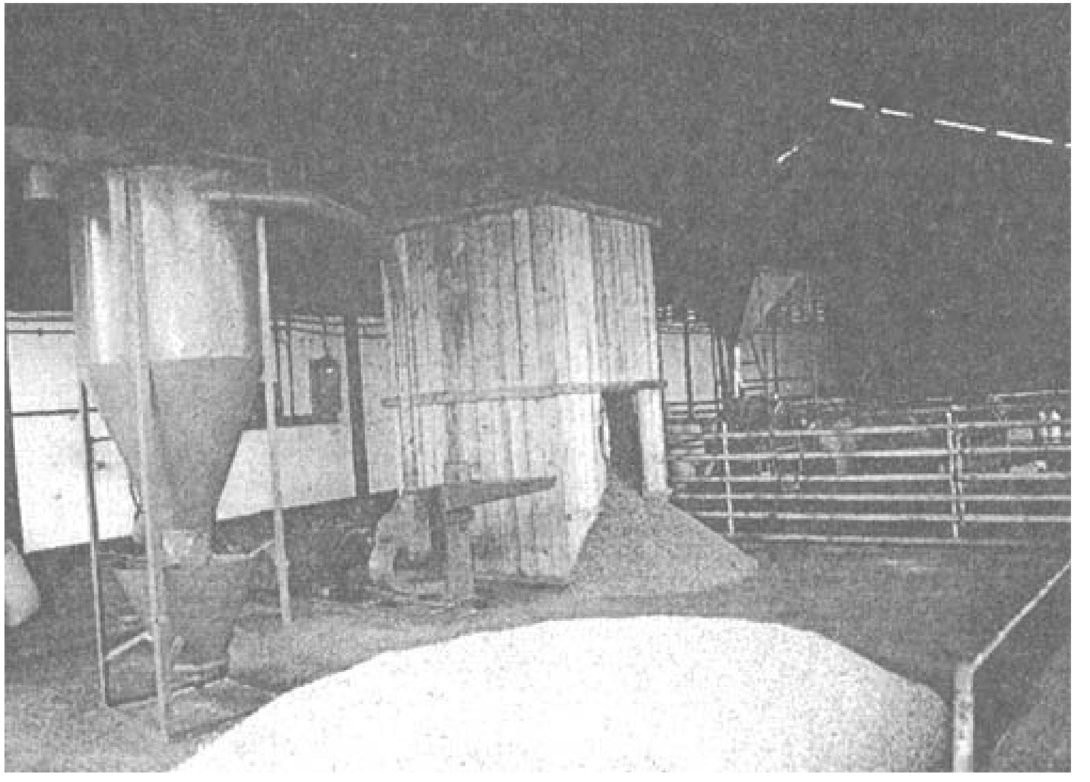
- **Unfiltered oil: this is also a raw material for manufacturing Neemroc and is only sold for experimental purposes. It has hardly any significance at all for the profit of the company.**

- **NEEMSAR "O": this is a filtered oil for pharmaceutical purposes and has to be regarded as a by-product. It is used as an insect repellent and to treat skin diseases such as fungal infections.**

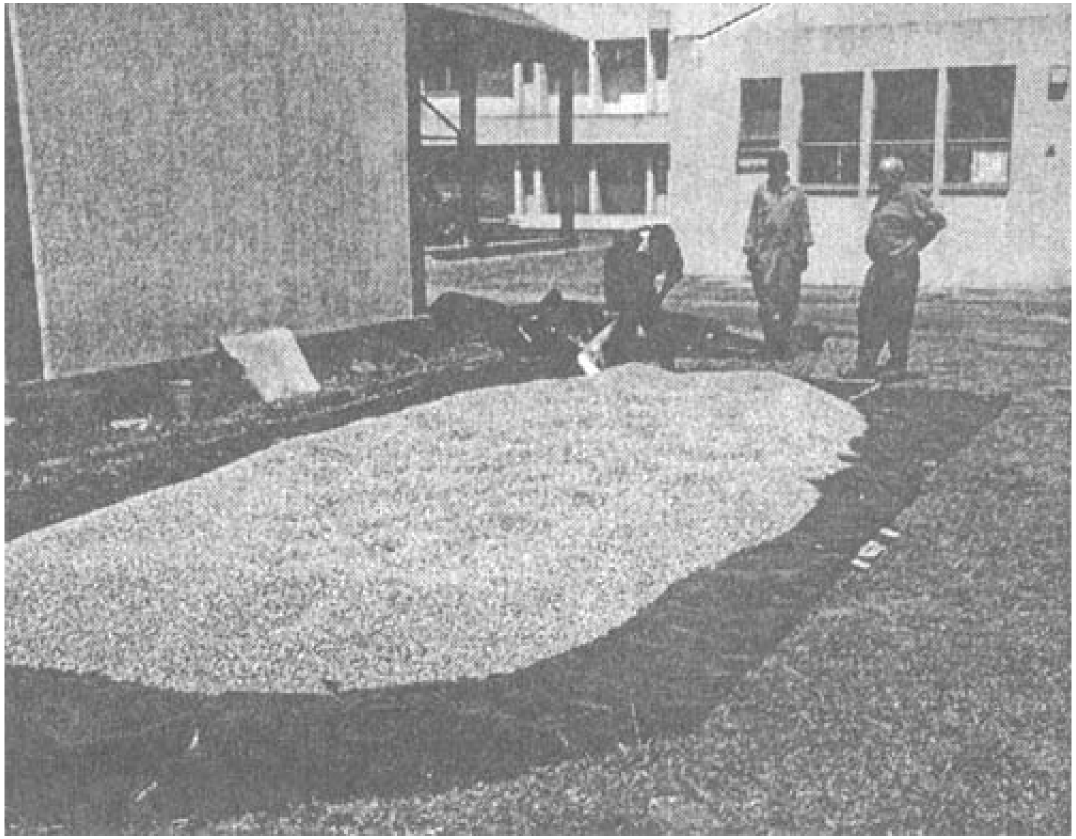
- **ULV formulated oil: this product is based on neem oil and is used for experiments in mosquito control by application to water. Currently the product is under investigation.**

At the end of 1999 the following products were of commercial and economic relevance for the company:

Neemroc, Neemros, and to a certain extent Neemsar "O" (skin oil).



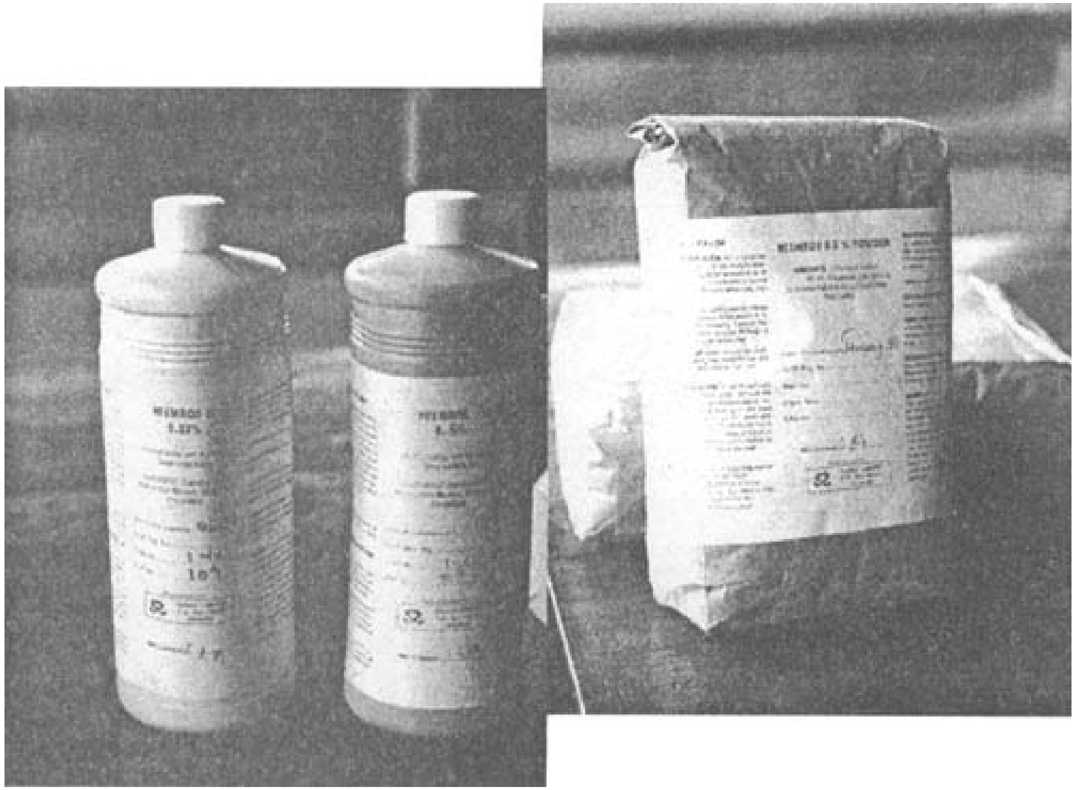
SARONEEM BIOPESTICIDES' neem-processing unit at Techno Parc, ICIPE



Drying neem seeds at ICIPE

Cold pressing of neem oil

Labelling and packing a mosquito-repellent based on neem oil



SARONEEM BIOPESTICIDES' registered neem products: standardised formulated neem oil and neem cake powder

4.1.4.2 Production costs

Investment and fixed costs

Saroneem Biopesticides Ltd has rented a plot of land and a building, including the technical equipment, from ICIPE. The company has to pay for any maintenance and investments in new equipment. This is important for an economic evaluation since Saroneem Biopesticides Ltd did not have to pay the costs of land and building etc but has to take into consideration the depreciation of the old

equipment. The present value of the buildings, including installations and the land is approx. KSH 5,000,000. Although the value of the buildings is of little interest, since no depreciation take place, their estimated value is provided for information.

Table 13 provides information about items of capital expenditure, technical equipment, specifications, cost of purchase and present value including the annual depreciation.

In Kenya it is customary (and also required by the tax laws) to depreciate the cost of investment items by 25% p.a, in a degressive way. This leads to the fact that at the beginning of the utilisation period high depreciation costs have to be considered, which decrease in the course of time. This calculation method was also applied here. The above listed packing machine for neem powder is not in use and therefore not considered in the depreciation.

Table 13: Technical equipment and its value

Equipment	Capacity	Cost of investment (KSH)	Actual value (KSH)	Actual depreciation	Life-time (years)*
Shell breaker	20	30,000	7,000	1,750	8
Wind-separator	200	5,000	2,100	525	8
Oil expeller DD 85 G 40	40	450,000	300,000	75,000	8
Hammer mill and	85	220,000	90,000	55,000	8

mixer					
Packing machine	200	200,000	100,000	25,000	8
Extraction plant	**	150,000	80,000	-	8
Large scale		45,000	20,000	5,000	8
Small scale		60,000	40,000	10,000	12
Bottling plant for small bottles		13,500	8,000	2,000	12
Bottles/h	200	1,500	800	200	8
Total depreciation				174,475	

*** purchase of new goods**
**** 360 kg per day**

With the exception of the two oil expellers, all investment goods are locally produced. The oil expellers were bought second-hand in Kenya. The quality standards of the technical equipment fulfil the market requirements. The prices listed in Table 14 include the costs of transport and installation.

The following table presents the calculated fixed costs of Saroneem Biopesticides Ltd for 1999/2000.

Table 14: Fixed costs of the neem-processing plant in Kenya

Position	Fixed cost per year (KSH)
Depreciation of the building	0
Maintenance of the building	0

Depreciation of machinery and equipment	174,475
Rent	120,000
Full-time staff	342,000
Issurances	30,000
Membership fee	0*
Cost for analysis	150,000
Total fixed costs	696,475

*** Membership costs were covered up to and including 1999 by Saroc Ltd and are not a specific liability of Saroneem Biopesticides Ltd.**

The most important item of the fixed costs is the full-time staff, at 49% of the total costs.

Variable costs

Table 15 provides information on the calculated variable costs of Saroneem Biopesticides Ltd for the period 1999/2000.

Table 15: Variable costs of the neem-processing wing of Saroc Ltd.

Item	Amount	Unit price (KSH)	Total price (KSH)
Raw material	31 148 kg	30	934,440

Part-time staff	3 LF, 8 months	250	138,000
Water			0
			0
Maintenance, machinery & equipment			190,000
Transport costs			50,000
Alcohol	6,300 l	50	315,000
Emulsifier	500 l	200	100,000
1 l plastic bottles	10,000 pc	12	12,000
20 ml plastic bottles	3,000 pc	4	12,000
Cardboard packing	850 pc	20	17,000
Labels	10,000	4	40,000
Paper bags	20,000 pc	5	100,000
	1,250	25	31,250
	100	50	5,000
Product development			75,000
Advertising			40,000
Administration & stationery (including telephone, postage, etc.), bottling; transport from the plant			250,000
Interest on variable costs	16% PA for 6 months		193,415
Total variable costs			2,611,105

Discussion of the costs listed above:

Detailed consideration and interpretation of each cost item reveals that there is no potential for rationalisation, in either the fixed costs or the variable costs.

The items where a potential for rationalisation usually exists are discussed below.

<u>Fixed costs:</u>

The permanent employees are necessary for production.

Both "marketing" and "sales" are underdeveloped due to a lack of personnel, and would actually require more staff.

The other fixed costs cannot be reduced; in the case of "building" and "rent" they are already lower than the usual market price.

<u>Variable costs:</u>

The flexibility of the part-time staff to be employed only when work is available does not give any leeway for rationalisation.

The investments in advertising and product development are at a very low level. Especially in this area it would be advisable to intensify the activities. However, this would increase the variable costs.

It should be emphasised that it was not easy to allocate all the costs to a specific item, for example a non-quantifiable portion of the transport and the running costs

is actually part of the advertising and product development costs. Also, the operational costs of Saroneem Biopesticides Ltd were partly covered by the non-neem-manufacturing wing of Saroc.

The interest rate referring to a six-month period is line with the market conditions and cannot be reduced. The other costs are required to keep production running and cannot be reduced either.

Production cost per unit (l/kg or 1000 l/t)

The following table presents a cost breakdown for the specific costs of one product unit.

Table 16:

Costs	Amount	Production cost (KSH)
Raw materials	1 t	30,000
Alcohol	500 l	25,000
Emulsifier	25 l	5,000
1 l plastic bottles	500 pc	6,000
Cardboard packing	42 pc	840
Labels	500 pc	2,000
Neem oil	162 l	9,120
Labour and other costs		9,500
Distribution, advertising		3,000

Production costs of 500 l Neemroc	KSH 90,460
Production costs of 1000 l Neemroc	KSH 180,920
Production costs of 1 l Neemroc	KSH 181
Contribution to covering the fixed costs and the profit of the company	
for 1 l Neemroc	
retail price	KSH 219
wholesale price	KSH 149

Table 17 shows the production costs of 730 kg Neemros.

The production costs of 1 l neem oil are KSH 60. 120 kg neem oil has a value of KSH 7200. Since this neem oil is further processed within the company, it reduces the costs of the raw material. The value for the raw material is therefore subtracted from the cost of the raw material. The costs of KSH 22 800 have to be calculated for the interim products such as 639 kg of neem cake and 100 kg neem shells.

Table 17: Production costs of Neemros:

Cost item	Amount	Production costs (KSH)
Raw material	1 t	30,000
Neem cake & shells	730 kg	22,800
Paper bags	3,000 pc*	15,000

Cardboard packing	108 pc	2,160
Labour and other costs		29,000
Distribution & advertising		5,000

*** Based on selling the total amount in 250 g paper bags. If the product is sold in greater units e.g. 2 kg, 25 kg, the costs of packing are reduced.**

Production costs of 730 kg Neemros	KSH	73,960
Production costs of 1 t Neemros	KSH	101,315
Production cost of 1 kg Neemros	KSH	101
Contribution to covering the fixed costs and profit:		
Expectation of the company for 1 kg Neemros is		
- considering the retail price	KSH	99
- considering the wholesale price	KSH	59

The next table provides details on the production costs for 1000 l Neemsar "O".

Table 18: Costs of production of Neemsar "O"

Cost item	Amount	Production costs (KSH)
Neem oil	1,000 l	60,000
20 ml plastic bottles	50,000	200,000
Labour and other costs		15,000
Distribution & advertising		3,000

Distribution & advertising		[illegible]

Costs of production of 1000 l Neemsar "O"	KSH 278,000
Cost of production of 1 l Neemsar "O"	KSH 278
Contribution to covering the fixed costs and profit of the company:	
from 1 l Neemsar "O"	
- considering the retail price	KSH 322
- considering the wholesale price	KSH 222

External costs

No external costs such as environmental damage are caused by the neem-processing plant.

Cash flow

Below is a calculation the cash flow of Saroneem Biopesticides Ltd in 1999.

From the raw material purchased the following products were manufactured:

- **10000 l Neemroc**
- **10000 kg Neemros**
- **60 l Neemsar "O".**

This has to be multiplied by the specific wholesale or retail price.

Table 19: Calculated cash flow of Saroneem Biopesticides Ltd (with non-representative cost factors eliminated):

Position	KSH
Income: total income	5,261,800
Costs:	
- variable costs	2,721,265
profit	2,540,535
+ interest on variable costs	201,575
- fixed costs	816,475
Profit (before tax)	1,925,635
+ depreciation	174,475
Cash flow	2,100,110

It is assumed that the entire production will be sold. Since most of the production will be purchased by large companies at wholesale prices (as in the past), a ratio of 30% retail prices to 70% wholesale prices is calculated.

This calculation shows that even with consideration of the representative market costs the neem plant in Kenya is a profitable business.

It should be taken into consideration that a range of further products can be developed and sold based on the present products (see section 3.1.6.4 below)

For example, it is known that extracted neem cake still contains nutrients and

other active ingredients which show a positive impact on plant growth. This could be sold as a by-product of the insecticide production. To develop this product line it would require other marketing activities by Saroneem Biopesticides. The target group for this organic fertiliser would be small farmers growing vegetables. The retail price for 1 kg of extract neem cake could be about KSH 10.

This product alone would increase the cash flow and subsequently the profit by at least KSH 50000.

4.1.5 Market potential, investment possibilities, marketing and development strategies

4.1.5.1 Marketing of neem products to date

The project has worked in collaboration with the ICIPE Awareness Project to disseminate information on the use of neem as a pesticide and on the availability of neem products in Kenya. Thus, staff involved in the industrialisation project participated as resource persons in several training workshops organised by the ICIPE Awareness Project. Information posters and products were exhibited at the Mombasa Agricultural show and an IPM exhibition organised by the IPM Working Group in Kenya. As a result, a number of contacts were established with farmers, both as suppliers of neem seeds and as purchasers of neem products. A lot of interest arose, particularly about the neem-processing unit and the fact that neem products were locally available. The production unit was always open to visitors and samples given out for testing purposes.

Contacts were made with the Kenya Institute of Organic Farming (KIOF). It was

agreed that a representative of the company would attend meetings in the Central Province to advise farmers. The neem products will be made available to them through Muthama District Cooperative Union distribution network.

As soon as there were indications that the products were likely to be registered in the near future, a concerted sales effort was undertaken by Saroc Ltd. Some larger vegetable and flower growers who were producing for export were approached and samples were offered to them for evaluation. In some cases excellent pest control was achieved and sales developed slowly.

4.1.5.2 Market potential

The current share of neem pesticides in the Kenyan market is limited due to the following factors:

- The short time since the pesticides were registered (at the end of 1998)
- Limited production capacities of the neem-processing plant
- Limited resources for advertising and distribution
- Investment required in demonstration and training

In the period from 1 October 1998 to 30 September 1999 11 t of neem pesticides from Saroneem Biopesticides were sold, with a value of KSH 2.725 million.

This resulted in a share of the market for different groups of pesticides as shown in Table 20.

Table 20: Market share of neem pesticides

Market/group of pesticides/Market segment	Market share* of neem pesticides Products in %*	
	Ref. value	**Ref. volume**
Total pesticide market	0.09	0.14
Insecticide	0.24	0.63
Market segment "General Horticulture" (not including potatoes & pineapples)		
Total pesticides		1.53
Insecticides		3.28

*** The market share has been calculated according to the volumes of registered neem pesticides; no illegally imported pesticides are considered. The real share for neem products will therefore be slightly higher.**

Besides the two pesticides registered and sold by Saroneem Biopesticides Ltd, one Indian product has been registered and application was made for registration of two other products from the US and India in 1999.

There is a certain market potential for neem pesticides in Kenya and there are many factors which support the assumptions that the demand will increase in the near future.

4.1.5.3 Analysis of Economic production with and without the use of neem pesticides

In 1999 economic analysis of horticultural and agricultural practice with and

without the application of neem-based pesticides was not easy and was based on niche applications with only a few examples. The reasons were the following:

- **Neem-based pesticides are not regularly applied in standard crop production.**
- **The market for neem pesticides is still a niche market. Neem pesticides are only applied on a few crops and under certain frame conditions.**
- **Only very few ICM or IPM concepts exist which integrate neem products; however, no evaluations from the fields were available.**

For these reasons no detailed data based on field experience were available at the end of 1999.

The current and potential market for neem-based pesticides can be defined according to following criteria:

Parameter for the application of neem as a commercial pesticide:

1.) tested and registered for crop species
2.) production methods, e.g. organic farming, IPM
3.) access to information on neem-based pesticides
4.) farm size
5.) efficacy of conventional pesticides
6.) market for agricultural and horticultural products
7.) significance of pesticide residue level on agricultural produce
8.) price compared to conventional pesticides

The different criteria are discussed below:

1.) Crop species:

Neem-based pesticides are only registered for and applied to the few crops listed above (see page 34). At the end of 1999 neem had been tried in other crop species on a trial basis only. With continued testing and registration of neem-based products in further crops against further pests, both market and demand will increase.

Also due to the limited time which has elapsed since neem products were registered and have been marketed, there is only a little experience from farming practice available. It is well known that the most important flow of information is from farmer to farmer.

2.) Production methods:

The NGO Kenyan Institute of Organic Farming (KIOF), among others, is promoting organic farming in Kenya. So far organic certification and separate market chains are not very well developed in east Africa, including Kenya. To date neem has been applied in Kenyan organic farming systems only to a very limited extent. However, there is considerable potential for integrating neem products into organic farming systems. No data is available on the total area under certification which is cultivated with the crops suitable for the application of neem pesticides. According to KIOF the main constraint for the restricted use of neem in organic farming in Kenya so far has been the limited access to neem products.

It can be stated, however that there is potentially a higher demand for neem

products in organic farming systems in the future.

No systematic integration into the ICM or IPM systems has been worked out so far, except for very few crops; nothing from the ICM or IPM has been transferred on a large scale and tested in practice. This aspect is also related to point 3 below:

3.) Access to information about neem:

Only farmers who have sufficient information on the potential and mode of action of neem pesticides apply these pesticides. Information on the following aspects is essential:

- **Which crops is the neem product registered for?**
- **Which crops can be treated?**
- **Which pests can be controlled with neem pesticides?**
- **What is the expected efficacy?**
- **What is the mode of action?**
- **Easy access to suppliers of the neem pesticides;**
- **Training and knowledge about how to apply neem pesticides.**

At the end of 1999 the following groups in Kenya were well informed about the potentials of neem:

- **farmers who had already applied neem pesticides, mainly large flower and vegetable**
- **growers;**
- **organic farming associations, the agrochemical industry, exporters on administrative level;**

- **some farmers using organic farming systems;**
- **large multinational agrochemical companies.**

In general most of the small farmers, most of the large farmers not producing flowers and vegetables, the government administration, the extension service on district level and a great number of the flower and vegetable producers had insufficient information on neem-based pesticides.

With the "trickle down" effect of information and more intense marketing, the demand for neem products will increase in the future.

4.) Farm size:

At the end of 1999 Saroneem Biopesticides Ltd realised 99% of its turnover with large farms, while only between 100 and 200 kg of neem pesticides were sold to small farmers over the last 3 years. The main consumers of neem-based products are large growers of ornamentals and vegetable-producing farms.

It can be assumed that also small flower and vegetable-producing farms would apply neem, e.g. around Mt Kenya and near Nairobi, where approx. 10 000 to 15 000 small farmers are cultivating plots of 1/2 - 5 ha in size. This, however, would require more intense marketing activities and an efficient distribution system.

In 1999 the British American Tobacco Company (BAT) purchased a large amount of neem products which were distributed to small farmers in Kenya and Uganda who were growing tobacco.

This aspect is also very much related to the access of information.

5.) Efficacy of conventional pesticides:

Indiscriminate use of pesticides leads increasingly to the appearance of resistant pests (see Chapter 2.1). Despite sophisticated pesticide management, especially in ornamentals and vegetables, conventional pesticides are increasingly losing their efficacy against a range of pests. Neem pesticides are regarded as an effective tool to break the cycle.

Table 21: Lists those pests which have often shown resistance to conventional pesticides:

Crop	Pest
Ornamentals	Leaf miners (Diptera)
White cabbage	*Plutella xylostella* (Lepitoptera)
Roses	Spider mites, caterpillars (Lepidoptera)
French beans	Leaf miners, aphids
Tobacco	Whiteflies, leaf miners, nematodes

Neem pesticides were successfully applied against all the pests mentioned except spider mites.

It can be concluded that neem pesticides are increasingly used where conventional pesticides are no longer effective. This market is expected to increase in the future.

6.) Market for agricultural and horticultural products, and

7.) Significance of pesticide residue level on agricultural produce:

Agricultural production in Kenya can be divided in two sectors: production for the domestic market and for the export market, which is of some relevance for the demand for neem.

The majority of the agricultural produce exported is designated for the European Union and has to fulfil the strict requirements for minimum residual levels of pesticides (MRLs). The guidelines for MRLs will be even stricter and better enforced in future. Since neem decays very fast in the environment, the demand will be related to the export volume of agricultural produce. Based on both factors (MRLs and volume) it can be expected that the demand will rise in future.

At the end of 1999 the agricultural produce in Kenya assigned to domestic markets was not checked against the MRLs and most of the consumers did not show any concern or sensitivity with regard to this problem. Recently, however, the authorities have appealed to farmers to reduce the application of conventional pesticides (see Chapter 2).

It can be expected for the future that as in many other countries the consumers will show increasing concern about the contamination by pesticides. In the long-term it might be expected that the Kenyan authorities will pass and enforce MRLs for internal markets.

An increasing demand for neem-based products can be expected on both the domestic and foreign markets.

8.) Price of neem products relative to conventional pesticides

The relevance of the prices to the demand for neem-based pesticides depends on the specific situation of the farmers.

If the farmers have severe pest problems, e.g. due to resistant pests, the price of neem products is of secondary importance. The same holds in cases of pest gradations in (certified) organic farming systems, e.g. according to IFOAM standards.

The price relative to conventional pesticides could be of some importance for other producers applying pesticides not for the sole reason of resistant pests. The medium and long-term effects of switching to neem have to be taken into consideration, including the avoidance of side-effects such as intoxication, costs arising from environmental hazards and water contamination. One good example is described above (see pests of cut flowers).

More information and more knowledge about such benefits will improve the cost-benefit relationship and will certainly increase the demand for neem products in the future.

4.1.5.4 Market growth potential and substitution possibilities

For the reasons mentioned above, there is little doubt that the market potential for neem pesticides in Kenya is much higher than the market existing at the end of 1999.

Assuming that the volume of conventional pesticides used will be stable or increase in the future, it is clear that there will be an increasing demand for neem-based pesticides in the future.

The following reasons are given (dynamic scenario):

- **An increasing population will lead to an increase in agricultural production, which will result in increased pesticide application.**

- **This will increase the problem of resistant pests and further typical results of the "pesticide treadmill".**

- **The growing concern of consumers and decision-makers will lead to stricter controls of MRLs, in the short run for the export market and also in the medium-term for internal markets.**

- **Currently the market share of neem pesticides is low, leaving sufficient space for exponential increase of sales of neem pesticides.**

- **The potential of neem in farming systems is not exploited to its full extent (see below). Research will open new market opportunities.**

Potential new markets:

<u>Fungicidal effects</u>

Trials are currently being conducted on the control of *Alternaria* and *Phytophtora* in potato and fusarium in tomato. (These are not formal trials which could be used for registration, but are demonstration trials on farmers fields, coordinated by Saroneem staff.)

Further potential target diseases are the coffee berry disease *(Colletotrichum)* and

coffee rust *(Hemileia).*

Effects promoting plant growth

In addition to the fungicidal and insecticidal effects of neem pesticides it has been reported that the application of neem has growth-promoting effects. If these additional properties of neem pesticides could be communicated to small horticulture cropping farmers this would greatly increase their demand for neem products.

Veterinary uses

Preliminary trials on tick control with neem conducted at ICIPE have revealed excellent effects on cattle, sheep and goats. The price would be lower than synthetic control agents and the potential market is about KSH 250 million.

Control of malaria vector (mosquito)

A further potential must be seen in using neem products to control mosquitoes in water and housing areas. Preliminary tests conducted in Mali and at ICIPE revealed good control properties of neem.

The market potential of all neem pesticides applicable in this field is estimated at about KSH 100 million.

Storage

The treatment of stored agricultural produce such as pulses and corn is only

advisable if the products are guaranteed free of aflatoxin.

Aflatoxin degrades fast under UV rays, but these do not penetrate storage rooms. Currently Kenyan neem products cannot be guaranteed free of aflatoxin.

Currently 500 t of insecticides are used in Kenya to control storage pests.

Pesticides

Apart from describing the potential market, one comparison with synthetic pesticides could be based on the price and recommendations concerning the registered neem products.

For an economic evaluation, a product/target pest/crop matrix is required. The effects of further active substances in neem (i.e. in addition to azadirachtin) and synergistic effects of substances added to the formulations must be taken into consideration. Further criteria such as the abundance of resistant pests, pesticide management, and limits on pesticide residues are also of importance. To compare the product prices alone is not very helpful if the additional information is not provided. Even comparison of the price per application per ha is only of limited information value. The best thing would be to compare cropping systems which make use of different neem products. However, hardly any models or studies exist on this topic.

The recommended application of azadirachtin on vegetables and ornamentals is 25 g/ha. If the azadirachtin content of the pesticide is 0.5% this comes to about 5 l Neemroc or 5 kg Neemros per ha.

Based on the retail prices, this amounts to KSH 2000/ha for Neemroc and KSH 1000/ha for Neemros.

The following (22) compares the price with that of competing synthetic pesticides.

Table 22: Price comparison analyses for neem insecticides versus conventional pesticides.

Product KSH kg/l	Rate/ha KSH	Cost/unit	Cost/ha	Difference/ha a: Neemroc b: Neemros KSH
Brigade 025 EC	1.0 l	1,341.36	1,341.36	a: 658.64
				b: 341.36
Orthane 750 SP	1.2 l	1,978.00	2,373.60	a: 373.60
				b: 1,373.60
Lannate 900 SP	1.0 l	2,720.00	2,720.00	a: 720.00
				b: 1,720.00
Marshall 250 EC	1.5 l	1,020.50	1,530.75	a: 469.25
				b: 530.75
Bulldock 0.05 GR	8.0 kg	98.28	786.24	a: 1,213.76
				b: 213.76
Stalkborer	8.0 kg	75.00	600.00	a: 1,400.00
				b: 400.00
Bulldock 025	0.6 l	1,156.62	693.97	a: 1,306.03

Bulldock 025	0.6 l	1,156.02	693.97	a: 1,306.03
				b: 306.03
Fastac 10 EC	1.0 l	2,739.00	2,739.00	a: 739.00
				b: 1,739.00
Dimethoate 400 EC	1.5 l	488.75	733.13	a: 1,266.87
				b: 266.87
Ripcord 5%	1.0 l	931.50	931.50	a: 1,068.50
				b: 68.50
Diazinon 600	2.5 l	764.00	1,910.00	a: 90.00
				b: 910.00
Decis 025 EC	0.4 l	2,125.00	850.00	a: 1,150.00
				b: 150.00
Karate 17,5 EC	0.75	908.50	681.38	a: 1,318.62
				b: 318.62
Confidor 200 SL	4.0 l	7,284.38	29,137.52	a: 27,137.52
				b: 28,137.52
Temik 15 GR	20.0 kg	1,027.00	20,540.00	a: 18,540.00
				b: 19,540.00
Rhodocide 500 EC	1.5 l	1,199.00	1,798.50	a: 201.50
				b: 798.50
Folimat 500 SI	1.75 l	1,665.00	2,913.75	a: 913.75
				b: 1,913.75

Sumithion 50% EC	2.5 l	1,150.00	2,787.50	a: 787.50
				b: 1,787.50
Dursban 480 EL	0.75 l	1,127.00	845.25	a: 1,154.75
				b: 154.75
Fenitrothion	2.0 l	776.25	1,552.50	a: 447.50
				b: 552.50
Gaucho 350 FS	0.20 l	8,671.87	1,734.37	a: 265.63
				b: 734.37
Furadan 350 ST	0.70 l	1,030.70	721.49	a: 1,278.51
				b: 278.51
Lebaycid 500 EC	2.0 l	1,225.62	2,451.24	a: 451.24
				b: 1,451.24
Fenitrothion 500E	2.0 l	805.00	1,610.00	a: 390.00
				b: 610.00
Metasystox 250EC	0.50 l	896.09	448.04	a: 1,551.96
				b: 551.96
Azocord 290 EC	0.75 l	979.20	734.40	a: 1,265.60
				b: 265.60
Sherpa 5%	1.5 l	717.00	1,075.00	a: 925.00
				b: 75.00
Peropal 25 WP	1.2 kg	2,717.19	3,260.63	a: 1,260.63

				b: 2,260,63
Pentac AF	0.50 kg	6,960.00	3,480.00	a: 1,480.00
				b: 2,480.00
Dynamec	0.50 kg	4,207.00	2,103.50	a: 103.50
				b: 1,103.50
Secure	0.40 kg	27,000.00	10,800.00	a: 8,800.00
				b: 9,800.00
Apollo 50 SC	0.70 kg	9,396.00	6,577.20	a: 4,57720
				b: 5,577.20
Talstar 100 EC	0.25 l	5,365.45	1,341.36	a: 658.64
				b: 341.36
Sherpa DL	1.0 l	1,539.00	1,539.00	a: 461.00
				b: 539.00
Polytrin C440EC	1.0 l	1,330.00	1,330.00	a: 670.00
				b: 330.00
Marshal 250 EC	1.5 l	1,020.50	1,530.75	a: 469.25
				b: 530.75
Xentari	0.50 kg	3,072.72	1,536.36	a: 463.64
				b: 536.36
Dipel	0.50 kg	2,800.00	1,400.00	a: 600.00
				b: 400.00
Thuricide HP	0.50 kg	1,713.00	856.00	a: 1,144.00

Thuricide HP	0.50 kg	1,713.00	856.00	a: 1,144.00
				b: 144.00

This survey indicates that Neemroc is competitive with other pesticides in 16 cases and Neemros is competitive with other pesticides in 28 cases.

If future demand is restricted to the present applications such as large ornamentals, vegetables and tobacco farms, the market potential will be somewhat restricted. There is, however, no doubt that this potential alone justifies neem production.

To open up this market at least to a certain extent it is necessary to promote neem for other purposes too. Further advantages of neem products should be demonstrated, such as promotion of plant growth, no negative effects on health and soil fertility.

Further market potential exists in the neighbouring countries such as Uganda, where all Neemroc and Neemros products are registered as insecticides for all crops. A further promising country is Tanzania, as are other countries where neem pesticides have been registered, such as Israel.

4.1.6 ''Lessons learnt''

4.1.6.1 Project concept

The main problem during the development of the project was shortage of funds. The budget allocated for the development of the project (US$ 100 000) proved to be too low. It was foreseen that the money from sales would flow into the project

activities. However, sales could not be started until the products were registered. Temporary registration was granted in March 1998, which was towards the end of the project. Thus, the budget was not sufficient to develop products further and to conduct more efficacy trials.

The successful completion of the project (Varela & Rocco 1998) was possible due to the backing of projects such as GTZ-IPM Horticulture, which funded students working on master's degrees on the efficacy of the neem products developed for the management of key pests of horticultural crops. The ICIPE-USAID Export Vegetable IPM Project conducted trials on crops covered by its programme (e.g. French beans, okra). The ICIPE Awareness Project tested the products developed by the Industrialisation Project on maize and banana. Similarly flowers, fruit and vegetable producers offered inputs such as staff and fields free of charge, out of interest in neem as an alternative to synthetic pesticides. Only a few trials could be conducted with governmental institutions such as KARI, due to the lack of funds. Saroneem Biopesticides Ltd provided staff, transport and postal and telephone communication, as well as laboratory facilities for formulating products. The managing director of Saroneem Biopesticides Ltd, Mr Rocco, gave his time free of charge during the entire duration of the project.

Seed collection was initially hampered by lack of confidence on the part of the collectors, who had previously not been paid for their seeds as promised. In some cases the seeds were not transported speedily enough and they became contaminated with fungus. These problems were, however, overcome after the initial collections. Unfortunately the project vehicle was stolen in Tanzania during a seed collection exercise. The seeds were later recovered but not the vehicle. Vehicles from ICIPE and from Saroneem Biopesticides Ltd were rented for further

seed collection until the end of the project.

Some problems were experienced with the formulation of the products, for instance maximisation of oil extraction from seeds. When the seeds were not sufficiently dry, or when the spindle of the mill was worn out, a considerable amount of oil remained in the cake. This led to a reduction in the amount of oil available for formulation of Neemroc® and affected the quality of the neem cake-based product. For example, differences in the effects of different samples of neem powder on germination of tomato seeds are likely to be due to differences in the neem oil content of the product. It was thought that the oil content in the cake should not exceed 8%.

The project initially concentrated on the production of simple pesticides based on neem oil and neem cake, as these are the easiest and cheapest ways of getting neem pesticides onto the market. Neemros®, the neem cake-based product, proved to be inappropriate for use in large production areas due to its bulkiness and the processes involved before it can used for foliar sprays, namely extraction in water and filtering. If filtration is not carried out properly, the particles block the nozzles of the spraying equipment. Neemroc® is user-friendlier, as it can be mixed with water and sprayed immediately.

The registration of neem products took longer than expected. Data generated by the students could not be used until they had completed their thesis work. Additionally, some of the field trials were affected by low pest incidence due to unusually long rains during "El Nino" phenomena, especially in 1998. The labelling of the products caused considerable delays, as the labels had to be modified several times.

4.1.6.2 Marketing and development strategies

One of the greatest obstacles is having to conquer a certain sustainable share of the total pesticide market for neem pesticides. It is much easier to defend an existing marketing share than to expand into the market.

In principle the existing distribution system is suitable for selling neem products. Until the end of 1999 this was realised by the non-neem-processing wing of Saroneem Biopesticides Ltd. Only a small percentage of the neem pesticides are sold directly from the factory gate.

After the separation of Saroc Ltd, the distribution and selling rights could be awarded to Saroneem Biopesticides Ltd or to other companies. In any case a minimum retail price should be determined.

Until the end of 1999 the user could only purchase neem products from Saroc Ltd (now Saroneem Biopesticides Ltd). This is one reason why only a few small farmers are buying neem products even if they are cropping according to organic farming principles. Further reasons might be:

- **Unavailable or insufficient information on neem products and their effects;**
- **Unavailable or insufficient information on providers of neem products;**
- **Unavailable or insufficient information on minimum residue levels of export crops;**
- **Possible alternatives for minimising and avoiding pesticide residues.**

A strategy for marketing neem pesticides to vegetable farmers has to consider the

above aspects.

The focus should be placed on making neem products available to local distributors and rural stockists. There should be emphasis on the areas where the farm size and main crops could be expected to allow a greater demand for neem products. Target regions are e.g. the "Vegetable Belt" around Mount Kenya, the areas around Naivasha and Nakuru as well as the area around Nairobi.

Additionally, local substations at model farms should be set up within the reach of local farmers to demonstrate the effects of neem products on selected crops.

The model farmers should work as multipliers. Their selection should include psychological and social criteria. First and foremost, those farmers should be selected as model farmers who are cropping according to good agricultural practices and have high yields. Also they should be broadly respected by the local population. Ideally the local spokesmen/women should be the model farmers.

The idea is that potential consumers of neem products get advice on how and where to apply neem products and how they work, and they should be able to purchase them at the same time.

As an incentive the agents would get the difference between the wholesale and retail price. They would sell the neem products on a commission basis. The entire model is like a franchise system. Several legal aspects of the proposed system have to be discussed with the PCPB.

The model farmers would be trained and equipped by two or three representatives of Saroneem Biopesticides Ltd, who would have to be newly employed. They

would have the additional task of informing and training the farmers cultivating vegetables and ornamentals on how to apply neem pesticides and to convince them about the advantages of neem products.

There should also be concurrent presentations, information days and on-farm demonstration days.

The neem demonstration campaigns should be designed as follows:

Demonstration fields of approx. 1000 sq m should be set up at the model farms in the target region, and also on other farms keeping to standard cultivation techniques. On the demonstration fields neem pesticides should be applied free of charge. With this demonstration it is intended to convince small farmers not only of the pesticidal but also of the other properties of neem, e.g. as a growth stimulant and fertiliser.

Should this assumption show some success, it can be expected that a good proportion of the small farmers would favour neem pesticides despite a possible price difference and/or a more laborious and complicated form of application.

Simultaneously the farmers should be taught about the MRL situation (see above) and potential pest resistance against pesticides.

In view of the different mode of action of neem pesticides as compared with synthetic ones, farmers will remain disappointed if, soon after application, they do not perceive immediate mortality of the insect pests on their crops. It will be a long and difficult task to persuade small farmers to start spraying early enough to give the neem application a chance to produce an antifeedant effect in the pests,

as well as enhancing the presence of predators to act against the targeted insects. This will mean that sales of neem pesticides will be slow to take off.

Therefore promotion and training supported by governmental or other donors are required.

4.1.7 Investment possibilities

It was of interest to find out whether neem pesticides and products could be offered more cheaply and subsequently gain a larger market share if the production units and volume of raw material were larger. For example the costs (especially the fixed costs/unit) would decrease if neem manufacturing were carried out on a larger scale.

Based on the data available in Kenya, Quentin (1999) calculated that 300 t of neem kernels could be processed into the following products:

- 100,000 l Neemroc
- 100,000 kg Neemros
- 6,000 l Neemsar "O"

It was assumed that only a minor portion of the products would be sold directly to the final consumers and that most of the products would be sold to wholesalers.

Based on this calculation and the availability of capital for investment, the profit would be 39% of the turnover. This would result in a good profit, despite a high depreciation in the first year. In the eighth year the profit would be even better, assuming that all frame conditions remain constant.

Such processing would enable the company to build up its own capital which is required for example to purchase 300 t of neem kernels (KSH 9 000 000) in the next harvesting season. This would be an important step in the elimination of risks such as those arising from the severe fluctuations in interest rates in developing countries.

However, even calculations based on 50% or 100% credit for the start-up and investment costs and the repayments consequently required would result theoretically in a profitable business. Even neem manufacturing based totally on credit* would enable entrepreneurs to build up their own capital.

The calculation is based on larger volumes of the product currently offered, new product lines could increase the profit more.

Interest rates of 8% based on the US dollar - Basis

4.1.8 Post-project experience

ICIPE

Awareness of the potential of neem has increased remarkably, in large part due to the ICIPE's Awareness Project and to the Neem Industrialisation Project. Since 1994 thousands of seedlings and viable seeds have been distributed among farmers, schools, churches, NGOs and other interested groups in Kenya. This has stimulated the establishment of numerous nurseries in Kenya and neighbouring countries. More than 650 persons from seven east African countries have been trained.

Demonstration trials have also been organised by agricultural officers of several divisions.

Neem is mainly promoted by other NGOs in addition to the ICIPE. Thus, as mentioned earlier, KIOF has been promoting the use of home-made neem products by farmers, and it is interested in promoting the available neem-based products. An agreement has been reached with Saroneem Biopesticides Ltd to make neem products available to farmers through the Muthama District Cooperative Union distribution network. NGOs play an important role in knowledge dissemination.

NGOs

Two organisations, the NGO the "Kenya Neem Foundation" and the "Kenya Neem Development and Herbal Health Awareness Agency" were registered in 1997, These two organisations are promoting the neem tree in Kenya. The "Kenya Neem Foundation" has organised neem awareness meetings in several districts of Coast Province, Nyanza Province, Western Province and Rift Valley Province. Mr Anthony Kithini Mwongo of the second organisation conducts seminars to sensitise people to the potential of the neem tree in rural development and income generation. Another NGO, "Details, Kenya", working in development and training through appropriate initiatives for local set-ups, is creating awareness through seminars. This NGO is seeking funds in order to boost propagation of the tree, to conduct demonstration trials, and to create awareness of the multiple uses of the neem tree, in the areas surrounding the lakes Bogoria and Baringo.

IPM Projects

Other IPM projects in the region have also incorporated neem-based pesticides in their programmes. Thus, some projects have purchased neem products from ICIPE/Saroneem Biopesticides Ltd for testing purposes. These projects include the peri-urban vegetable IPM Project in Kenya, (developed the by the National Resources Institute (NRI) and the CABI African Regional Centre), the Tanzanian-German IPM Project and the GTZ "Urban Vegetable Promotion Project" in Tanzania.

Industry

The industrial and the cottage industry sectors in Kenya have also shown interest in the production of neem-based pesticides. This has included interest from local businessmen in starting production of neem-based pesticides. Some of them have visited the neem factory at ICIPE, but so far no one has started.

Several companies producing neem-based pesticides, mainly from India, but also the EU, have shown interest in the Kenyan market. They have visited and given samples for testing to several flower and vegetable growers. One Indian product, "Godrej Achook" has been granted temporary registration by the PCPB for horticultural use in Kenya.

Research

Research on the use of neem products in horticulture has gone a step further. It has concentrated on studies of the suitability of neem products in IPM programmes for the major pests. Thus, studies on the effect of neem products on parasitoids of leaf miners in tomatoes were conducted as part of a PhD thesis at

ICIPE. Studies on the effects of neem products on natural enemies of the main pest of cabbage, namely the diamond-back moth and aphids were conducted by a Kenyatta University student for a master's degree funded by the GTZ-IPMH Project. Similarly, the effects of neem products on the parasitoids of the diamond-back moth are being studied by a PhD student at ICIPE.

Research on the effects of neem products in malaria control is going on at ICIPE. The use of neem oil as a larvicide for mosquito control is being studied in the laboratory and field trials are planned for the near future. Preliminary trials on the treatment of bednets with neem products have also been conducted.

Studies on the use of neem products for control of tick and tick-related diseases have continued, but the project on tick management has finished. A proposal for the integrated management of ticks with neem as one of the components has been prepared by ICIPE.

Saroc Ltd/Saroneem Biopesticides Ltd.

Saroneem Biopesticides Ltd is continuing production of neem-based pesticides. However, the present financial situation of the company merely allows it to pay for the raw material to be purchased next year and the processing into formulated products. There is not enough capital for further development of products or to conduct further trials on efficacy. As a consequence the sales increase very slowly, mainly through personal activity. Based on the efficacy trials performed in Kenya and results of trials conducted in Uganda, registration for use of neem-based pesticides in Uganda was granted early this year.

The company is working on the formulation of new neem-based products: an alcoholic extract and a formulation containing 20% pyrethrum. The alcoholic extract is a formulation suitable for use in large-scale applications. The neem-pyrethrum formulation is aimed at flower production. The available neem products are not suitable for pest management on flowers due to the slow action of the neem products and to the extremely low tolerance to pest damage in produce for export.

The new company Saroneem Biopesticides Ltd has been registered and started to operate in January 2000. Besides taking over the production and marketing of neem products in the region, this company will deal with other natural pesticides such as microbial pesticides.

Currently, the main buyers of neem-based products are large-scale horticultural producers. Due to the relatively high price of neem, these products are mainly used for the management of pests that have become resistant or are difficult to manage with conventional insecticides such as the diamond-back moth and leaf miners. As already mentioned, horticultural production for export is facing difficult times due to the maximum residue restrictions in the European market. Neem could have a role as an alternative to synthetic pesticides, depending on its acceptance, e.g. registration for use in horticulture in Europe. According to some vegetable and flower producers exporting to the UK, some supermarkets accept produce treated with neem products during its production.

Small-scale producers constitute a large potential market, but this potential has not yet been exploited due to economic constraints as mentioned above.

Neem-based pesticides are also in demand, though on a small scale, for organic production of vegetables and cotton. Thus, a GTZ-supported group of cotton farmers in Llama has purchased Neemros® for further distribution to its members. Few growers are involved in the production of organic vegetables, which are offered locally targeting the expatriate market. For instance, the neem products have been tested in a farm in Limuru, where organic vegetables are produced on a small scale and sold in Nairobi. The Kenya Institute of Organic Farming is also promoting the use of neem and contacts have been made with Saroneem Biopesticides Ltd, but activities have not yet started.

Another organisation involved in organic farming is Farmers Own Ltd, a subsidiary of the Kenyan/British governmental organisation, Association for Better Land Husbandry (ABLE). This association is aiming at poverty alleviation by establishing market-driven systems, rehabilitation of the environment and marketing of health foods. Currently, they have pilot projects in several districts in Western Kenya and in the Central Province. ABLE is promoting the development of Organic and Conservation Supreme Standards and Certification Schemes for Farmers Own Business in Kenya, in order to enable farmers to produce for the local organic market as well as for export (The Analyst, December 1999).

A lot of expectations have been created with both the Neem Awareness Project and the Industrialisation Project. Nurseries have been established and a lot of neem seedlings have been planted. It is now important to create a market for the seeds and other neem products which could be available in the near future.

From the experience in Kenya it is clear that when planning a project like this, aspects such as economy of production, marketing strategies and market potential

should be investigated. A final evaluation and follow-up after the completion of the project are desirable to monitor the transition from a subsidised activity to a fully independent viable industry.

RISKS

It should also be borne in mind that neem processing is prone to a double risk concerning the climatic conditions: in the harvesting year the weather should be appropriate to produce sufficient neem fruits (which might be affected by too much rain, for example the effects of "El Nino"). For selling the produce any severe draught, as in 2000, will effect the sales of the products, as much fewer vegetables, ornamentals and fruits are produced. Such considerable climatic risks must be covered by a stock of capital or else the small enterprises will go to the wall. This is especially true since interest rates in developing countries often fluctuate considerably.

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4.2 Documentation of neem activities in Thailand with special reference to the Thai Neem Products Company Ltd and the assistance provided to the DoA, Toxicological Division by CiM

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4.2.1 Introduction

The agricultural cropping systems in Thailand are relatively intense. The typical situation of increasing impacts of pesticide application on health and the environment, and the development of resistance to pesticides described above (see Chapter II) holds especially true for Thailand. In spite of the impacts mentioned, both the total imported quantity and the amount of locally formulated synthetic pesticides are steadily increasing.

The government became aware of the problem in the 1980s and set up a programme to improve awareness, production, application and use of botanical pesticides. Therefore, compared with other countries, the political and administrative frame conditions for producing and using alternatives to pesticides are comparatively good.

However, alternative pest control such as botanicals is still limited. This is to a certain extent due to the immense market pressure and cheap availability of synthetic pesticides and the incomplete enforcement of the pesticide regulations. In Thailand synthetic pesticides are extremely cheap and often of low quality,

especially if the active ingredients are imported from China and the pesticides are locally formulated by small backyard companies.

On the other hand, there are many plant species with pesticidal properties growing in Thailand and the traditional use of botanicals was widespread in previous generations of farmers. However, the constraints on making use of them in the form of home-made pesticides are the same as those found elsewhere (see Chapter II). This leads to the next step of offering ready-to-use botanical pesticides and manufacturing them locally. The first initiative came at the beginning of the 1990s.

The lack of quality control and standardisation of plant-derived pesticides has led to a loss of credibility for botanically based pesticides.

The government of Thailand was aware of this problem and has supported facilities to upgrade and improve production methods of plant-derived pesticides in cooperation with pesticide manufacturers, and has aimed to develop standard requirements. It was within the scope of consultancy to the DoA that a German expert from CiM (Centrum fr internationale Migration und Entwicklung) assisted neem manufacturers in Thailand for 5 years (from 1994 to 1999). This chapter presents the neem-processing plant of the Thai Neem Products Company Ltd as an example of small-scale neem processing in Thailand. The Thai Neem Products Company was cooperating closely with the CiM expert in the fields of technology development and quality control improvement. Additionally Dr Praneetvatakul and her research team have investigated the economics of neem processing and carried out a marketing study for neem products on behalf of the GTZ's Pesticide Service Project.

4.2.2 Previous activities and other projects in relation to neem

The use of simple water-based extracts of neem fruits and seeds - and other botanical pesticides - for pest control is traditional knowledge which has been passed down from one generation to the next. During the time when the "green revolution" was being introduced and advocated (especially during the 1970s and 1980s) and chemical pesticides were being introduced, this knowledge was largely lost and botanical pesticides were not common practice any more.

Since the late 1980s, when the effects of pesticides on farmers, resources and consumers became obvious to everyone, the government has changed its policy and put more emphasis on the use of botanicals. A range of projects has started to advocate the re-introduction of botanicals and revive the traditional knowledge.

It has been the policy of the government since the beginning of the 1990s to assist the realisation of the self-help potential of Thai farmers in applying alternatives to broad-spectrum pesticides with low toxicity and low residues. One example was that in Thailand the Department of Agricultural Extension (DoAE 1998) permitted and promoted the extension service's buying and dissemination of neem seeds and the sale of half-finished or ready-to-use neem products.

The focus of the governmental policy was placed on the following aspects:

- **Investigation and promotion of botanical pesticides which could be used in crude form by the farmers (mainly investigated by the Department of Entomology of Kasetsart University, Bangkok)**

- **Development of technologies to formulate botanicals, (responsible**

department: DoA, Division of Toxic Agricultural Substances)

- **Demonstrations and training for farmers to understand the nature and advantages of botanical pesticides, (responsible department: DoAE)**

The media have spread knowledge about model farmers successfully working solely with non-synthetic pesticides.

The use and improvement of home-made products and the development of standardised neem extracts was assisted in the late 1980s and the early 1990s by the NGO-supporting component of the GTZ project "Production of Natural Insecticides from Tropical Plants". Additionally a laboratory for neem analysis for quality control has been set up.

A range of further organisations and institutions such as RENPAP/UNIDO/UNDP (1994), FAO (1994), CUSO, the University of Minnesota, Misereor etc. have supported the new governmental activities to put emphasis on the use of botanicals, with various conferences, workshops and projects, and have investigated the adoption rate and the constraints (Mitchell 1993, Tran 1998).

Neem can be considered as an economically significant and practically applicable means of pest control in rural areas as has been shown by the relevant scientific research. Neem showed considerable potential for controlling various insect pests such as *Plutella xylostella, Spodoptera litura, S. exigua, Hellula undalis, Phyllocnistis citrella, Helicoverpa armigera, Ohiomyia phaseloi, Nephotettix virescens* and spider mites (Sombatsiri et al. 1990, 1995, 1998, Sanguanpong 1993).

The practice of mixing neem materials, especially neem oil, with store products in a warehouse trial showed effective protection against certain store pests (Sanguanpong 1996).

Today the knowledge is again generally available to rural farmers. Certain farmers' groups are applying plant-derived pesticides to a sometimes amazing extent. The constraints concerning labour, availability of raw materials and standardisation, however, still remain the same as described earlier (cf. Chapter II, Foerster & Moser 2000) and by the authors presented below:

Sukthamraksa (1994) conducted an interesting farm survey in Ratchaburi Province, Central Plains of Thailand, six years after training on the use of neem products in 1988. After the training, about 65.4% of the sampled households had accepted the use of neem products, mainly on vegetables (kale, asparagus and cabbage) and ornamentals. Six years after the training, 44% of the sampled households were still using neem pesticides. These farmers have used and plan to use neem in the future because of the lower input costs, no negative impacts on health, and higher efficacy than synthetic pesticides.

Of the farmers investigated, 21.4% have stopped using neem products, due to lack of neem raw material, easy access to synthetic pesticides and swapping from asparagus or other vegetables to field crops.

The other farmers use synthetic pesticides, because they are easy to come by, they are convenient to use, because of the efficacy and efficient services and lack of information about any alternatives. More than 50% of the group have reduced their use of synthetic pesticides due to the high costs of these pesticides (on

average 1000 baht per rai per year), and the health and environmental impacts (6.25 rai = 1 ha).

About 94.4% of the farmers who apply neem extracts use home-made extracts. The reasons were the cheaper price and assured quality. Neem fruit costs about 6 baht/kg from the extension officers and ground neem fruit costs 7 to 10 baht/kg.

The suggestions taken from this study were:

- **Provide the raw material, promote planting of neem trees in local areas, conduct research on neem products.**

Poorod (1995) conducted a farm survey in Phathum Thani province, another province of the Central Plains. About 21.6% of the sampled households used neem products in their citrus plantations for the same reasons as listed above.

Most of the farmers (78.4%) did not apply neem products, for the following reasons:

- **Applying neem products requires great quantities of raw material and more time.**
- **Extraction of neem is relatively complex.**
- **Lack of labour and frequent spraying of neem products.**
- **Lack of experience in the proper application of neem products.**
- **Low efficacy when using neem products if compared with synthetic pesticides.**

The factors which made farmers interested in neem products were:

- **Number of years in growing citrus (more than 10 years).**
- **Availability of information about using neem products (positive sign).**
- **Farm size (positive sign).**

Tongdang (1994) studied the factors which influence the farmers' decision for or against applying neem pesticides in Suphan Buri province, Central Plain of Thailand. The main motivation for farmers who have used neem products for at least 2 years was the low toxicity. Problems raised by the farmers include the low quality of the neem water extracts, the laborious preparation of extracts, application and storage. The farmers observed that using neem products lowered yields, compared to using synthetic pesticides. However, 93% of the households continued to apply neem products due to cost savings, safety, efficacy and higher price for the products. Only 7% stopped using neem products. The reasons given were:

- **No time for preparation, complicated extraction procedure, not effective in terms of controlling pests.**

In this survey, about 60% of the households used neem products in rice fields, 40% in vegetable crops, 20% on fruits and 12% in flowers (some farmers applied neem on different crops). About 73.3% of the sampled households applied neem products every year and 26.7% sometimes. While 58% used neem products on their own, 42% mixed them with synthetic pesticides. The farmers using neem products formed a group for purchasing the raw material more cheaply in bulk amounts.

The conclusion drawn from these studies is that there is a potential for marketing

ready-made neem products. Farmers mentioned that one of the constraints on using neem products was the complex extraction process. On the other hand, the farmers pay more attention to the quality of home-made neem products than they would if they purchased them.

In the beginning of the 1990s a range of neem pesticides, often a mixture of different plant extracts was offered by some companies on the markets. Occasional checks of quality and efficacy by the DoA, however, revealed that the efficacy of the products was not reliable and the products are not standardised.

Therefore the DoA supported the development and improvement of technologies for production and formulation of biological/neem pesticides. A pilot plant for improving neem-processing technology has been set up, including neem oil pressing and a second extraction step for enriched neem powder. This project was assisted by an integrated German expert from 1994 to 1999.

4.2.3 Situation found concerning abundance of neem trees and of raw material supply

Sadao, the local name for Thai neem *(Azadirachta siamensis),* can be found in the north, central, north-east and south of Thailand. It is popularly used as a farm border and a roadside tree and grows well at altitudes below 200 metres (Willan et al. 1990). Similarly to "Sadao Thai", the other two varieties, *A indica* and *A. excelsa,* are naturally found in western and southern parts of Thailand respectively. Due to the fact that Thai neem is naturally widespread, this species is considered as the main source of raw material for commercial production in Thailand.

It is estimated that today there are approx. 1 million neem trees in Thailand, of which 70% are *A. siamensis.* In the 1990s the Forestry Department and private entrepreneurs started to use neem in their reafforestration activities, mainly with Thai neem. Some entrepreneurs established large plantations of 300 000 trees.

A *siamensis* is not as suitable for pesticide production as *A indica.* The reason is its generally lower azadirachtin content. Additionally, the higher chlorophyll content of the kernels leads to faster degradation of azadirachtin compared to the kernels of *A. indica* and greater difficulties in drying the kernels for storage.

The botanical characteristics and chemical composition of *A*. *siamensis* are different from *A. indica* and *A. excelsa* as shown in Tables 23 and Table 24 respectively.

Table 23: Botanical characteristics of three neem species

Characteristic	***A. siamensis***	***A. indica***	***A. excelsa***
Tree form	open crown, moderate branching	dense crown, heavy branching	open, uneven crown
Height	15-20 m	15-20 m	40-50 m
Flowering period	December-January	March-April	March
Fruit-ripening period	April- May	July-August	May-June
Seed size	1.5-2.2 cm long	1.3-1.7 cm long	1.7-3.2 cm long
	1.0-1.6 cm wide	0.8-1.1 cm wide	1.2-2.5 cm wide

Source: Tran, 1988

Table 24: Major chemical constituents of three neem species

Variety	Azadirachtin A	Azadirachtin B	1-t-3-az*	Nimbin	Salannin	Marrangin
A. siamensis	++	++	++	-	-	++
A. indica	++	++	-	++	++	-
A. excelsa	+	++	++	-	-	++

Compound identified as 1 -trigloyl-3-acetylazadirachtol (Kalinowski et al. 1997)
Source: Ermel et al. 1997

4.2.4 Small-scale commercial neem production

Commercial neem products in Thailand

In Thailand, there are several commercial neem-based products manufactured and available on the market. The locally produced neem products are all manufactured by a few small companies. Other neem pesticides will be imported from abroad in the near future and application has already been made for registration (see registration below).

The Thai Neem Products Company in Suphan Buri Province is one of the neem manufacturers who have closely cooperated with the quality control laboratory of DoA. The main product of the Thai Neem Products Company is a neem extract called "SADAO THAI 111". After this product line was successfully set up, several

others were produced such as "SADAO THAI 222", "SADAO THAI 444", SADAO THAI 555", and the most recent one, "Nee-mA" (Table 27).

The following table (25) and Table 2.9 in the chapter *Technical Description* give an overview of the products of Thai Neem Products Co. Ltd., Suphan Buri Province, as an example of a commercial neem business:

SADAO THAI 111 is a liquid neem concentrate extracted from Thai neem seed using methanol. It contains azadiracthin as the active ingredient, at about 0.3% (w/w) (Ermel 1999, personal communication). Recommended application is spraying 2-3 times over the first two weeks of control, preferably in the evening, since UV radiation, heat and humidity rapidly destroy the active ingredient. Later the spraying interval can be modified depending on pest infestation. Target pests are the larval stages of insects. The active compound disrupts their hormone system during the moulting and pupation stages. The effectiveness ranges from highly effective to less effective and ineffective (see Chapter "Results of the efficacy trials" below, p. 78).

SADAO THAI 111 is effectively utilised on citrus and orchid farms against leaf miners.

Table 25: Neem products produced by the Thai Neem Products Company Limited

Product name	Product description	Size of packaging
SADAO THAI 111	Neem seed formulation extracted by methanol	5 litre
		1 litre
		500 ml

		[illegible]
		100 ml
SADAO THAI 222	Neem cake pellet	700 g
SADAO THAI 444	Dried neem fruit powder	700 g
SADAO THAI 555	Neem cake powder	700 g
Nee-mA	Neem oil liquid soap	350 ml

SADAO THAI 222 is a form of neem cake pellet prepared from a mixture of neem cake powder (neem seeds after extraction), neem oil and dried neem fruit powder. This product contains several plant nutrients such as nitrogen, phosphorus, potassium, calcium, magnesium, sulphur, carbohydrates and proteins. It therefore serves as a slow release fertiliser for plants. It also comprises nematicidal and insecticidal compounds (Ermel 1999, personal communication). For target pests see below.

SADAO THAI 444 is a powder of dried neem fruit supplied in a bag. The method of packaging as a "tea bag" allows rapid and easy extraction of the powder with water. The product contains trace amounts of azadiracthin A (Ermel 1999, personal communication) but the extracts show good antifeedant efficiency against a broad spectrum of insect pests. Long-term trials have shown that it does not harm the beneficial insects and has no negative impact on the environment. For target pests see below.

Application of SADAO THAI 444 can be prepared by soaking the "tea bag" (700 g) in 20 litres of water for 12-14 hours. It is recommended to add an adjuvant as a sticker or spreader to the aqueous extract before spraying. Spraying three times

every 5-7 days is recommended. Later, the time interval between sprayings may be modified depending on pest infestation. The by-products from the extracted fruit powder can also be used as a fertiliser and to control soil-borne pathogens.

SADAO THAI 555 is the by-product of alcoholic neem seed extraction. It acts as a fertiliser since it contains several plant nutrients such as nitrogen, phosphorus, potassium, calcium, magnesium, and sulphur. It can be used in several kinds of vegetables, by applying 350 g of SADAO THAI 555 per square metre to the soil or pot in a ratio of 1:5. For crop species see below.

Nee-mA is a liquid neem oil soap for pets. The product can be applied against ticks and fleas. Nee-mA is mixed with water in a ratio of 1:1 for application. Application is recommended once every seven days.

The Rangsit Settakit Kan Kaset Company in Bangkok is another producer of neem products for crop protection. The raw material that stems mainly from Central Plains (Lopburi, Saraburi, Ratburi, Kanchanaburi, Chainat, etc.) and the north-eastern region of Thailand includes neem fruit (200 tonnes/year) and neem seed (20 tonnes/year). The product, NEEM BOND-A, is a mixture of neem extract and other herbs such as lemon grass and galangal. It contains 0.1 w/v % azadirachtin SL and was registered in 1998. Additionally, the ground neem fruit has been sold (approximately 150 tonnes at 15-20 baht/kg in 1999) until October 1999. Within the next three years the company plans to register a new neem product for pest protection in rice and field crops.

The Ladda Company in Bangkok buys neem a product from India (containing 3% azadirachtin) and plans to sell it in Thailand. However, at present this product is

only at the research stage (application on vegetables) for obtaining registration, which may take another year.

The Agro Thai Company in Bangkok is preparing for registration of a neem product. From an interview, it was obvious that Agro Thai has also produced neem products on request, but the amount was not significant for the market. Ground dried neem seeds are also available on the market at a cost of 40 baht/kg.

As mentioned before, Thai farmers have experience in using neem products for crop protection. There are three neem products registered, only two of which are available on the market. This indicates that there might be some constraints on production, for example capital investment, lack of technology or know-how, market potential, etc.

Neem fruit/seed collection in Thailand

In contrast to many other countries, neem fruits are of considerable importance as raw material for the production of neem pesticides in Thailand. The reason is that the costs of depulping in Thailand are rather high, often making it unprofitable to apply neem kernels or process them further into pesticides.

Seed treatment such as depulping, drying and decorticating is done without any machinery. This is carried out by the collectors who do the harvesting. Neem fruits are picked up from the ground or from the tree and mixed with sand. The pulp is removed by trampling or rubbing by hand. After depulping the seeds are washed and dried in the sun for 2-3 days.

As mentioned above, seeds or fruits are often bought by the governmental

extension service or the extension service of the pesticide companies, and sold to the neem manufacturers.

The company Thai Neem Products Ltd basically needs two main types of raw materials i.e. dried neem fruits and neem seeds. Recently, neem oil has become another important raw material for the pet shampoo.

The main geographical sources of raw material are the central, north-eastern and northern regions of Thailand, such as Karnchanaburi (228 km), Nakhon Ratchasima (257 km), Surin (557 km), Uthai Thani (319 km), and Nakhon Sawan provinces (340 km). The distances in parenthesis are the average driving distances when delivering the raw material to the company.

When neem manufacturing was in its infancy, the raw materials had to be bought at the places where neem grew. Later on, a contract was developed between buyers and sellers. Eventually the farmers from several provinces came to sell the neem seeds and the dried neem fruits to the company at its site (see Figure 3).

Fruiting begins in April. May is the peak period when the company requires high liquidity (ready cash) to buy neem fruits and seeds in order to store them for the whole year's production. When there is a shortage neem seeds and extracts are imported from Myanmar. Neem from Myanmar is of better quality (concerning the azadirachtin content) than that from Thailand.

Until the end of 1999, the company imported a small amount of raw material from abroad but it mainly processes raw material from domestic sources.

The prices which have to be paid by the manufacturer for the raw material are

given in the following table.

Table 26: Price of neem raw material in Thailand

Raw material	Price (baht/kg)
Neem fruit	4-7
Neem seed (pre-dried)	15-25

Note: 20 baht = DM 1 (exchange rate in 1999)
Source: Interview

Processing: description of the processing steps

Despite recognition of the advantage of neem-based extracts as effective and environmentally friendly botanical insecticides, adoption of neem products for pest control in Thailand is still limited. The reason may be seen in the limited availability of technology and equipment on the village-scale. Furthermore, the development of appropriate technology is required not only out of economic necessity but also for improving processing quality.

The following figure (Fig. 4) and describes selected processing steps, using the Thai Neem Products Company Ltd as an example:

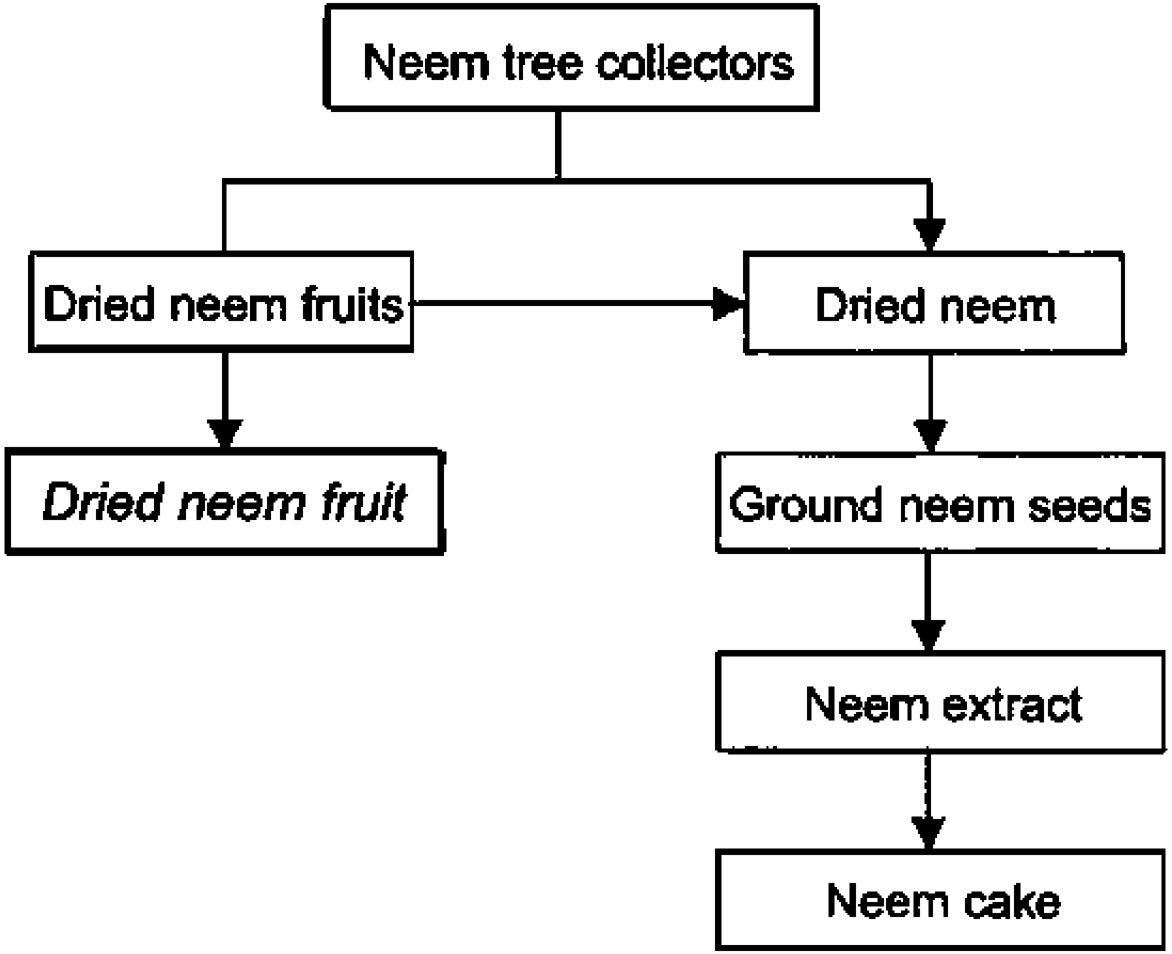


Figure 4: Flow chart of the path from raw material to end products

Drying. **The neem seeds are bought from the farmers or collectors after they have been initially dried in the sun. For storage, and to maintain good quality of the neem seed, it is essential to dry the seeds so that their moisture content is lower than 10%. This is performed at the Thai Neem Products Ltd using a rice dryer which operates a temperature of 80 C. It requires 10 hours to reduce the moisture content of the purchased seeds from nearly 70% to the required level.**

Storing the seeds. **Dried neem seeds are stored in the cold store at a temperature of 18-20 C.**

Grinding. **Dried neem seeds are ground in a locally made grinder which has a capacity of 100 kg per hour.**

Description of the alcoholic extraction process

Extraction with methanol.

The best-known product of good quality is prepared from neem seeds by extraction with methanol. For commercial EC formulations in Thailand, a single-step extraction method is used to produce a neem-based extract (see Chapter II.2.2.3). At Thai Neem Products Ltd. 100 kg of ground neem seeds are mixed with 300 litres of methanol in a tank and stirred for 1-2 hours. This results in 200 litres of neem extracts and neem cake, which still contains about 100 litres of methanol.

The 200 l of neem extracts is concentrated using a vacuum evaporator. After about 3-4 hours, about 60 l of methanolic neem extract concentrate is obtained (see Table 27).

Bottling & storing: **The extract is then transferred to big plastic containers and kept in a cold store. The extract is only bottled and shipped on request.**

Neem extracts are packed in different bottle sizes: 5 l, 1 l, 500 ml, and 100 ml. The bottles are labelled and are then ready for shipment.

Table 27: Current production capacity of the Thai Neem Products Company Limited

Products	Maximum production capacity	Current production capacity*
Neem extract	200 l per day	60 l per day
Neem oil	20 l per day	6 l per day
Neem cake	270 kg per day	80 kg per day

Notes: * The company does not operate the machine every day.

Simple description of neem cake pellet process

Drying and grinding of the neem fruits are the same as for seed.

Mixing.

Ground neem fruits are mixed with neem cake and neem oil in the proportions 50:30:20 in a mixing machine.

Pellet pressing.

The neem fruit-cake-oil mixture is then extruded by a pellet-pressing machine (see figure 5).

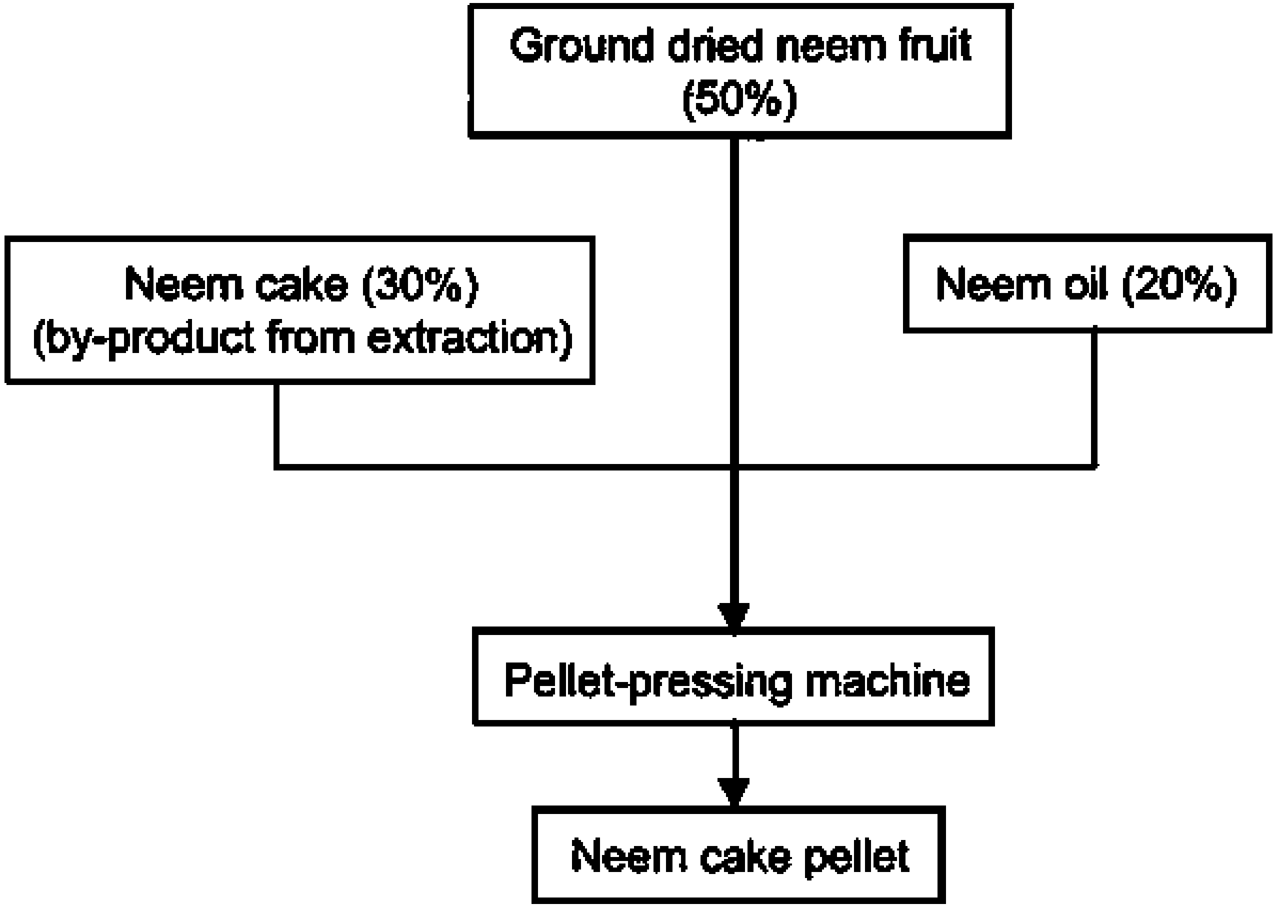


Figure 5: Flow chart of neem cake pellet production

Packaging.

700 g of neem pellets is packed and sealed in a plastic bag. The bag is labelled as Thai Neem 222.

Description of neem cake powder process

Drying.

The by-product of extract manufacturing, called "extracted cake", is dried for 2-3 days.

Packaging.

700 g of dried cake is packed in a plastic bag and labelled as Thai Neem 555.

Description of dried neem fruit powder process

Grinding.

Dried neem fruits are ground to a powder using the grinder described above.

Packaging.

700 grams of ground neem fruit powder is packed in a cotton bag and labelled as Thai Neem 444.

Quality control

The DoA (1998) was aware of the importance of the quality control aspect for manufacturing reliable botanically-based pesticides. Therefore research has been carried out during recent years to find out which factors have to be improved in the production chain for botanical pesticides. Technologies have been developed and manufacturers trained free of charge on request by the DoA.

A lot of research work showed that suitable post-harvest technology (in particular seed drying) is necessary to achieve good quality of the raw material. High

ambient temperature and high moisture content cause rapid degradation of azadirachtin and its analogues (Ermel et al. 1997). Thus there is a need for investigation of and investment in the drying temperature and the equipment. Sanguanpong (1997) reported that different drying temperatures ranging from 60-75-90 C can be used to reduce seed moisture content from initial 60% MC to 14% moisture content without any statistical change of the azadirachtin content in neem seed. Furthermore it has been found that the drying time required at a high temperature (90 C) was the shortest, at only 8 hours, while drying in the sun for 1 day followed by further drying at 60 C took 21 hours. In addition, the sun drying performed by the farmers is not as effective as drying at high temperatures.

To apply this finding to the improvement of processing quality, there must be investment in certain equipment such as seed dryers, which must then be employed. However, it is still necessary to develop suitable equipment in further experiments.

Moreover, it is also necessary for such processes as seed crushing, extraction and evaporation to invest in equipment such as depulverisers, overhead stirrers or mixers and vacuum evaporators.

The quality (i.e. the azadirachtin content) of neem pesticides is checked about four times a year. The neem extract is randomly sampled and sent to the Office of Research and Development of Botanical Pesticides at the Department of Agriculture to check the azadirachtin content by HPLC. As a result, it is certified that the neem extract produced contains more than 0.1% w/w azadiracthin. Hence the product meets the quality criterion set by the government. Nonetheless, there is no quality control of other products which do not contain azadirachtin.

Additionally the DoA offered the manufacturers their service free of charge. However, not all were interested in improving the quality of their products.

Pesticide registration policy

In 1991, the Ministry of Agriculture and Cooperation had revised and amended the Toxic Substance Act B.E. 2510 (1967) and B.E. 2516 (1973). This revision included the phased registration scheme which followed closely the guidelines prescribed by the FAO's international "Code of Conduct on the Distribution and Use of Pesticides", a phased registration scheme comprising three steps:

- **Trial or experimental clearance**
- **Provisional or limited clearance**
- **Commercial or full registration.**

In 1992, the Ministry of Industry introduced the Hazardous Substances Act, B.E. 2535, which is published and has been in force since 1995, and repealed two former Acts. The Ministry of Agriculture and Co-operation is responsible for regulating and overseeing matters of registration, import, domestic production, and export concerning toxic substances. It is in charge of quality control, container examination, testing, labelling, storage, destruction and other relevant matters. Application for registration must be made for any substances imported for sale or produced for export, and even the possession and storage of such substances. This registration consists of three steps.

Even though the Thai government tries to control and prevent any negative impacts upon human or animal health or the environment arising from the use of

hazardous substances, the adverse effects still continue to some extent (Sombatsiri 1999).

Regarding legal constraints on pesticide use and pesticide imports, Thailand has banned about 41 hazardous synthetic pesticides. However there is no strict enforcement of registration policy for synthetic chemical products or for neem products.

At present, several companies are selling neem products on the pesticide market in Thailand. Four companies are the major players in the neem business and only two of them have registered their products. In total three products are registered. There are still neem products on the market which are not registered.

The government of Thailand is trying to promote the use of bio-pesticides to replace the synthetic ones. To achieve this objective, the Department of Agriculture promotes alternative methods. *Bacillus thuringiensis,* Nuclear Polyhedrosis Virus (NPV) and neem extracts do not require toxicological data for registration (Wong-Ek et al. 1997). The registration guideline set by the Department of Agriculture in the first half of the 1990s requires La. that a neem formulation contain at least 0.1% azadirachtin and be effective in controlling the pests specified on the label, which has to be proved in a one-year efficacy test. In contrast to many other countries, the efficacy tests required by the authorised institutions in Thailand do not incur any costs to the companies applying. The registration fee is low and the product is registered for three years.

Table 28 shows the neem products which were registered at the end of 1999.

Table 28: Registered neem-based pesticides in Thailand (as of 1999)

Company name	Product	Azadirachtin content	Registration date	Raw material
Thai Neem Products Co Ltd	SADAO THAI 111	0.1 w/v % liquid	25 March 1997	Neem seed
Thai Neem Products Co Ltd	SADAO THAI 777[10]	0.7 w/v % SL	13 January 1999	Neem seed
Rangsit Settakit Karn Kaset Company	NEEM BOND-A	0.1 w/v % SL	5 February 1998	Neem fruit

[10] This product is not available on the market (October 1999).

Source: Interview

Technical, quality, packaging and labelling requirements for neem pesticides

The technical and quality requirements for neem pesticides in Thailand have been taken from the registration of synthetic pesticides:

- **Chemical and physical properties**
- **Toxicology**
- **Toxic residue on agricultural products**
- **Impact on environment and animals (bees, birds, fish, etc.)**
- **Efficacy data**
- **Toxic residue analysis method**

Packaging requirements are as follows:

- **For hazardous liquids the packaging material should be glass or plastic bottles (100 ml, 250 ml, 1,000 ml and 2,000 ml)**
- **For hazardous powders the packaging material can be cans, plastic bottles, or plastic bags in paper boxes (100 g, 250 g, 500 g, and 1,000 g)**
- **For hazardous pellets the packaging material can be plastic bags or thick paper bags (10, 15, 20 and 25 kg)**

Labelling requirements for any pesticides consist of

- **a label with the words "Hazardous Substance" written in red**
- **the scientific name of active ingredient**
- **the name and location of producer**
- **the quantity of the hazardous substance with the proportion of the active ingredient**
- **the expiry date**
- **instructions for applying the products, information on the benefits and storage, including a warning and diagnosis of poisoning, first aid measures and medical treatment**

Results of the efficacy trials

Thai farmers apply neem products on fruit trees (citrus, mango and grape), vegetables (asparagus[11], cabbage, Chinese kale, etc.[12]) and flowers (jasmine, roses, marigolds and crown of thorns, etc.[13]) including orchids (Prompard 1994).

> **11 Neem extracts are proven to act against the beet army worm on asparagus in Thailand (Sombatsiri 1993, Sombatsiri & Choeikamhaeng 1997).**
>
> **12 Green mustard, Chinese cabbage, onion, multiplier onion, angle loafs, winter melon, tomato, chilli, basil, sweet basil, sweet potato, Chinese radish, taro, cucumber, yard-long bean**
>
> **13 Rose bay, queen of the night, Chinese rose, impala lily, white champak, and aglanema plants**

The efficacy of neem products against pests can be divided into three levels:

- **High efficacy: caterpillars, leaf miners, leaf rollers, cutworms, psyllids, aphids**
- **Moderate efficacy: borers, fruit flies, thrips, spider mites**
- **Little or no efficacy: beaters, weevils, bugs, rust mites**

If there is a pest outbreak, neem products might not effective enough on their own and it might be necessary to apply synthetic pesticides also in order to control the pests. More research is required on using neem products against different pests and varying severity of pest outbreak.

Efficacy tests on the products of the Thai Neem Products Co Ltd have revealed the following effects:

Sadao 111 (alcoholic extract): the highly susceptible insects are cutworms, beet army worm, leaf-chewing caterpillars e.g. the diamond-back moth, leaf-rollers, leaf-miners, aphids and psyllids. The less susceptible insects are the American army worm, rice stem borer, shoot-boring maggots, topborer, leaf hoppers, thrips, whiteflies, and red mites.

The insects not affected by the neem extract are flea beatles, sucking bugs, weevils, and mealy bugs. At present, SADAO THAI 111 is effectively used in citrus and orchid farms against leaf miners.

Sadao 222 (cake pellet): the main target pests are insect larvae and nematodes that damage the plant roots at an early stage of growth. The application of SADAO THAI 222 is also recommended for vegetable crops such as Chinese kale, green mustard, cabbage, onion, and multiplier onion at a rate of 1 kg/30 - 40 sq m once a month. Other suggested plants are sweet potato, Chinese radish, taro, cucumber, yard-long bean, and asparagus. The recommended dose is 5 -10 g (0.5 tablespoon) per hole applied to the soil around the plants once a month. For ornamentals such as crown of thorns, jasmine, roses, marigolds, orchids, rose bay, queen of the night, Chinese rose and impala lily, 0.5 tablespoon per plant pot is recommended.

Sadao 444 (tea bag powder): the extracts prepared can control leaf miners, leaf rollers, leaf-chewing caterpillars, cutworm, diamond-back moth, beet army worm, borers, citrus caterpillars, aphids, thrips and red mites.

Sadao 555 (cake powder): this can be used on several kinds of vegetables such as Chinese kale, green mustard, cabbage, Chinese cabbage, onion, cucumber, angle loafs, winter melon, tomato, chilli, asparagus, basil and sweet basil. It can also be applied to several types of ornamentals such as crown of thorns, jasmine, roses, marigolds, orchids, white champak, Chinese roses and aglanema plants.

Other potential uses of neem-based pesticides

Neem may not only be used to manufacture azadirachtin-containing products, but also byproducts such as oil and cake are obtained during processing (see technical description in Chapter II).

Neem oil also is used in pet shampoos and neem cake can generally be used as an ingredient in animal feeds, or as a fertiliser. It is sold as neem cake powder or neem cake pellet. They have multiple uses, e.g. as fertilisers and pesticides for controlling nematodes.

The use of neem cake as an ingredient for cattle feed seems to be possible, but this is not practised in Thailand. When using neem as a fertiliser, a distinction has to be made between using neem cake as organic manure or as a nitrification inhibitor together with urea. Using neem cakes as organic manure requires huge quantities before a significant yield increase can be observed. Using the cake as a nitrification inhibitor together with urea requires only amounts of up to 25 kg/ha for yield increases of 5 and 10% (Ketkar & Ketkar 1995).

4.2.5 Economical assessment of Thai Neem Products Company Ltd

4.2.5.1 Selected key data of the plant

Thai Neem Products Company Limited is located in Suphan Buri Province, Thailand, and managed by the Jampa-Ngern family. In total the company employs 5 permanent staff and other labourers on a day-to-day basis.

The company was established in 1994 on an area of 1,600 sq m.

The neem extraction plant has a capacity of approximately 60 litres per day.

The production is operative on 100 days per year.

Machinery for neem processing

For processing steps see Chapter II. figure 1 and 2. For small-scale manufacturers such as the Thai Neem Products Co Ltd, investment is needed in certain equipment, as shown in Table 29.

Table 29: Machinery used by the Thai Neem Products Company Ltd and production capacities

Items	Production capacity
Cold store	70 t of seed
Grinding machine	100 kg/h
Stirring tanks	25 l/h
Vacuum evaporator	40 l/h
Mixing machine	600 kg/h
Pellet-pressing machine	400 kg/day

[illegible]	[illegible]
Plastic containers	200 l
Bottle closer machine	30 l/h

The processing of neem involves many operations (as shown in Chapter II) and requires a set of equipment. This requires a certain amount of investment on the part of small-scale manufacturers such as the Thai Neem Products Co Ltd, as shown in Table 30.

Table 30: Types and capacities of equipment for neem processing used by the Thai Neem Products Co Ltd, Thailand

No.	Process	Equipment	Quantity (pcs.)	Price/unit (baht)	Capacity (kg or l/h)
2	Depulping	Pulper- finisher	-	-	not used
3	Seed drying	Seed dryer	-	-	in fabrication
4	Seed shelling	Decorticator	-	-	not used
5	Seed crushing	Pulveriser/mill	2	40,000	500-800 kg/8 h
6	Extraction	Overhead stirrer	6	50,000	200 l/8 h
7	Evaporation	Vacuum evaporator	1	700,000	80 l/8 h
8	Storage	Settling tank	10	450	200 l
	Packaging	Liquid filler	2	60,000	30,000 l/h

Neem products and prices are described in Chapter 11.2.4 above and listed in the following table of products, volumes and prices:

Table 31: Commercial neem-based extracts from the Thai Neem Products Co Ltd

No.	Trade name	Product type	Concentration (% AI)	Pack size (ml or g)	Price (baht/unit)	Application
	SADAO-THAI 111	Methanolic extract	0.10-0.30	1,000	580	see 1.
			0.10-0.30	500	300	
			0.10-0.30	100	80	
	SADAO-THAI 222	Neem cake Pellet	-	700	40	see 2.
	SADAO-THAI 444	Dried fruit powder (tea-bag)	n.a.	700	40	see 3.
	SADAO-THAI 555	Neem cake powder	n.a.	700	30	see 4.
	Nee-mA	Neem oil shampoo For pets	n.a.	350	85	see 5.

1. Mix 25-50 ml of the product directly with 20 litres of water; for controlling leaf miner *(Phyllocnistis citrella)* apply to the crop 3 times daily for 5-7 days.

2. 40-50 kg/rai (1 hectare = 6.25 rai) as a soil additive and controlling

agent against soil insects and nematodes, for vegetable crops such as Chinese kale, cabbage, onion, asparagus, yard-long bean etc., flowering plants such as roses, jasmine and orchids etc.

3. Using the Tea-bag method, soaking 1 bag in 20 litres of water for 12-24 hrs, and apply to the crop 3 times daily for 5-7 days.

4. Use 350 g/sq m as a soil additive or soil insect controlling agent on vegetable crops such as Chinese kale, cabbage, lettuce, tomato etc.

5. Apply Nee-mA on wet hair, leave for 5 minutes and rinse off; shampooing every week is recommended.

4.2.5.2 Production costs

Investment costs

The investment required for establishing a small-scale neem industry is not high. Investment items are land, preparation of land, water supply, buildings and machinery for neem processing.

Land. **The Thai Neem Products Company Ltd is using a 1600 sq m (1 rai) plot for manufacturing which are part of a 10 rai pomelo plantation. The current price of land in Suphan Buri Province is about 300,000 to 400,000 baht per rai (Table 2.10). If unpaved land is bought, the preparation of the land also has be considered, which will cost about 200,000 baht per rai.**

The rent of land is rather cheap, at about 10,000 baht per rai per year.

Water and energy supply. **Thai Neem Products Company has built a well as the main source of water. The total investment was about 100,000 baht for the motor and the pipes. The well supplies the whole plant with water.**

Electricity is locally available.

Buildings. **The buildings the Thai Neem Products Company use for neem production are quite simple. The owner has designed everything himself. About 500,000 baht was invested in the buildings. Most of the residential parts were converted to industrial uses or have multiple uses. The cold store was built at an investment cost of 300,000 baht.**

Machinery. **Several machines such as those for stirring, grinding, sealing, mixing, seed screening, pellet pressing, and closing bottle had to be bought for neem processing. The most expensive machine is the vacuum evaporator, costing about 700,000 baht. The investment costs of each machine are listed in Table 32.**

Fixed costs

The fixed costs comprise depreciation, maintenance costs and interest paid.

Depreciation. **Depreciation is calculated by the strength line method. The initial price minus the salvage value gives a value which is divided by the effective life-time, to give the depreciation per year. Based on this calculation, the depreciation equals 122,034 baht per year (see Table 33).**

Maintenance costs. **Maintenance costs are considered as one component of the fixed costs, since the machinery needs to be kept in good working order, whether**

the business is operating or not. The maintenance costs per year of the Thai Neem Products Company total 47,500 baht.

Interest paid. **Interest of about 48,000 baht per year has been paid.**

The total fixed costs of the Thai Neem Products Company are about 217,534 baht per year.

Table 32: Investment items of the Thai Neem Products Company Limited

Items	Amount and unit	Price per unit (baht)	Production capacity (kg or litre/unit)	Salvage value (baht/unit)	Usable time (years)
Land	1 rai[14]	350,000			
Land preparation	1 rai (1600 sq m)	200,000			
Deep well	1 well	100,000			
Building	1 building	500,000			
Cold store	1 room	300,000	70 t		15
Stirring tanks type 1	3 pcs	20,000	25 l/h	0	15
Stirring tanks type 2	2 pcs	75,000	25 l/h	0	15
Vacuum	1 set	700,000	40 l/h	2,000	15

Vacuum evaporator	1 set	700,000	40 l/h	2,000	15
Grinder	2 machines	40,000	100 kg/h	2,000	15
Sealing machine	3 machines	2,000		0	10
Mixing machine	1 machine	20,000	600 kg/h	1,000	15
Seed-screening machine	1 machine	10,000		1,000	15
Pellet-pressing machine	1 machine	20,000	400 kg/day	1,000	15
Plastic containers	10 tanks	450	200 I	0	5
Bottle closer	2 machines	60,000	30 l/h	1,000	10
Lifting car	1 car	100,000		30,000	15
Truck	1 car	400,000		10,000	23

[14] 6.25 rai equals 1 ha.

Table 33: Depreciation and maintenance costs at the Thai Neem Products Company Limited

Items	Amount	Depreciation (baht/year)	Maintenance costs (baht/year)
Deep well	1	3,333	0
Building	1	16,667	0
Freezer	1 room	20,000	10,000
Stirring tanks type 1	3 pcs	4,000	1,500
Stirring tanks type 2	2 pcs	10,000	1,500
Evaporator machine	1 machine	46,533	5,000
Grinder	2 machines	5,067	0
Sealing machine	3 machines	600	1,500
Mixing machine	1 machine	1,267	2,000
Seed-screening machine	1 machine	600	0
Pellet-pressing machine	1 machine	1,267	5,000
Plastic containers	10 tanks	900	0
Bottle closer	2 machines	11,800	0
Lifting car	1 car	0	1,000

Truck	1 truck	0	20,000
Total		**122,034**	**47,500**

The Thai Neem Products Company Ltd pays interest of 48000 baht/year, which forms part of the fixed costs.

Operating or variable costs

Operating or variable costs are those arising when the business is in operation. They include labour, materials, packaging, electricity, communication, marketing, transportation and other costs, as well as sales tax. They are described below.

Costs of materials. **The main variable cost is that of the raw material and accounts for 43% of the total variable costs. It requires high liquidity during May and June. The supply of raw material fluctuates from year to year depending on the climatic conditions, e.g. in 1998 neem seeds were abundant while in 1999, due to heavy rains, there was a shortage of seeds. This is one reason why the costs of raw materials vary each year (see Table 34). The prices of dried neem seeds and dried neem fruits are about 15 and 5 baht per kg respectively (Table 26). The total material costs come to 1,034,700 baht per year.**

Table 34: Costs of raw materials purchased by the Thai Neem Products Company Limited

Year	Raw materials purchased	Quantity (tonnes)	Total raw material costs (baht/year)
1994	Dried neem fruits	30	150,000

1995	Dried neem fruits	100	
	Neem seeds	20	800,000
1996	Dried neem fruits	150	
	Neem seeds	50	1,500,000
1997	Dried neem fruits	30	
	Neem seeds	50	900,000
1998	Dried neem fruits	150	
	Neem seeds	60	1,650,000
1999*	Dried neem fruits	5	
	Neem seeds	50	
	Neem oil	1,000 litre	825,000

Note: *Data for the year 1999 are estimated.

Labour costs. **Like most small-scale industries in Thailand, the Thai Neem Products Company is operated as a family business. The manager, assistant manager the supervisor, two accountants and one driver are employed and receive a fixed salary per month. Labourers are hired on a daily basis and no permanent labourers are employed. The temporary labourers receive about 125 baht per day. This means that the total labour costs per year run to 781,000 baht, which makes up about 30% of the total variable costs.**

Packaging costs. **The costs for each package are estimated based on the material used: cotton bags, plastic bags, plastic bottles, glass bottles, labels etc. For**

example, the estimated packaging costs of 1 litre neem extract amount to 13 baht. Total packaging costs vary with the amounts sold. In 1999 they were estimated to be about 155,977 baht.

Marketing costs. **Marketing promotion is done through advertising in print. Each month the company spends about 10,000 baht on advertising these products in agricultural journals.**

Electricity costs. **Electricity is the main source of energy. All the company's machines use electricity. The estimated annual costs of electricity are about 180,000 baht, which accounts for 7 per cent of the total variable costs.**

Communication costs. **Fax and telephone costs are estimated to come to 5,000 baht per month.**

Transportation costs. **These include car and truck rentals. It is assumed that if the business is not operating, there is no need to rent a car. Petrol is the main fuel used for transportation of most products to the market. However, the transportation costs of dried neem fruit powder that sent to the Department of Agricultural Extension are paid based on the weight (in kg) of products sold. Total transportation costs are about 144,500 baht per year.**

Table 35: Estimated variable costs of the Thai Neem Products Company Limited in the production year 1999

Items of variable costs	Unit	Price (baht/unit)	Amount (unit)	Variable costs	%

				(baht/year)	
Labour costs: 1 evaporator controller, 4 hired labourers (daily wage); the manager, assistant manager the supervisor, two accountants and one driver				781,000	30
Costs of materials				1,034,700	40
- Dried neem fruits, neem seeds, neem oil				825,000	
- Methanol	litre	15	13,000	195,000	
- Other substances	litre	70	210	14,700	
Packaging costs for Neem-ma and dried fruit powder				155,977	6
Marketing costs, advertising				120,000	5
Electricity costs				180,000	7
Communication costs				60,000	2
Transportation costs				144,500	6
- Truck, car rental, petrol; transportation costs for neem bags	month	3,000	12	36,000	
Other operating costs: seed drying, sales taxes				126,836	5
Total				2,603,013	100

Other operating costs. **Since the company does not own a seed dryer it had to pay**

for drying the seed. However, the Thai Neem Products Company has already invested in the installation of a dryer, which will soon be working. The other operating cost is the sales tax. Due to the economic crisis in Thailand, the Thai government has levied a sales tax of 5%. However, based on negotiation, the company can reduce the sales tax to 3%. In addition, products that are sold to the Department of Agricultural Extension are subjected to a sales tax of only 1%.

External costs

Based on the interview and observations, it seems that there are no external costs or environmental damage from the Thai Neem Products company. Nearly everything is recycled and all by-products of neem processing are used.

Cash flow

Break-even yield. **Based on the calculation, the minimum production required to cover the variable costs, so that the company can survive and continue the business, is about 11,183 litre per year of neem extract. If we assume 300 working days a year, at least 47 litres per day of neem extract are needed to reach a profitable level (see Table 36).**

Break-even point of operating days. **With the current production capacity of 60 litres per day, at least 186 days of production per year are required to generate enough revenue to pay the costs.**

Break-even price. **The minimum price that will cover the costs is about 252 baht per litre (see Table 36). It implies that with the increasing production or a reduction of the costs for the raw material, which is main item of total costs, the**

price of the product can be set lower.

Table 36: Results of a break-even analysis

Items	Unit	Break-even point
Break-even yield	Litres of neem extract/year	11,183
	Litres of neem extract/day (assuming 300 operating days a year)	47
Break-even point of operating day	days/year (assuming current production capacity of 60 litres/day)	186
Break-even price	baht/litre	252

4.2.5.3 Investment possibilities

Assumptions of investment feasibility

Praneetvatakul et al. (1999) carried out a financial investment analysis for neem processing on a larger scale based on the following assumptions:

- **A new company would be set up with investment costs of 5.2 million baht.**
- **Investment items include land purchase, land preparation, water and energy supply installations, machinery; operating costs are based on the key data taken from the Thai Neem Products Company Ltd.**

- Raw materials are assumed to be available within the country. Neem seeds are the main raw material used to produce neem extract. Nonetheless, neem fruits are also used to produce neem fruit powder.

- Production capacity is set at 60 litres of neem extract and 330 operating days per year. The growth rate of production is assumed to be constant for the next 15 years. A period of fifteen years was used for investment analysis since most machinery is no longer used after 15 years.

- An eight per cent discount rate was used for the calculation of net present value.

- Short-term credit is assumed to cover variable costs each year with an interest rate of 10%. Long-term credit is also assumed to have a 10% interest rate.

Table 37: Estimated yearly production of a small-scale neem industry

Products	Unit	Production quantity	Estimated price (baht/unit)
Neem extract	litre	20,000	450
Dried neem fruit powder	kg	5,000	46
Neem cake	kg	25,000	24

A cost-benefit analysis is given below.

Results of financial investment analysis

Based on the financial investment analysis of the base case model, investing in a small-scale neem industry is quite profitable.

Four criteria are used to investigate the investment feasibility.

- **Net Present Value (NPV)**

The net present value is the annual sum of net return over a defined period of years. It is the present value of benefits minus the present value of costs.

The investment analysis for this small-scale neem business reveals a net present value of 15 years of 35.7 million baht. The present value of net benefits (benefits minus costs) over the next 15 years is a value greater than zero, indicating that it is feasible to invest in the project.

- **Benefit-Cost Ratio (BCR)**

The benefit-cost ratio is the ratio of the present value of benefits to the present value of costs. It is a criterion of relative net gain.

The investment analysis reveals a benefit-cost ratio of 1.88, which indicates that the value of benefit over cost is greater than 1 and hence it is profitable to invest in the project.

- **Internal Rate of Return (IRR)**

The internal rate of return is the discount rate needed for the present value of benefits to equal the present value of costs, or it is the rate at which the net

present value will equal zero.

The investment analysis shows that the internal rate of return equals 76%. Based on economic theory, all alternatives with an internal rate of return exceeding the discount rate are profitable and desirable. For instance, this implies that the money invested in the small-scale neem business is more profitable than if it were deposited at the bank where the present interest rate in Thailand is only 6%.

- **Payback period**

If the investment in a project is paid back within a specified time, usually in the order of 3-4 years, the project is accepted.

Here the payback period equals two years, which implies that the investment costs are already covered only two years after the business goes into operation. This shows a very quick return on investment and hence the neem business is quite acceptable for investment.

To summarise, with initial investment costs of about 6 million baht it is quite attractive to invest in the neem business. It provides high benefits, a high rate of return and quick investment turnover.

1. Sensitivity analysis

Sensitivity analysis aims at testing the unpredictable events that might occur, for instance, what would happen if the benefit of a small-scale neem industry were not as high as expected in the base model, or if the costs were higher than expected in the base model.

The results of sensitivity analysis show that if there were a reduction in benefits by 20% and/or an increase in the costs by 20%, investment in a neem business would still be profitable.

Table 38: Results of investment analysis for a small-scale neem industry

Items	NPV	B/C	IRR	Payback period
Base case	35,729,027	1.88	76%	2
Benefit reduced by 20%	18,901,092	1.50	42%	2
Costs increased by 20%	27,113,997	1.59	58%	2
Benefit reduced by 20% and costs increased by 20%	9,524,132	1.28	34%	2

Notes: NPV: Net Present Value (million baht)
B/C: Benefit-Cost Ratio
IRR: Internal Rate of Return (%)
Payback period is given in years

2. Break-even analysis

Although there are several products produced by the neem business, neem extract is the principal product of this company. Therefore the break-even analysis will be investigated based on the revenue generated from neem extract. Based on the data of financial investment analysis, total costs (as used for the analysis) come to

5,032,450 baht per year. The sale price of neem extract is 450 baht per litre. Total production of neem extract is 20,000 litre per year.

Break-even yield. **Based on the calculation, the minimum production required to cover the variable costs, so that the company can survive and continue the business, is about 11,183 litre per year of neem extract. If we assume 300 working days a year, at least 47 litres per day of neem extract are needed to reach a profitable level.**

Break-even point of operating days. **With the current production capacity of 60 litres per day, at least 186 days of production per year are required to generate enough revenue to cover the costs.**

Break-even price. **The minimum price that will cover the costs is about 252 baht per litre. This suggests that increasing production or reducing the costs of the raw material, which is main item of total costs, would allow the price of the product to be set lower.**

Table 39: Results of a break-even analysis

Item	Unit	Break-even point
Break-even yield	litres of neem extract/year	11,183
	litres of neem extract/day (assuming 300 operating days a year)	47
Break-even point of	days/year (assuming current production capacity	186

operating day	of 60 litres/day)	
Break-even price	baht/litre	252

4.2.6 Market potential, marketing and development strategies

4.2.6.1 The pesticide market in Thailand

Before the 1980s, agricultural productivity and growth of crop output were mainly based on increasing the land area under cultivation, rather than on yield improvements. Since the 1980s, yield improvements have become instrumental to the maintenance of agricultural output levels. The first measure required for yield increases was the minimisation of crop losses due to pest infestation (ADB 1987, cited by Ruhs et al. 1999). Since then, crop protection has become a major concern of farmers and scientists in Thailand.

Thailand's pesticide market can be classified as liberal. Import and sale of pesticides are handled by the private sector. The main objective in using pesticides is to improve the productivity and/or to reduce the production risk at the farm level. Driving forces for the increasing use of pesticides in Thailand (see Table 2.15) include limited land resources, improvement of crop productivity, growing high value crops, inefficient use of pesticides[15], easy access to pesticides, and institutional factors, etc. The latter include direct subsidies or taxes, indirect subsidies, interventions in input and the commodity market, and research, education and extension systems (Pincus et al. 1999).

[15] Information on synthetic pesticides use was mainly obtained from the private companies which produce, import and sell them. The quality of the

products is often not as specified on the label, which might lead to misuse or inefficient use of the pesticides.

On the other hand, the indiscriminate use of pesticides has incurred external costs such as those to the environment, and the health of producers and consumers, etc. Jungbluth (1996) studied the guidelines of a pesticide policy in Thailand and quantified the major externalities relating to pesticide use. The calculations showed that the ratio of pesticide sales to externalities is almost one to one.

The main group of pesticides used in Thailand is insecticides. The use of insecticides almost doubled from 1981 to 1990 (see Table 40). This indicates intensification in Thai agricultural production. Most of the insecticides consumed are imported.

Table 40: Domestic consumption of insecticides and imported quantities in Thailand 1981-1998

Year	Domestic consumption (t)	Imports (t)
1981	14,069	6,625
1990	24,364	9,356
1995	6,573	10,560
1998	NA	12,823

Note: During 1981-1991 the amount of insecticides consumed was recorded as formulated products; during 1993-1996 the amount of insecticides consumed was recorded as active ingredients and the amount

of insecticides imported was recorded as formulated products; NA = not available.

Source: Pesticides Statistics, Regulatory Division, Department of Agriculture

The amount of insecticides imported has increased moderately. In 1998 the top ten pesticides made up almost 90% of total imports. This indicates that the markets concentrate on a few insecticides. Imported insecticides can be either formulated products or active ingredients that are then formulated within the country.

One problem associated with pesticide production is the insufficient quality of the products (Tayaputch 1992, Grandstaff 1992 cited by Jungbluth 1996). The pesticide market in Thailand is a product differentiation market, which means a single active ingredient can be found in various products with different registered names. This makes it very difficult for the Designated National Authorities to control the market and enforce the pesticide regulations.

The liberal market encourages competition between pesticide companies. They try to undersell each other, which in turn is driving market prices down (see Table 41) (see Ruhs et al. 1999). In addition, factors affecting prices of pesticides include low input costs and external factors such as government tax policy.

Table 41: Real average price of 18 selected pesticides in per cent in 1986-1996

No.	Common Name	1986	1996
1	Carbofuran	27	18

1	Carbofuran	27	16
2	Monocrothopos	236	141
3	Carbaryl	218	121
4	Endosulfan	174	117
5	Fenitrothion	249	134
6	Paraquat	114	70
7	Mancozep	218	96
8	Diazinon	299	214
9	Phanthoate	239	131
10	Dimethoate	155	80
11	2,4-D Ester	147	76
12	Captan	131	82
13	Malathion	118	80
14	Diazinon	100	74
15	Methyl Parathion	112	87
16	Zinc Phosphide	157	134
17	Cypermethrin	653	151
18	Denthion	249	167
Average		200	110

Source: Ruhs et al. 1999

Thirty-seven pesticide companies are large-scale producers belonging to the Thai

Crop Protection Association. The main segments in the pesticide market are covered by international companies.

The remaining companies are small to medium-scale producers, only some of whom belong to the Local Thai Association of Pesticides, which currently has 46 members.

Another group of insecticides are derived from plants or other organisms, and are imported to Thailand, but are of quite low quantity and value. There are about three or four types, namely *Bacillus thuringiensis* (78,337 kg, 51,229,366 baht in 1997), Nuclear Polyhedrosis Virus (NPV[16]), neem extract (trade name is AZA[17], azadirachtin 3% EC), and Rotenone (imported 3,000 kg, 83,602 baht in 1997).

> **16 There is no record of this at the Regulatory Division.**
>
> **17 There is no record of this at the Regulatory Division; the amount imported is assumed to be insignificant. Moreover, it is not possible to get information from the company that imports this product. All that is known is the trade name and the fact that it comes from India.**

The largest amounts of pesticides are applied in the horticultural (tropical fruits and vegetables) and rice sectors, for example high value crops which rely on pesticides, such as fruit trees, vegetables, cotton, sugarcane, and so on. It is, however, difficult to obtain detailed information on the quantities applied on each crop.

4.2.6.2 Marketing of neem products to date

Distribution of neem products can be classified as selective. The target groups in the agricultural sector are people who can afford to pay for the product, for example farmers growing ornamentals or farmers using neem in fruit orchards. Due to the relatively high costs of neem formulations, most farmers cannot afford to buy them. Instead they buy the raw material[18] and prepare their own extracts.

> **18 The farmers can either buy directly from the company or through the extension officer in the area.**

Additionally, the neem market has been improved due to the sensitisation and increasing awareness of toxic pesticides which affect both producers and consumers. This provides a good opportunity for the neem products. The channel of product distribution ranges from the producer to the retailing institutions and the consumers, and sometimes the product is sold directly to the farmers[19] (see Figure 2.3).

> **19 Direct sales in this case include a) direct contact with the consumers and b) direct sales at the farmers' training on using neem products (from survey).**

To promote of their products, the neem manufacturing companies cooperate with the government and education institutes. Some small-scale neem producers started to distribute their products through cooperation with the government officers that are working on this issue. In Thailand neem products in agriculture are promoted by the government. Kasetsart University and the Department of Agriculture have conducted training for farmers on the use of neem every year.

Representatives of companies are also invited as guest speakers. It gives them a chance to present and sell their products directly to the farmers or participants. This is a short and direct channel for product.

Some companies also distribute their products through department stores and hypermarkets, or sometimes to the special markets (herb products). It should be noted that companies produce on request[20] and do not keep stocks, because of the short shelf-life (one year) of the product.

> **[20] Taking Thai Neem Products Co as an example, there are at least 50 to 100 litres in stock. The producer is therefore quite flexible and able to produce on request (interview).**

At present, the use of neem in Thailand's agriculture can be classified into two types:

- **Use of dried neem fruit (purchased or subsidised[21]**
- **Use of neem extracts (purchased)**

> **[21] Department of Agricultural Extension had provided the farmers with dried neem fruit for crop protection until 1998.**

The farmers using neem at present have had problems when applying synthetic pesticides, for example impacts on health and resistance of the pests. Therefore they switched to neem to protect their crops. However, the farmers who have had no problems with synthetic pesticides still apply them. The constraints on using

neem products are the same as those mentioned in Chapter II:

- **Relatively high price**
- **Lack of confidence in using neem products**
- **No knockdown effect and slow action**
- **Efficacy[22]**

> **[22] Ermel et al. (1997) reported that the low profile of the locally made neem insecticides mainly depended on the quality of the raw material. Neem seed kernels obtained from the Thai neem tree contain lower amounts of azadirachtin A than kernels from Indian neem (Chirathamjaree et al. 1997). Additionally, the harvesting and post-harvest conditions may adversely affect the quality.**

4.2.6.3 Market potential

Neem extracts and pure compounds have been evaluated against more than 400 species of insect pests (Schmutterer 1995).

Neem extracts have been compared with synthetic pesticides for controlling insect pests, for example:

- **Control of insect pests of crucifera and citrus. The results showed that the effectiveness of the neem extracts was not significantly different from abamectin pesticide (Sombatsiri 1995).**

- **Control of insect pests of soya bean (Chaowattanawong 1988)**

- ***Ophiomyia phaseoli*** **(high efficacy - as prothiophos 0.15%)**
- ***Lamposema spp.*** **(high efficacy - as monocrotophos 0.15%)**
- ***Empoasca sp.*** **(moderate efficacy)**
- ***Nezara viridula*** **(no efficacy)**

A limited price survey of retailers in Bangkok and Rangsit in Pathum Thani Province the following prices of the insecticides, including neem products from the could be found (see Table 42).

Table 42: Selected insecticides with trade name and price from retailers in Bangkok and Pathum Thani, Thailand 1999

Common name	Trade name	Price (baht)	Per unit
Bacillus thuringiensis	Thuricide HP	700	1 kg
Carbaryl	Sevin 85% WP	40-45	100 g
Carbofuran	Carbofuran 3% G	60	1 kg
Carbofuran	Nafudan 3% G	600	15 kg
Carbosulfan	Posse	270	500 ml
Delamethrin	Decis 3	120	100 ml
Diazinon	Basudin 60 EC	550	1000 ml
Lambda-cyhalothrin	Karate 5 EC	100	100 ml
Methomyl	Lannate	85	100 g
Monocrotophos	Azodrin 60	60	100 ml
Monocrotophos	Nuvacron 60	250	500 ml

Azadirachtin	SADAO THAI 555	35	700 g
Azadirachtin	ADVANTAGE	210-260	1000 cc
Neem products	BIO-INSECT	40	100 cc
Neem products	BIO-M	45	150 cc

Note: 20 baht = DM 1 (exchange rate in 1999)
Source: Survey in 1999

Only a few retail shops were offering neem products at all, indicating again the need to put emphasis on developing efficient distribution and marketing concepts for the neem pesticides. The staff of the retail shops report that neem products have not been popular in the area, due to the lack of a knockdown effect and the slow action, indicating the need for more efforts in marketing, training and demonstration. There were other pesticides and fertilisers listing their active ingredient as neem but not specifying the quantities nor any concentration of active ingredients.

It is not realistic to make a comparison between the costs of using synthetic and neem products without field experiments. Only limited data has been available to date on the economics of IPM systems including neem, compared to conventional IPM systems recommended by the agricultural extension department or farmers' practice. This sort of data and studies would provide a clearer picture of potential markets for neem pesticides and/or the steps required for marketing neem products. However, the information on the recommended pest control methods of some selected crops may give a rough idea on which (synthetic) pesticides can be substituted by neem pesticides (see Table 43).

Table 43: Some selected crop protection recommendations from the Department of Agriculture, 1998, and the Thai Neem product company

Crops	Insects	Insecticides	Trade name	Rate	Cost (baht/ application)	Application
Vegetable				0.16 ha use 160 litre		
Crucifers and other vegetables	*Plutella xylostella Trichoplusia ni*	*Bacillus thuringiensis*	Thuricide HP	60-100 ml/20 litre	70	Spray every 4-7 days
		Delamethrin	Decis	10-20 ml/20 litre	10-24	
		Lambda-cyhalothrin	Karate 2.5 EC	20-30 ml/20 litre	20-30	
	Spodoptera exigua	*Bacillus thuringiensis*	Thuricide HP	60-80 ml/20	56	Spray every 4-7 days

				litre		
	Liriomyza brassieae	*Carbosulfan*	Posse	50-70 ml/20 litre	3-4,5	Spray every 4-7 days
	Phyllotreta sinuata	*Carbosulfan*	Posse	50-75 ml/20 litre	3-4,5	Spray every 4-7 days
	Hellula undalis	*Lambda-cyhalothrin*	Karate 2.5 EC	20-40 ml/20 litre	20-40	Spray every 4-7 days
Tangerine, pomelo and lime (when 5 years old use 5 litres)	*Archips sp.*	*Bacillus thuringiensis*		60-80 g/20 litre	56	Spray every 3-5 days
	Othreis fullonia	*Carbaryl*	Servin 85%	20 g/20 litre	8	
Mango (when 7 years old use 10 litres)	*Idioscopus clypealis, I. niveosparsus*	*Lambda-cyhalothrin*	Karate 2.5 EC	10 ml/20 litre	10	Spray before flowering stage

		Delamethrin	Decis	10 ml/20 litre	12	
		Carbaryl	Servin 85%	60 g/20 litre	24	
	Scirtothrips dorsalis	*Lambda-cyhalothrin*	Karate 2.5 EC	10 ml/20 litre	10	Spray every 7-10 days
		Carbaryl	Servin 85%	60 g/20 litre	24	
Orchid (0.16 ha use 120 - 140 litre)	*Thrips palmi and Dichromothrips corbetti*	*Carbosulfan*	Posse	30-50 ml/20 litre	54	Spray every 4 days
Crucifers and other vegetables	Plutella xylostella *Trichoplusia ni* *Spodoptera exigua* *Liriomyza brassieae* *Phyllocnisties*	*Azadirachtin*	SADAO 111	25-50 ml/20 litre	29	7 days

Note: For costs of insecticides see Table 2.8
Source: DoA (1998)

This table indicates that considering only the cost per application (not taking into consideration long-term effects and the advantages concerning the environment and health), the neem products are cheaper than specific pesticides such as *Bacillus thuringiensis* but more expensive than standard broad-spectrum insecticides such as Karate or Decis.

Neem products can replace any synthetic insecticides that are used to control the following insects: caterpillars, leaf miners, leaf rollers, cutworms, psyllids, aphids, borers, fruit flies, thrips, spider mites and so on. There is a potential for neem use on vegetables, fruit trees, flowers, rice and other field crops (maize, sorghum, soya bean, mung bean, cotton, and sesame) in Thailand.

Despite a lack of in-depth investigations and adequate data the following studies can provide some indications:

Teepasiri (1995) conducted a comparative study of vegetable production costs, revenues and profits between cultivation practices using synthetic pesticides and those using synthetic pesticides together with neem extracts in Sai Noi district, Nonthaburi Province. The results showed that costs, revenues and profit per unit area of farmers who used synthetic pesticides together with neem extracts were greater than those of the farmers who used only synthetic pesticides in vegetable production (see Table 44). It is possible to introduce neem products with other synthetic pesticides.

Table 44: Vegetable production costs, revenues and profits in different cultivation practices, Nonthaburi Province, Thailand

Items	Chinese kale	Chinese turnip

Items (baht/rai)	Chinese kale		Chinese turnip	
	Synthetic pesticides	**Synthetic pesticides + neem**	**Synthetic pesticides**	**Synthetic pesticides + neem**
Production (kg/rai)	2,596.40	2,789.68	1,959.10	2,123.02
Revenue	15,589.89	16,636.13	5,896.89	6,390.29
Total costs	9,515.92	10,061.52	5,670.99	6,148.26
Profit	6,073.97	6,574.61	225.90	242.03
Variable costs	7,086.99	7,221.53	4,900.55	5,373.37
Gross margin	8,502.90	9,414.60	996.34	1,016.92
Costs of synthetic pesticides	404.03	622.14	272.24	377.80
Costs of neem extracts	-	72.74	-	47.58

Note: 20 baht = DM 1 (exchange rate in 1999)
Source: Teepasiri (1995)

If there is a pest outbreak, neem extracts alone might not be an ideal concept for controlling pests. In the short run, using neem products requires higher input costs.

In the long run, the costs might be lower than those of applying synthetic pesticides. This is because using neem products contributes to maintaining or

creating an ecological balance in farming systems and reduces the likelihood of pest outbreak.

A further demand for neem products might result from the export of vegetables and fruits and the increasing controls on pesticide residue levels by the authorities of the importing countries. However, even today some exporters are reporting that pesticide-free products are more competitive and fetch a higher price.

In Thailand, there is limited promotion of applying neem products in agriculture. However, some government policies (such as pesticide-free vegetable products, awareness of toxic synthetic pesticides via government projects, media and the national "economic and social development plan") encourage use of bio-pesticides such as neem products.

Due to increasing consumer awareness of toxic synthetic pesticides, it can be expected that there will be a growing market for neem pesticides in the future.

The reasons are as follows:

- **The amount of neem products sold increases every year.**

- **Due to the promotion of neem products used in agriculture by Kasetsart University, training has transferred information, knowledge and technology from the scientists to the farmers. In addition, the successful application in some orchards (mango, citrus, orchid and vegetables) will spread among the farmers.**

- **Regarding resistance of insects to synthetic insecticides, an alternative**

may be the application of plant-derived or other organism-derived insecticides instead of synthetic pesticides.

- **Awareness of the producers and consumers of hygienic products.**

- **Government effort to control agricultural products (vegetables) without hazardous chemicals on the market, Bangkok.**

The higher demand will be an opportunity for increased production and better business with neem.

The questions to be answered are, whether the neem producers can afford to cope with an increasing demand; and whether the market is guaranteed. Other constraints in this business should be considered, for example:

- **Lack of raw material[23]**
- **Inferior quality of raw material**
- **Short shelf-life of the products**
- **Competitiveness in the markets for synthetic and other insecticides**

> **[23] The fluctuation of neem seed yield is the main problem in estimating the future supply of neem products (expert opinion). Harvesting neem fruit is labour-intensive.**

More research on marketing and dissemination concepts is required for neem products to communicate the information on neem to the users (farmers), so that use of neem products can be more effective and there will be less impact on the

health of both producers and consumers. More information is required for comparison of the use of neem products (ready-to-use products) and other conventional insecticides on any insects or crops.

4.2.6.4 Market promotion

According to marketing theory, consumers seldom have complete knowledge about a product. Their exposure to the information is limited and the information about the products changes over time (Ward 1997). Therefore, advertising and promotion will help to provide the consumer with useful information for their decision to purchase. For example, farmers may not be aware of a new neem product with improved azadirachtin content (e.g. neem containing 0.7% azadirachtin) which provides more effective pest control (the positive impacts of the neem product on the natural enemies, ecology and the environment, etc.).

There are two concepts of advertising and promotion: generic and brand. Brand advertising and promotion refers to advertising exposure for specific brands, whereas generic advertising and promotion emphasise the product's attributes instead of being brand-specific. Normally, the main objective of brand advertising is to increase the market share.

Assuming that consumers can hardly make a clear distinction concerning the quality of neem products in the market, generic advertising and promotion are recommended. Since neem products are not well known by most farmers (Purod 1995), advertising and promotion of neem products in general is more appropriate. The main objective of generic advertising and promotion is to change consumers' perception and to expand their knowledge about the neem products.

However, this activity requires a considerable budget and thus support from the national government.

In addition, the government should enforce a strict registration policy for neem products. Otherwise, farmers who do not have the knowledge will buy the cheap but ineffective products on the market, which would spoil the reputation of neem pesticides in general. This would also target those companies who have invested in improving the quality of neem production.

The message in the promotion of neem products should address the following issues:

- **Environmental education on the effects and detrimental side-effects of pesticides**
- **Changing pesticide usage patterns**
- **Providing information on neem products**
- **Making farmers aware of the attributes and quality of the existing neem products**

The media for promoting neem products are as follows:

- **Radio**
- **Newspapers**
- **Books**
- **Stores**
- **Institutional distribution, e.g. Department of Agricultural Extension**

4.2.6.5 Marketing channel and distribution

Distribution, as a marketing function, serves consumption by making products available to consumer in the right form, time and place (Meulenberg 1997). In some markets, distribution can stimulate demand by making products available at a specific place and time.

The two main objectives in the distribution for neem products are to maximise the access to target groups, and to minimise the distribution costs. Storage and transport are core elements in a distribution process.

Storage. **According to economic theory, identification of the quantity of stock which minimises total inventory costs per time period depends on the order quantity, carrying costs per unit of time period, ordering costs per order, and product demand per time period. Moreover, the quality of neem products are negatively influenced by longer storing periods. The neem company should avoid stocking the products for a long time but deliver them at exactly the right time. So the appropriate stock for a neem company will have to be tailored to match these demands. Since the Thai Neem Company is already producing on demand and holds only low stocks, not much can be improved at the present stage.**

Transport. **The choice of a transport mode is based on a trade-off between customer service and transportation costs. For example, sending neem products via the railways or a contracting transport agency for the supply of certain customers might be cheaper than distributing the product via the company's own transport facilities. Nevertheless, selecting the appropriate mode of transportation depends on the operating characteristics such as speed, availability, reliability, capability, and frequency (Meulenberg 1997). In addition, transport planning is another important element in marketing management for a neem company. In**

economic theory, there are transportation models available to minimise the transportation costs. However, this might be too sophisticated for a small-scale neem company. Nevertheless, a company should keep transportation planning in mind to minimise total transportation costs, to satisfy the requirements of the demand in a certain location, and not exceed the capacity constraints of the vehicles.

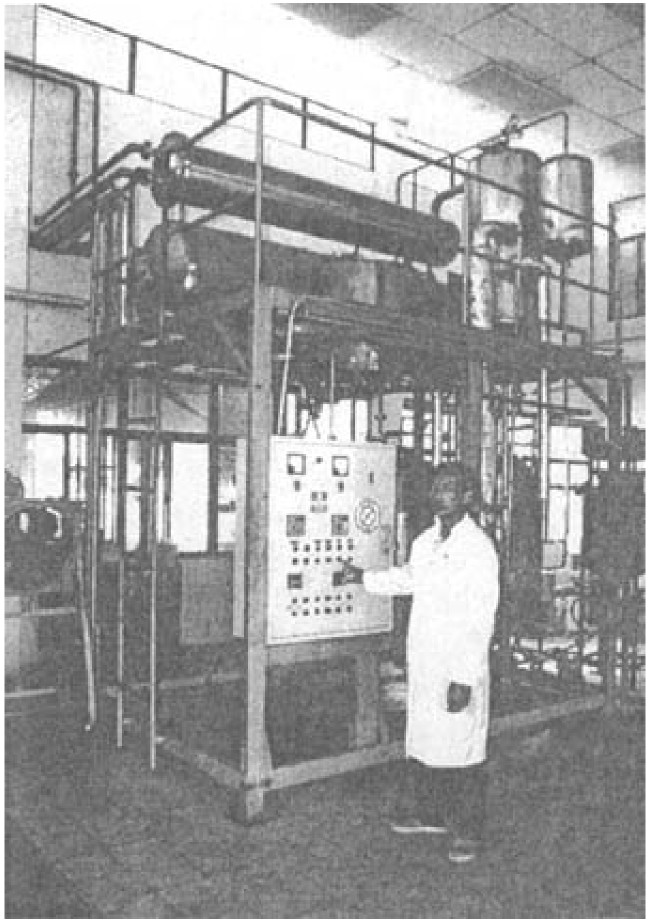
To summarise, the performance of distribution of neem products can be improved by better planning methods, integrated planning of purchasing inputs, management in the factory, and the physical distribution of final products.

Distribution strategy. **Access to the target group, distribution efficiency and marketing channel power are the key elements of distribution strategy. For a neem company, an intensive distribution strategy is more appropriate than selective or exclusive distribution. That is to say a neem company should sell the neem products through as many channels as possible.**

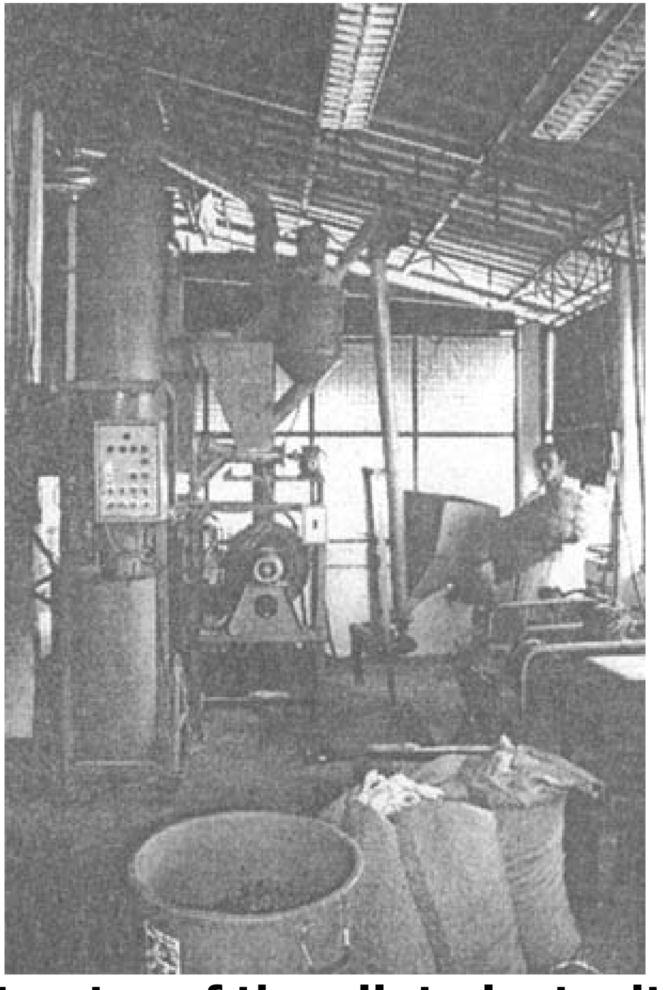
Marketing channel.

For producers and distribution chains see Figure 6.

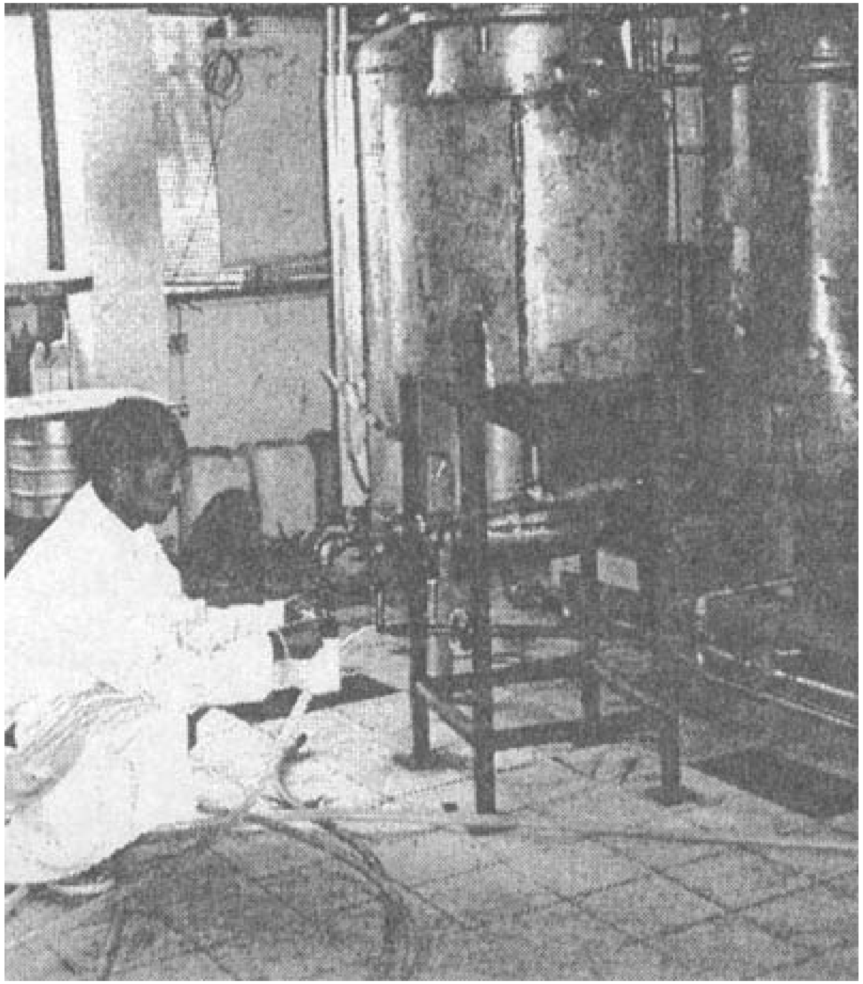
In 1996, there were about 28 formulators, 68 repackaging plants, 438 distributors and around 4,095 retailers conducting pesticide business in Thailand. Distribution of agro-chemicals in Thailand goes from the producer to the dealers and afterwards to sub-dealers or retailers. The pesticide companies employ sales personnel for the wholesale business, as well as for retail at the farmer's level (see Figure 6).



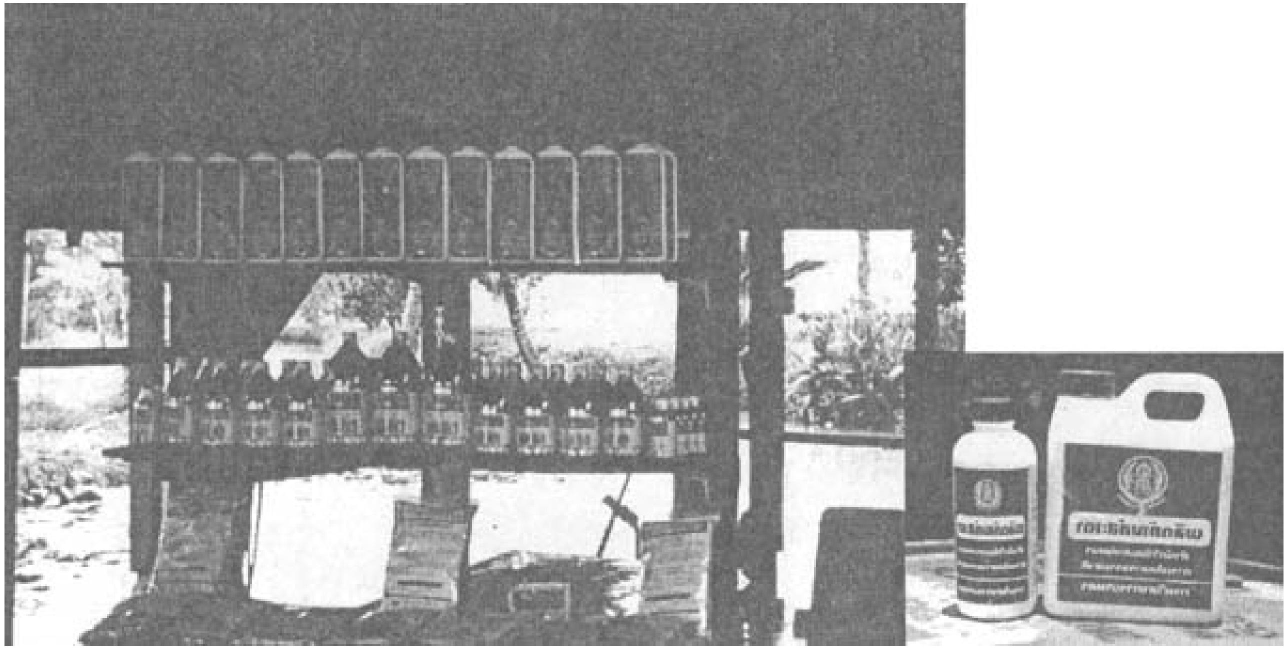
Pilot plant at the Toxic Division of the Department of Agriculture, Thailand



Filling the extractor of the pilot plant with neem cake



Bottling the neem extract



Neem products from the Thai Neem Products Company Ltd

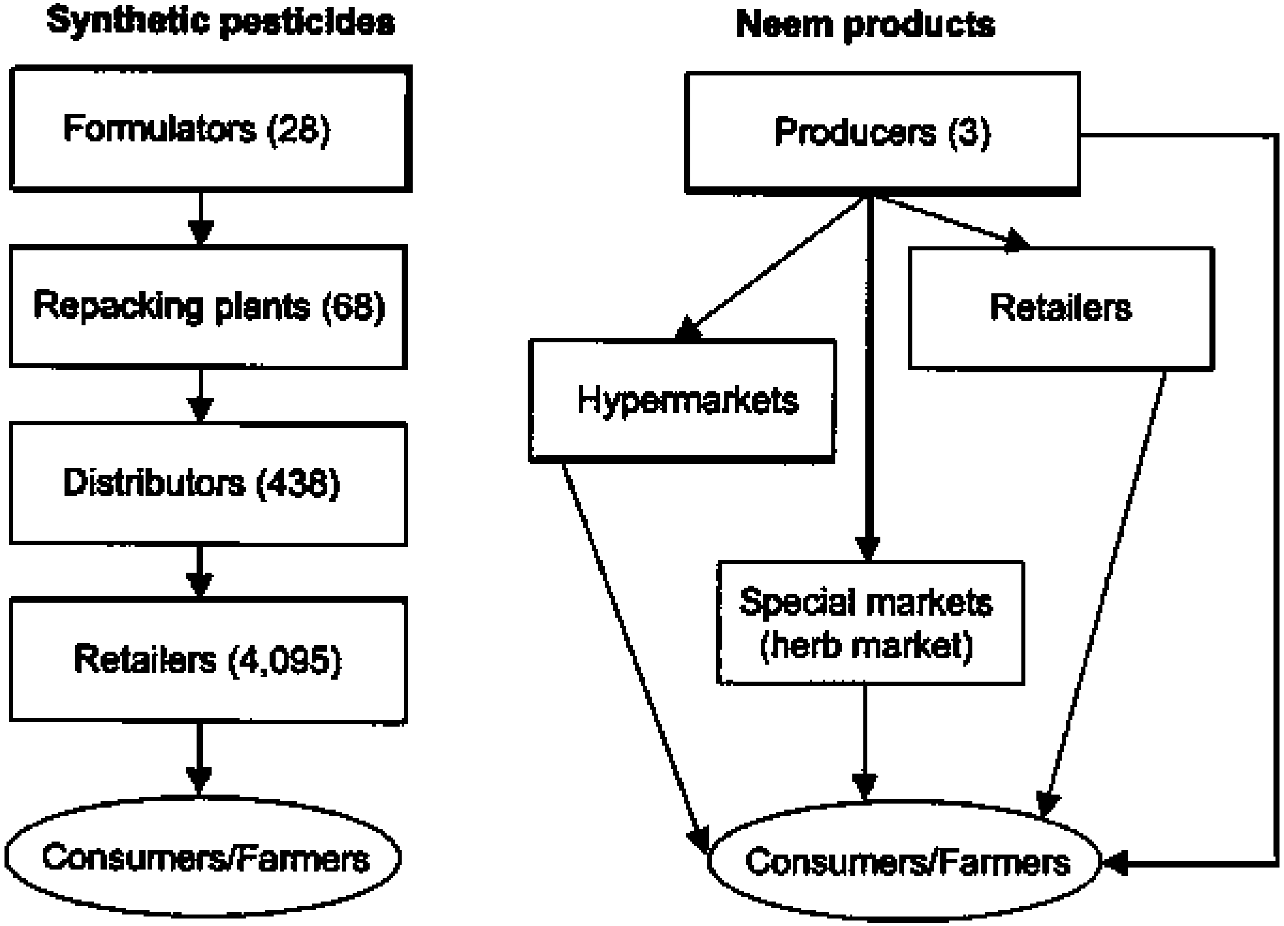


Figure 6: Marketing channels of synthetic pesticides and neem products in Thailand

Note: Numbers in parenthesis are the numbers of producers, dealers, etc.

Wholesaling is a recommended marketing channel for neem products. A study showed that farmers in Thailand have changed their purchasing behaviour from local markets to wholesale supermarkets such as Macro (Matichon 1999). The advantage of wholesalers is that they are more effective distributors because of

their market knowledge and handling of large product volumes. The wholesale market for neem products supplies local pesticide shops in every province and wholesale supermarkets e.g. Lotus.

Retailing is another option for a marketing channel for neem products. A low price, such as by discounting, is an example of a recommended retail price strategy for some neem products, e.g. neem powder. This is because price and product policies are correlated. Low price strategy is suitable for a product which require limited advise, has low purchase price and quick inventory turnover.

A high price strategy is appropriate for high quality products and the offer of a better service. This could be achieved by labelling the products and providing information on them. Due to the current concern about natural resources and the environment, labelling is another marketing strategy for promoting neem products.

Additionally further complementary products beside neem, such as Bt and virus products, should be offered within a "green mark" system. This is also another attractive marketing strategy.

4.2.6.6 Analysis of economic production with and without the use of neem pesticides

Based on the present estimated costs for neem products, producers' opinion, and literature reviews, the prices of neem pesticides are hardly competing with those of synthetic pesticides. However, a study on socio-economic factors affecting the acceptance of neem extracts claimed that the difference in cost of a pesticide is

not the main determinant for acceptance (Sukthamraksa 1994). That is to say there are several types of synthetic pesticides in the market; some are very cheap while others are very expensive. Consumers or farmers usually select a certain kind of pesticide based on different criteria, such as social or community communication, existing knowledge, information available, type of crops, experience of pesticide poisoning, etc. In addition, based on the calculation, the profit margin of neem extract is about 100% of the cost per unit, i.e. the profit margin is about 250 baht per litre. Hence, neem products have a chance in the pesticide market and can compete with synthetic pesticides, if the appropriate information is supplied and if they can enter the common marketing channel.

4.2.7 ''Lessons learnt'' and recommendations

Technical information. **There is still a lack of technical information on the level of the manufacturers. For instance, the by-product neem oil has not yet been fully used due to the lack of appropriate machinery and technology. More technical information about oil pressing would add more value to neem processing without increasing the costs. Consequently,**

> **(i) the costs of raw material may be reduced if neem oil is used to its full potential, and**
>
> **(ii) the quality of neem extract remains unchanged while the cost is reduced - hence the price of product can be lower.**

This is an important point in making a neem product more competitive than a synthetic pesticide.

Input supply. **The supply of neem seeds and fruits fluctuates from year to year. Raw material seems to be the most important issue in the business. Regarding the capacity of the neem business investigated, there is no problem with production capacity. For the time being, this means that the production can still be expanded within the existing plant. However, an increasing supply of neem seed raw material, either domestic or from neighbouring countries, will contribute to the expansion of neem pesticide production. In particular, neem supply in Thailand has yet to be investigated. This may become the bottleneck of neem production in the future, if more companies decide to invest in neem. Therefore, research on the raw material of neem is needed urgently. Moreover, there has to be a programme for selecting and/or breeding the Thai neem tree to improve the azadirachtin content of seed kernels.**

Quality conservation. **Since azadirachtin is the most important active ingredient in neem product, it can function as a quality marker. At present, all existing neem extracts in Thailand exhibits rapid degradation of the active ingredient during storage. Therefore, a technology for producing neem formulations which are more stable during storage needs to be found and implemented, in order to improve neem products in Thailand.**

Recommended development and/or government support programmes

- **A generic advertising and promotion programme for neem products,**
- **Regular investigation of sub-standard and/or unregistered neem-based insecticides on the market,**

- **Consideration of lower tax on the raw materials for neem products such as ethyl or isopropyl alcohol, which are environmentally friendly and may be used as substitutes for methanol.**

- **An intensive survey of the existing neem seed potential in Thailand,**

- **Government support programme for neem tree plantation,**

- **Research on bio-technology to improve the neem trees (fruit production and azadirachtin content).**

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4.3. Small-scale industrial manufacturing of neem-based pesticides in the Dominican Republic

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4.3.1 Introduction

Agricultural production in the Dominican Republic is comparatively intense. The typical cycle of pesticide application as described in Chapter II is also found in the Dominican Republic.

The MRL regulations (see Chapter II) enforced by the industrialised countries are restricting the export of agricultural produce from the Dominican Republic.

It is against this background that the planting and use of neem trees were promoted in the Dominican Republic side of the island of Hispaniola by the GTZ project "Production of natural Insecticide from tropical Plants" in the Dominican Republic in the 1980s and first half of the 1990s (Hellpap 1996, Brechelt 1995, Brechelt & Hellpap 1994). Later a lot of private farmers planted neem and the NGO FAMA *(Fundacion Agricultura y Medio Ambiente)* continued to promote the use of neem trees within its agricultural training programmes. Additionally, the

manufacturing of neem products was improved and made more professional.

On the other side of Hispaniola a lot of neem was planted as a shade tree during the 1960s by US American church groups such as "Double Harvest" in cooperation with the national road department.

The case study presented here aims to analyse the present state of neem manufacture and use in the Dominican Republic. It intends to identify constraints and the intervention opportunities which are needed to help neem pesticides acquire a greater market share and contribute substantially to a reduction of the impacts and problems caused by synthetic pesticides.

4.3.2 Previous activities and other projects related to neem

In contrast to many countries in Asia and Africa there was no long-term traditional use by the local population of the neem tree. The tree was newly introduced and disseminated in many countries in central and southern America only few decades ago, such as in the Dominican Republic and Nicaragua.

While the planting of trees was first promoted as shade tree in Haiti by US church groups such as "Double Harvest", the field station of the supra-regional project "Production of natural Insecticide from tropical Plants" in the Dominican Republic (based at the Loyola Centre, San Cristobal) established about 500 000 neem trees from 1987 to 1995 along roadsides, irrigation canals and small plots of fallow land. Most of the seeds originate from Togo, although there were some seeds locally available from the few fruit-bearing trees (which probably originated from Nigeria). Further planting was carried out by farmers, other projects and sugar

cane growers on eroded and saline land.

At the same time the GTZ project imported neem seeds from Haiti. These seeds were given to the farmers to train them in processing and application of neem water extract. From 1992 onwards a collection system was set up in the Dominican Republic, based on village traders. The raw material was bought depending on certain quality parameters. The project modified and improved appropriate processing machines and equipment for producing aqueous extracts and made them available to the villagers.

Source: Hellpap, C. (1993): Experiences with Neem in the Dominican Republic, pp. 39-42. 2nd Trifolio WS 1993.

4.3.3 Small-scale commercial neem manufacturing in the Dominican Republic

FAMA *(Fundacion Agriculura y Medio Ambiente)* is a non-profit foundation which took over neem processing from the *Instituto Politecnico Loyola.* The neem products are distributed by an independent company called Exproeco *(Exportadora de Productos Ecologicos, C*.). The founding members of FAMA are the sole shareholders of Exproeco. The neem-processing plant of FAMA is located in San Cristobal, Ingenio Nuevo, near the highway to Santo Domingo, which is 28 km away.

The original concept was that the farmers' association should provide the processed neem raw material and in return FAMA would provide them with the neem pesticides for distribution to the association's members. This concept however failed. The association's members are prepared only to collect and

process the neem raw material, not to buy and apply the relatively expensive neem pesticides. Due to the laborious process of preparing and applying aqueous extracts of neem kernels and the high labour costs, hardly any of the 200 cooperating farmers sustainably applied the method of NKWE.

As an alternative FAMA developed a close marketing relationship with a German importer of their products, who provide partial financing for developing and manufacturing neem products.

Abundance of neem trees

It is estimated that at the end of 1999 there were about 1 million neem trees planted in the Dominican Republic, which would result in a potential total yield of 4500 tonnes neem fruits or 562.5 tonnes of neem seeds. The high price (see below) of the Dominican seeds caused the manufacturer to look for alternative sources of the raw material which could be obtained from neighbouring Haiti, amongst other places.

Seed collection

Neem seed collection and wet processing in the Dominican Republic is organised by the farmers' association in the south of the island.

Three buying points for neem seeds have been set up (in Villa Fundacion, Ganadero Azua and Duverge) with assistance of the GTZ and the NGO "Deutsche Welthungerhilfe".

The centres are autonomous and run by farmers' associations. The seeds are dried

again in the shade at FAMA. Since no artificial dryer is available (e.g. a solar dryer) there is a great risk that the seeds will start to mould in the humid tropical climate.

Women and children harvest the neem fruits, and depulp, wash and dry the seeds. Once or twice a week the seeds are picked up by a transport sent by FAMA. Originally the wet processing involved modified coffee depulping machines. It turned out, however, that the depulping machines damaged the neem seeds and eventually resulted in faster fungal attack.

Therefore depulping is carried out by hand. After depulping and washing the seeds are simply dried in the sunlight for three days. For further details see Chapter II.

Labourers in the Dominican Republic earn comparatively high wages of US$ 7-8/day. This factor, together with the rather inefficient depulping technique, leads to high prices for neem seeds of Dominican origin. Based on the prices for the Dominican raw material the manufacture of neem-based pesticides is not profitable under the present economic conditions.

The average distance of neem trees from the decentralised collection and buying points is about 0-5 km, and the distance between the buying points and the neem-processing unit in San Cristobal is about 120 km. About 1500 2 - 6-year-old neem trees grow around the collection and processing centre for neem fruits in Duverge growing. According to FAMA these trees produce 12 kg fruit per tree and it is expected that the yields will increase to 20 kg/tree in 2001 (total amount of neem seeds: 306 tonnes). According to the experience of Leupolz it is unrealistic to expect that all fruits from a particular tree can be harvested. It is more realistic to

expect a yield of about 4 - 5 kg fruit per tree.

The distance from San Cristobal to Haiti (Double Harvest) is about 320 km.

Processing

Description of FAMA's neem-processing pilot plant in San Cristobal and processing steps:

For a general description of the technology see Chapter II.

The raw material (such as dry neem seeds, amongst other things) is stored at the processing unit.

Production of ground neem seeds

Neem seeds are milled in a hammer mill (maximum capacity: 500 kg/h). Afterwards the seeds are packed in polyethylene bags of 50 g, 250 g, 1 kg, or 2 kg size, which are then sealed and packed in cardboard containers.

Production of neem oil

Neem seeds are decorticated in an electric thresher and afterwards pressed in an oil expeller ("Comet", from the Monforts company, Germany). Two kg of neem seeds results in 1 kg neem kernels after the shells are removed. After a first pressing 1 kg of neem kernels produces 260 ml oil and 740 g neem cake. For producing 1 l neem oil approximately 4 kg neem kernels or 8 kg neem seeds are required.

Additionally FAMA imports neem oil and blends it with the locally produced one. Afterwards the oil is bottled and packed in units of 50 ml, 100 ml, 1 l or 200 l.

Manufacture of formulated neem oil

The following ingredients are used to manufacture 1 l formulated neem oil:

- **500 ml raw neem oil**
- **50 g Tween 60**
- **50 g Nonil Fenol 9**
- **50 ml isopropyl alcohol**
- **350 ml distilled water**

The mixing of the ingredients results in 1 l formulated neem oil, type ACE-Nim EC, with an azadirachtin content of 0.05%. The mixing of neem raw oil, emulsifiers and water takes place in a stirrer which takes 1 h for 100 l solution. Afterwards the oil is bottled in 100 ml, 1 l, 3,5 l and 200 l units.

Manufacture of neem cake

The press cake is a by-product of oil pressing. The cake is processed in a hammer mill and afterwards packed and sealed in plastic bags of 20 g, 250 g, 1 kg and 2 kg.

Summary of the calculation:

After depulping and drying 100 kg neem fruits results in 12 kg dried neem seeds with a moisture content of 8%. Threshing 12 kg neem seeds results in 6 kg neem

kernels. This

6 kg neem kernels produces about 1560 ml oil and 4440 g neem cake.

Quality control

There is no laboratory in the Dominican Republic which is able to carry out analysis of azadirachtin content. In the past some analysis has been carried out abroad to check the quality. Today quality control is therefore mainly a check on whether the product is free of impurities and whether the quantities are bottled correctly.

Registration of neem products

The legal regulations on the import and handling of pesticides are laid down in the regulation no. 311 on trading of agricultural inputs and produce and extended by Reglement 1390, of 6 October 1972. The *Secretaria de Estado de Agriculura* (SEA) is the responsible national authority in the Dominican Republic and has for example banned the import of the "Dirty Dozen", the 12 most problematic pesticides.

For the registration of pesticides the following certifications are required:

- ***Certificado de Registro para la formuladora***
- ***Certificado de Regencia***

Furthermore, the chemical composition and toxicity of the product are checked. In the Dominican Republic only the formulated neem oil requires a registration;

registration is not required for ground neem seeds or neem cake.

For export FAMA requires registration of the products within the importing countries - which as yet it has either not applied for or has not received. This is a major constraint on the export of neem pesticides. Although FAMA's neem pesticides are cheaper than competing neem products, authorities often impede the import or delay it especially when other neem pesticides are registered in the country. The lack of registration and the increasing enforcement of plant protection regulations indicate that FAMA will be more restricted to the national market in future.

4.3.4 Economic assessment of the neem-processing plant in the Dominican Republic

4.3.4.1 Technical and economic description of FAMA's neem-processing plant

Key data

FAMA's neem-processing plant is situated in San Cristobal, Ingenio Nuevo, and comprises building of 192 sq m (housing an office, store room and processing hall).

The owner of the plant is the NGO FAMA.

Staff of the neem processing plant and distribution service:

4 labourers, full-time

2,5 administrations (part-time)

4 technicians (part-time)

The labourers work approx. 250 days/year.

Capital invested in the neem processing plant:

The total investment is 1,323,023 pesos (US$ 82,700)*[25]

[25] 16 pesos = US$ 1

Capacity of FAMA's neem-processing plant

According to FAMA, 50% of the capacity of the plant is used on average. However, this varies:

January - March: 75%

April - June and October - December: 30%

July-September: 100%

The daily capacity of the processing plant is determined mainly by the capacities of the machinery, which are given below:

Thresher: 30 - 50 kg/h, 8 h/day = 400 kg day
Hammer mill: 500 kg/h, 4000 kg/day

Monforts oil expeller 10 l/h, 80 l/day
Stirrer: 100 l volume, 400 l/day
Sealing machine: 100 1 kg bag/h, 800 kg/day

The main bottlenecks in neem processing are:

- **Oil expeller**
- **Sorting of seeds contaminated with fungi**
- **Drying the seeds**

The technique for manufacturing neem-based pesticides applied by FAMA follows the requirements of the Dominican market.

Table 45: Products manufactured by FAMA and their prices, in 1998

Products for plant protection	Unit	Price in pesos/unit	Price in pesos/l or kg
Neem raw oil	50 ml	25	800/l
see above	100 ml	40	180/l
see above	1 l	200	200/l
see above	200 l	30,400	152/l
Formulated neem oil	100 ml	20	200/l
ditto	1 l	130	130/l
ditto	3.5 l	410	115/l
ditto	200 l	20,000	100/l

Semilla molida (SM) (ground neem seeds)	2 × 50g	10	100/kg
ditto	250 g	15	60/kg
ditto	1 kg	30	30/kg
ditto	2 kg	60	30/kg
Torta molida/TM (ground neem cake)	2 × 20 g	7	1,757 kg
ditto	250 g	10	40/kg
ditto	1 kg	25	25/kg
ditto	2 kg	50	25/kg
Semillas enteras (whole seeds)	1 kg	20	20/kg
Semillas viables (viable seeds)	475 g	45	100/kg
Neem trees		5	
Veterinary products			
Neem paste	200 g	32	160/kg
ditto	400 g	54	135/kg
ditto	17 kg	855	5.30/kg
Neem by-products			
Neem soap	100 g	15	
Crude neem soap	Approx. 100 g	12	
Mosquito/insect repellent	125 ml	35	

ditto	250 ml	55	
Aromatic neem oil	25 ml	20	

Four staff are working directly for the plant 5 days/week, but there are only four productive working days per week.

Productive hours/day: 6 (60 min × 6 = 360 min)

Given 208 labour days/year, this adds up to 74880 min/year.

The working time for a "productive unit" is 6 min which is equivalent to the production of 1 l formulated neem oil and 1 kg neem cake. This calculation is based on the minimum capacity of the machinery. According to this calculation 12.5 t formulated neem oil and 12.5 t neem cake can be produced annually.

In 1998 the following quantities were produced:

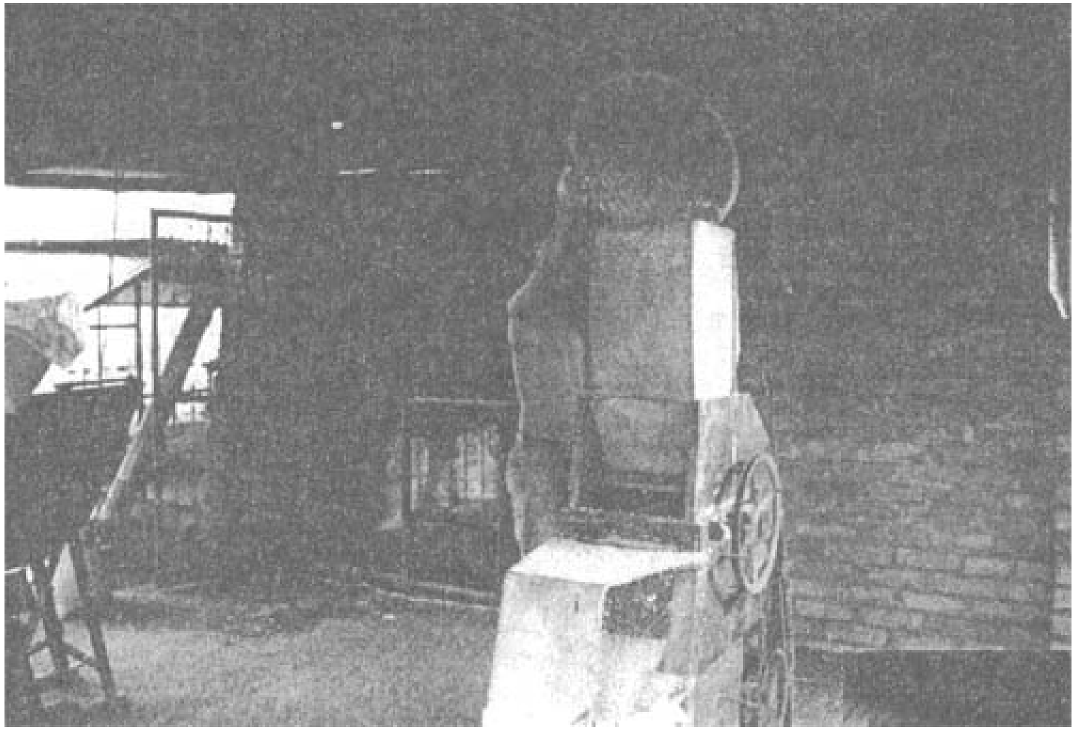
Formulated neem oil,	4.646 t
Raw oil	2.780 t
Total oil	7.426 t
Neem cake	4.941 t

59.5% of the capacity of the plant is used for oil and 39.6% for neem cake.

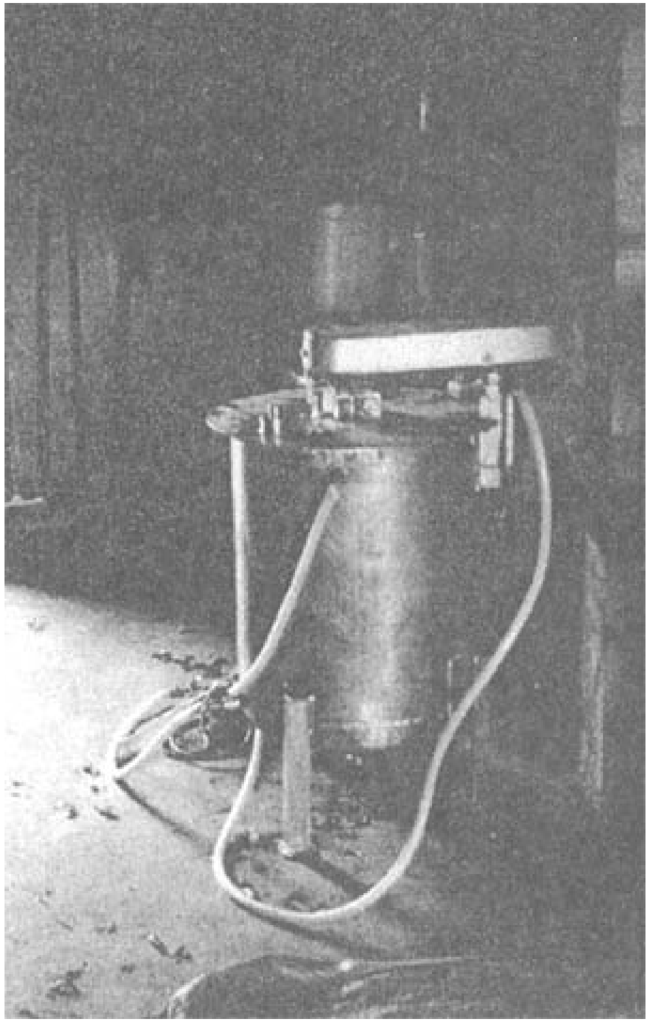
Ground neem seeds are not considered in this calculation. The grinding is, however, not very laborious and it takes 2 hours to grind 500 kg of seeds.

Given the total amount of 11 244 tonnes annually, this processing requires a total of 22.5 to 45 hours a year.

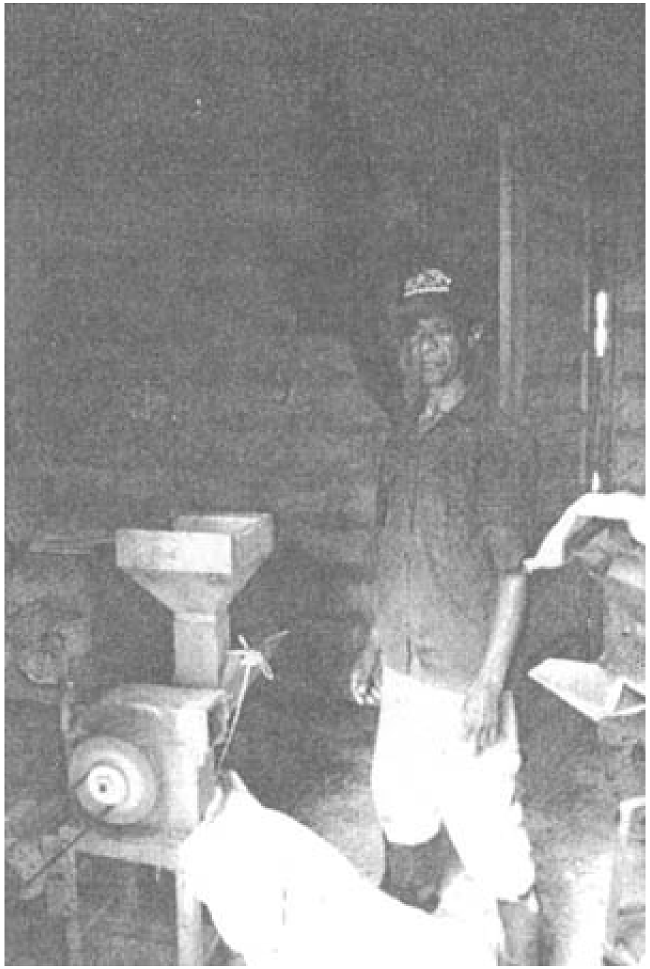
Bottling and labelling takes approx. 112 h/year with 2 labourers.



Threshing neem kernels



Stirrer for extracting active ingredients from neem cake with alcohol



Hammer mill for milling seeds and neem cake

Storage room

Harvesting neem leaves at FAMA

Collection point for neem seeds set up by FAMA

FAMA's neem products

4.3.4.2 Production costs of FAMA's neem-processing plant

Investment

Selected key data for analysing FAMA's manufacture of neem in 1998:

Invested capital in the neem-processing plant (16 peso = 1 US$):

area	120,000 pesos	(US$ 7,500)
transport	80,000 pesos	(US$ 5,000)
stationery and equipment	104,505 pesos	(US$ 6,530)
machinery	344,628 pesos	(US$ 21,540)
others	12,333 pesos	(US$ 770)
building (share)	670,557 pesos	(US$ 41,900)

building (share)	[illegible] pesos	(US$ [illegible])
total investment:	**1,323,023 pesos**	**(US$ 82,700)**

Machinery

- **Electric thresher: manufacturer "Saatmeister, Kurt Pelz, Maschinenbau", Germany, type: Universal thresher, k 50, capacity: 30 - 50 kg/h, value: 194527.50 pesos**
- **Oil expeller: IBG-Monforts & Reinerts, type: Comet, 2-screwed snail press, capacity: 25 kg kernel/h, value: 224320.00 pesos**
- **Hammer mill: Garcia und Llerand, brand DPM-Junior, electric motor, capacity: 500 kg/h, value: 28800. - pesos**
- **Stirrer: "Talleres Liranzo", Nicaragua**
- **Stainless steel tank incl. electric motor and stirrer, volume: 100 l, value: 21500.00 pesos**

Balance

Activa items are machinery and buildings, land, transport/car, equipment, etc.

total	1,332,023	pesos
- depreciation	84,763	pesos
total	1,247,260	pesos

Inventory items are:

books, journals, etc.; products ready for sale; raw material, half-finished products; items required for manufacturing; packing material; others:

Sum for inventory	629,229	pesos
Demand to customers	195,084	pesos
Demand to staff	106,973	pesos
Grand total	2,179,944	pesos

Passiva

Credit, seeds, land, neem oil, etc; debts to be paid with Loyola, suppliers and for investment; wage bills

Total	967,985	pesos external capital
Donations	1,211,959	pesos, companies capital (share)
Grand total	2,179,944	pesos

Income in 1998

Sale of products	1,675,901	pesos
Donations	1,260,677	pesos
Other	40,271	pesos
Services provided for others	131,071	pesos
Total	3,107,920	pesos

Costs

Variable costs

Purchase of neem raw material, packing materials, other agricultural products; costs of imported materials; transport; costs of distribution and sales

Total: 941,086 pesos

Raw materials

In 1998, FAMA bought 7704 kg washed neem seeds in the Dominican Republic. It also imported 27 t neem seeds from abroad; which including transport and other costs comes to US$ 17639 or US$ 0.65/kg seeds. The seeds are normally of good quality, dry and free of fungal infestation, and do not cause additional costs.

FAMA imported 5000 l neem oil at a CIF price of 46.58 pesos/l or US$ 3.02/l.

Fixed costs

Wages including diems and assurances for 3 labourers and employees; depreciation, maintenance for car, machinery, spares, service; communication, banking fees, stationery, Rent, maintenance for the office, assurances; donations; external consultancy; interest; costs of nursery; advertising; transport, distribution costs, sales, travel; other costs

Grand total of fixed costs: 1,086,939 pesos

Volume of produced neem products and raw material in 1998

Ground neem seeds/1 kg	1,426 kg
Ground neem seeds/100 g	2,613 kg
Ground neem seeds/250 g	7,205 kg
Neem cake/1 kg	1,151 kg
Neem cake/100 g	2,558 kg
Neem cake/250 g	1,232 kg
Raw oil/1 l	73 l
Raw oil/100 ml.	690 l
Raw oil/3.5 l	17.5 l
Raw oil 200 l	2,000 l
Formulated oil/1 l	1,054 l
Formulated oil/3:5 l	350 l
Formulated oil/100 ml	242 l
Formulated oil/200 l	3,000 l

By-products sold in 1998

Entire neem seeds 7,138 kg, turnover
Viable neem seeds 165 kg,

Mosquito repellent, 125 ml 1,096 units

Mosquito repellent, 250 ml 63 units

Aromatised neem oil 96 units

Citronella oil 14 units

Neem soap 4,380 pc

Neem soap, simple 1284 pc

Neem leaves/100 g 583 units

Neem leaves/0.5 100 units

Neem trees 7,420 pc

Total income: 311,500 pesos (US$ 19,500)

External costs

Only low quantities of waste and waste water are produced during neem manufacture. The shells of neem seeds are used for composting. In den Centros de Acopio (neem seed-processing units and domestic gardens of the farmers who depulp the seeds) waste water from washing and the pulp is produced, which however, does not cause any impacts or costs due to the small amounts.

Cash flow

The following is a cost/benefit analysis for FAMA's above-mentioned neem-based pesticides only.

Total income resulting from the following activities in 1998:

Sales of products 1,540,503.50 pesos

Sales of products	1,540,503.50	pesos
Variable costs	842,264.09	pesos
Fixed costs	1,003,131.00	pesos
Total costs	1,845,395.00	pesos
This resulted in a loss of	304,891.50	pesos[26]

[26] 16 Peso = 1 US$

It is therefore recommended

- **To increase the prices of the products (by applying the 120% rule);**
- **To increase the production (by 50%).**
- **This would require an investment in the underdeveloped marketing of the products.**

Production cost per unit

It is recommended to apply the "120% rule" to cover the losses. This means that the sales price should be 120% of the variable costs, to cover the fixed costs and produce a profit on the venture.

Example:

Applying the "120%" rule, the turnover would rise from 842,264.09 pesos to 1,010,716.80 pesos; adding in fixed costs of 842,264.09 pesos results in 1,852,980.80 pesos.

Subtract the total costs associated with the products mentioned of 7,585.80 pesos.

Success depends on the assumption that it is possible to sell the products at the increased prices and to increase the volume sold.

The following is a calculation based on the "120% rule".

Variable costs for the manufacture of the products, without the wages and labour costs:

Table 46: Costs for ground neem seeds (Semilla Molida)

Activity	Ground neem seeds 1 kg	Ground neem seeds 100 g	Ground neem seeds 250 g
Quantity sold in 1998	1,426 kg	2,613 kg	7,205 kg
Retail price	25 pesos	30.96 pesos	25.80 pesos
Variable costs - raw material and packing	12.11 pesos	13.73 pesos	12.64 pesos
Gross sale price	35,650.00 pesos	80,998.48 pesos	185,889.00 pesos
Variable total costs	17,268.86 pesos	35,876.49 pesos	91,071.20 pesos
Contribution of covering the fixed costs	18,381.14 pesos	45,021.99 pesos	94,817.80 pesos
New retail price (applying 120% rule to fixed costs)	26.64 pesos	30.21 pesos	27.81 pesos

Table 47: Cost calculation for raw neem oil

Activity	Raw neem oil 1 l	Raw neem oil 100 mml	Raw neem oil 3.5 l	Raw neem oil 200 l
Quantity sold in 1998	73 units	690 units	5 units	10 units
Retail price	200 pesos	16.6 pesos	700 pesos	26,814 pesos
Variable costs - raw material and packing	89.52 pesos	10.01 pesos	310.73 pesos	17,506 pesos
Gross sales price	14,600 pesos	11,081.40 pesos	3,500 pesos	268,140 pesos
Variable total costs	6,534.96 pesos	6,906.90 pesos	1,553.65 pesos	175,060 pesos
Contribution for covering the fixed costs	8,065.04 pesos	4,174.50 pesos	1,946.35 pesos	93,080.00 pesos
New retail price (applying 120% rule to fixed costs)	196.94 pesos	22.02	683.60	38,513.2

It is not particularly easy to allocate the costs and make clear which costs are incurred by neem manufacture and which by training on general agricultural activities. This is true for the costs for personnel, but also for the costs due to the use of the car and communication. The reason is that that all the staff work a certain amount of the time on production, information and distribution of neem products, and also on other activities.

There is no problem with transport or the energy and water supply here since the

company has its own generator. There are sufficient trained labourers and workers available for the manufacture of neem.

No external costs or environmental damage is caused by neem manufacture.

4.3.5 Market potential for neem pesticides in the Dominican Republic

4.3.5.1 Marketing to date

In the Dominican Republic it is common practice to apply synthetic insecticides. All pesticides are imported since no pesticides are manufactured in the country, except for neem pesticides.

The *Secretaria de Estado de Agriculura* (SEA), *Departemento de Sanidad Vegetal Division de Registro de Plaguicidas* is in charge of supervising the import of insecticides.

In 1998 957,729 l/kg of insecticides of US$ 6,810,527.51 value were imported to Dom Republic

In principle all agricultural inputs imported to the Dominican Republic are free of tax, to enhance agricultural production. This also applies to pesticides. However, traders usually have 80 - 100% mark-up on the wholesale price and thus increase the price of agricultural inputs considerably.

IPM systems have been introduced to overcome the problems caused by indiscriminate use of broad spectrum pesticides, but are not available for all crops and are not applied countrywide.

The obvious main pest the farmers encounter is the whitefly *Bemisia tabaci* which is resistant to all broad-spectrum insecticides. This problem has led to a special governmental directive, Resolution 37/99 Manejo on "Control y Prevencion de la Mosca Blanca", which regulates the cultivation areas and times for tomatoes.

FAMA's neem-based pesticides are most effective against the following groups of pests:

- **larvae of Lepidoptera**
- **aphids**
- **whitefly (*B. tabaci)***

Their neem-based pesticides compete with the pesticides shown below:

Table 48: Price, target pests and crops of products competing with neem pesticides in the Dominican Republic

Name of the product	Price of the product US$/kg	Pest	Crop
M.T.D. 600	5.00	Lepidoptera larvae	Cucurbitacea
			Solanacea
			Leguminosae
Decis	17.65	Lepidoptera larvae	Cucurbitacea
			Solanacea
			Leguminosae

Tamaron	10.00	Lepidoptera larvae	Cucurbitacea
			Solanacea
			Leguminosae
Lannate	22.00	Lepidoptera larvae	Cucurbitacea
			Solanacea
			Leguminosa
Monitor	10.00	Lepidoptera larvae	Cucurbitacea
			Solanacea
			Leguminosae
Diazinon	12.94	Lepidoptera and aphids	Solanacea
			Albemoschus
			Esculantum
Thiodan	11.88	Whitefly (*B. tabaci)*	Solanacea
Eviset	20.38	Whitefly (*B. tabaci)*	Cucurbitacea
			Leguminosae
Danitol	32.81	Whitefly (*B. tabaci)*	Cucurbitacea
			Leguminosae
Pegasus	75.25	Whitefly (*B. tabaci)*	Solanacea
			Cucurbitacea
Thionex	11.00	Whitefly (*B. tabaci)*	Solanaceas
Ekatin	9.15	Whitefly and	Cucurbitacea

Ekatin	9.15	Whitefly and Lepidoptera	Leguminosae
			Cucurbitacea
Javelin	27.94	Lepidoptera and whitefly	Many
Dipel	18	Lepidoptera and whitefly	Many

The above list indicates that neem products are some of the most expensive pesticides. An exception is the product "Pegasus" which is a selective pesticide against whiteflies and which is more expensive than neem.

Formulated neem oil is cheaper than ground neem seeds and easier to apply. However, these types of pesticides cannot be compared directly because to a certain extent they affecting different pest species.

While synthetic insecticides can be applied on all sorts of crops, neem products are currently only used in high-priced niche markets such as vegetables, fruit and flowers. Neem is not applied on staple crops such as corn and legumes. It is only competitive within some IPM concepts and where no synthetic insecticides are allowed (organic farming).

Farmers applying neem in the Dominican Republic are cropping according to IPM or organic farming principles, often assisted by projects.

To date the small-scale industrial production of neem products in the Dominican Republic is producing a considerable amount for export.

Trading chain

In the Dominican Republic pesticides, especially insecticides are distributed from importers to retailers. The addresses of retailers have to be registered in a special data base. Neem products are usually not sold via the normal agricultural supply trading system. One exception is the wholesaler LIGA.

The present market share of neem products can only be estimated: in 1998 FAMA produced 4 200 tonnes of formulated neem oil, of which 56% has been exported and 44% sold on the national market. Additionally most of the ground neem seeds and cake has been exported. Given that the total value of imported insecticides was 6.5 million dollars, neem pesticides have a market share of about 0.25%.

4.3.5.2 Market potential of neem pesticides

The agricultural sector in the Dominican Republic is characterised by unequal land distribution and sizes of farms (15% of farmers cultivate 50% of the agricultural area, 80% of all farms are smaller than 5 ha). Many farmers acquired 3-5 ha plots as the result of an agricultural reform process. The problem related to this land is that it could not be mortgaged, which would be necessary for buying agricultural inputs. In total nearly 2 million ha are used for agriculture.

The main agricultural export products are sugar cane, coffee, cocoa and tobacco, but also banana and pineapple. For local consumption mainly rice, maize and vegetables are produced.

In 1998 the following areas (in ha) were cultivated with following selected crops, which might have a potential for neem application (listed by the decreasing

potential for neem application):

brassicas	1,235 ha
okra	670 ha
melons, cucumber	1,180 ha
tomato	11,760 ha
capsicum	2,550 ha
egg plant	1,370 ha
tobacco	25,900 ha
potato	2,780 ha
orange	6,420 ha
maize	36,920 ha
rice	110,840 ha
coffee	12,560
cocoa	148,350
peas and other pulses	23,260 ha
beans	49,900 ha
pineapple	228,265 ha

The export market for vegetables, fruits and flowers, especially in the USA, is a market for neem pesticides, because the crops are checked for residues of synthetic pesticides.

Complaints of crop samples contaminated with pesticide residues over the

permitted levels result in heavy losses, because the entire container is sent back. It can be expected that the market demand will increase in the future.

Vegetables cropped for export and treated according to IPM concepts are brassicas, carrots, lettuce, onions, beetroot and garlic. According to the MoA there is a good opportunity for neem pesticides in following crop species:

- potatoes 1,570 ha
- fennel 125 ha
- cabbage 630 ha
- lettuce 3,500 ha
- carrots 220 ha
- broccoli 95 ha
- beetroot 250 ha
- onion 310 ha
- garlic 820 ha

The DoA recommended substituting three out of ten insecticide applications (e.g. in tomato) with neem.

The following table (49) lists the crop species and pests where this concept has been used successfully (according to FAMA):

Table 49: Cost comparison between neem oil and conventional pesticides

Crop	Pest	Costs of formulated	Costs for applying synthetic

		neem oil/ha US$	pesticides (US$/ha)
Melon	Lepidoptera	22.75	Decis 4.41
Melon	*B. Tabaci*	45.5	Pegasus 56.54
Capsicum	Aphids	40.56	Diazinon 12.94
Capsicum	Lepidoptera	20.25	Dipel 18.00
Capsicum	*B. Tabaci*	4,056	Eviset 10.29
Tomato	*B. Tabaci*	45.5	Pegasus 56.54
Tomato	Dipteros	22.75	Decis 4.41
Tomato	Aphids	45.50	Diazinon 12.94
Tomato	Lepidoptera	20.25	MTD600 3.75
Cabbage	Lepidoptera	27.30	Javelin 13.97
Cabbage	Aphids	54.60	Primor 14.25
Beetroot	Lepidoptera	20.25	Dipel 18.00
Beetroot	Aphids	40.56	Monitor 10.00
Okra	*B. Tabaci*	20.25	Thiodan 11.88
Okra	Lepidoptera	20.25	Lannate 16.5
Okra	Aphids	45.50	Primor 14.25
Auyama	Lepidoptera	34.12	Javelin 13.97
Auyama	*B. Tabaci*	68.25	Pegasus 56.54
Auyama	Aphids	68.25	Primor 14.25
Lettuce	Lepidoptera	20.25	Decis 4.41

Lettuce	Aphids	40.56	MTD600 3.75
Eggplant	Lepidoptera	34.12	Javelin 13.97
Eggplant	*B. Tabaci*	68.25	Pegasus 56.54
Watermelon	Lepidoptera	34.06	Dipel 18.00
Watermelon	*B. Tabaci*	68.25	Danitol 24.61
Watermelon	Aphids	68.25	Ekatin 9.13
Cucumber	Lepidoptera	22.75	Javelin 13.97
Cucumber	*B. Tabaci*	45.50	Thiodan 11.88
Cucumber	Aphids	45.50	Monitor 10.00

In principle the preparation of the pesticide solution based on formulated neem oil is similar to that of synthetic insecticides. The applications, however, have to be carried out more intensively and more thoroughly. It is also important to apply the neem pesticides in the evening or early morning to avoid fast degradation by UV light.

To prepare a pesticide solution of ground neem seeds much more time and additional equipment is required (see Chapter II, 2.1).

Although there are about 1000 - 2000 farmers cropping according to organic farming regulations, the market share for neem products has been very small in the past.

This is due to the fact that neem products are not very well known and tested in organic cropping systems. A further potential market for neem pesticides can be

expected in this sector.

4.3.5.3 Analysis of the economic production with and without the use of neem pesticides

For a comparison between cropping systems with synthetic insecticides and neem pesticides the following data are required:

- **costs of insecticides for the specific control strategy**
- **yields as result of the specific control strategy**
- **total costs of the specific control strategy**
- **share of the insecticide costs for specific control strategy**
- **profit of the specific control strategy**

A comprehensive study based on home-made aqueous neem kernel extract and subsidised half-finished neem products has been conducted by Leupolz (1995), who identified a range of constraints, and only a few crops where it was economical to apply aqueous neem kernel extracts.

To date there is no data available on economic evaluation and comparison of IPM systems with and without neem products or where medium and long-term effects of neem applications have been investigated.

To get an idea of the economic production with and without neem pesticides a rough approach might be to compare the costs of application on one hectare of neem and conventional pesticides competing with neem.

If formulated neem oil (4 l/ha = US$ 32.50/ha) is used as a substitute for

conventional insecticides, the following price differences can be calculated (Table 50):

Table 50: Price comparison between neem oil and conventional pesticides

Insecticide	Price US$/l or kg	Amount/ha	Price (US$/ha)	Price difference (US$/ha)
Thiodan	11.88	1 l	11.88	+22.62
Eviset	20.58	0.5 lb.	10.29	+22.21
Thionex	10.93	1 l	10.93	+21.57
Danitol	32.81	0.75 l	24.61	+7.89
Pegasus	75.25	0.75 l	56.44	-23.94
Diazinon	12.94	1 l	12.94	+19.56
Ekatin	9.13	1 l	9.13	+23.37
Monitor	10.00	1 l	10.00	+22.50
MTD 600	5.00	0.75 l	3.75	+28.75
Pirimor	19.00	0.75 kg	14.25	+18.25
Decis	17.65	0.25 l	4.41	+28.09
Lannate	22.00	0.75 kg	16.50	+16.00
Dipel	18.00	1 l	18.00	+14.5
Javelin	27.94	0.5 g	13.97	+18.53

The survey reveals that the market potential for neem pesticides has to be seen

primarily in the substitution of specialised expensive synthetic pesticides and expensive non-synthetic pesticides such as Pegasus, and less in the substitution of common cheap broad-spectrum insecticides.

4.3.5.4 Market growth potential and substitution possibilities

There is no doubt that there is a potential demand for neem pesticides and other non-synthetic pesticides, especially for vegetables and fruits produced for the export markets. Within the country resistance of pests to pesticides is increasing all the time. The market for certified organic produce is expanding greatly and will also require appropriate means for pest control.

One product competing with neem pesticides is Bt. Today neem-based pesticides cannot compete with cheap synthetic pesticides, but only with specialised synthetic products such as Pegasus, which is sold for 1204 pesos/l by Bayer Dominican Republic and has to be applied at 0.75 l/ha, while biological agents such as 500 g Bt (manufactured by Turilav) is sold for 280 pesos by LIGA (which works out at 420 pesos/ha).

A central constraint on the dissemination of neem pesticides is the lack of distribution by the agricultural supply trading agencies. The NGO FAMA is not in a position to set up an effective distribution service of its own. The only agricultural supply trader selling FAMA products is LIGA, which also sells other biological products. The area covered by LIGA's outlets is very limited, which means that FAMA's products are not available throughout the country, and not even in the main centres of agricultural production such as Constanza, San Juan, La Vega and San Jose de Ocoa.

In addition to LIGA's outlets neem products can be purchased at the "Centros des Acopio" in Azua and Bani, directly in San Cristobal at the neem plant and at FAMA's office in Santo Domingo. However there is no doubt that there are too few outlets.

A further related problem is that FAMA has limited staff resources and that the time spent on distribution reduces the time left for training and awareness-raising.

Training, qualification and extension services concerning pesticides in the Dominican Republic have to be carried out by the agricultural suppliers. Currently only LIGA is doing so for neem pesticides. The technicians of the governmental extension service SEA are given advice on neem products at IPM training. Additionally some NGOs provide information on neem within their project activities. For example the GTZ project "Asosiacion para el dessarollo de San Juan de Ocoa", is training about 4000 farmers, 30 of whom apply neem pesticides on vegetables.

Transport for the distribution of pesticides is not a problem in the Dominican Republic, if they are part of agricultural supply system.

The site where FAMA is location can be considered as optimal concerning import of raw material and distribution of products.

A further restriction is that neem products are not included in the widely applied credit scheme. Normally the farmers in the Dominican Republic get agricultural inputs on credit which has to be repaid within 30 days.

4.3.6 ''Lessons learnt'' - recommendations

Potential for reducing the costs has been identified in the following areas:

- **Increase of the total production and proportion of capacity used, especially in the months January, April, May, June, October, November and December.**

- **Reduce the costs of raw materials (by importing).**

- **Reduce advice and training of the Dominican producers of neem raw material.**

In future the interrelationship between conventional pesticide usage and the potential market for neem should be investigated. Emphasis should be placed on two aspects:

- **What are the conditions for integrating neem products into conventional trading channels?**
- **What investment is required for advertising, information materials and further promotion?**

Furthermore, it is important to provide the following services for introducing neem pesticides? Training and advice to farmers on:

- **Integration of neem pesticides into integrated pest management concepts (combination with other pesticides)**

- **Integration of neem pesticides into organic farming systems (combination with biological insecticides)**

Credit for neem pesticides

Farmers in the Dominican Republic are used to buying insecticides on credit. For small manufacturers of pesticides this is a problem because they do not have sufficient capital. If the manufacturer were to cooperate with the agricultural supply trading companies, credit could be provided by the trading company.

Neem should not be made into a political topic. Neem pesticides do not compete, at least to date, with the entire market of synthetic pesticides, but only with single, more expensive insecticides of good quality (selectivity). Due to the MRL regulation the agricultural supply trading has increasingly to consider the needs and requirements of IPM. Neem could play an important role within IPM concepts. There is no reason for the agricultural supply traders not to sell such an efficient and successful product.

The same marketing rules apply to the production and distribution of pesticides as for other products. This means that the manufacturers of pesticides has to decide if they want to market their products by emphasising the price or the quality. Because of the comparatively high production costs, neem products cannot be marketed on price, but the quality and advantages of the products should be emphasised.

Future increase in sales of neem products mainly depend on the successful integration of neem pesticides into the conventional trading channels. Interviews

of the retail traders reveal that the price of neem pesticides was not considered to be an important obstacle.

Need for investment

According to the analysis described above capital has to be invested in the marketing of neem products, especially to get FAMA's neem products into the conventional market channels. The trading agencies expect FAMA to supply them with information and advertising materials, advertisements for radio and TV, as well as print media.

Furthermore, sufficient samples for training and demonstration courses are required for the merchandisers.

All this adds up at least to approx. US$ 100000 which would be required for two years, which can be specified in a detailed marketing analysis.

Investment in processing equipment is not urgently needed until the capacity of the present plant is used to the full.

If more seeds are processed into oil, a surplus of neem cake can be expected which should be processed in an extraction unit.

4.4 Small-scale commercial neem production in Nicaragua

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4.4.1 Introduction

The intensity of agricultural production in Nicaragua is much lower than that in the Dominican Republic or Thailand but there has been frequent intoxication of the rural population and environmental pollution.

In the 1980s neem trees were planted often in plantations by a range of NGOs, projects and by the Forestry Department in Nicaragua. Until 1990 neem raw material was processed and pesticides and veterinary products were manufactured.

The case study presented here aims to analyse the present state of neem manufacture and use in Nicaraguan agriculture. It intends to identify constraints and interventions needed to help neem pesticides to gain a greater market share and contribute substantially to a reduction of the impacts and problems caused by synthetic pesticides.

4.4.2 Previous activities and other projects in relation to neem

As in many Latin American countries, the neem tree has been introduced only recently in Nicaragua.

In Nicaragua activities on planting, awareness and promotion started in 1983. The Forestry Department started to plant neem trees for timber usage on small plots and investigated the performance of neem under the local growing conditions (Gruber 1991). These trees formed the source of neem seeds for subsequent planting and processing activities. During the time of the Sandinistas the Forestry Department closely cooperated with a range of NGOs such as "Proyeto

Insecticidas Botanicos Nim" and "Copinim", which were promoting the planting of neem trees in plantations (of 3 ha - 200 ha), agro-forestry systems and in and around pastures and in villages (Mandellaub 1992, Sanchez & Gruber 1996).

In 1994 about 500 000 trees could be found in Nicaragua, and in 2000 the total number is estimated to be about 2 million fruit bearing trees. Seminars and field days have been held by NGOs to promote the use of home-made neem kernel water extracts and demonstration plots have been established in the farmers' fields. Neem has mainly been used on maize, brassicas and watermelon. The German foundation "Umverteilen" and other NGOs from abroad supported the promotion of neem usage in Nicaragua.

In a second phase processing units for neem fruits where were set up with the aim of obtaining consistently high quality neem kernels and storing them appropriately. One feature of Nicaraguan neem manufacture is that it is mainly based on neem plantations which enable better and controlled harvesting of neem fruits/seeds. Interesting experiments have been conducted to optimise harvesting and processing methods. Research has been carried out on the potential usage of neem within Nicaraguan agriculture, supported by a GTZ/IPM project (Hellpap & Mercado 1986).

Later processing units were established to produce standardised, registered neem products such as ground neem seeds, formulated neem oil, neem cake and alcoholic extract. Further products for veterinary uses were manufactured.

Source: C. Hellpap, personal communication

4.4.3 Small-scale commercial neem production in Nicaragua

4.4.3.1 Seed collection

In the 1980s and 1990s Copinim established decentralised units in La Trinidad, Leon and Managua-Sabana Grande to process neem fruits into dried neem kernels of high quality. Each of these centres cost about US$ 10000 to 20000.

However, these plants are not in use because the farmers prefer to depulp and wash the seeds by hand in their own homes, although this requires more time and water. These "Centros de Acopio" were built with donations from international NGOs. The NGOs failed to assist the farmers to build up a stable structure or a company which guaranteed sustainable production of neem seeds.

The farmers normally collect the seeds from their own fields or boundaries. The fruits are harvested directly from the trees. The framers depulp and wash them manually. Pruning takes place during harvesting time, which enables the collectors to pick the fruits directly from the branches lying on the ground. On average 30 kg could be picked in 6 h (5 kg/h) (Leupolz 1995). The collectors do not differentiate between ripe and unripe fruits, because that would require too much time. Unripe fruits are stored in the shade until they are ripe. The average yield per tree on neem plantations is about 5 kg fruit.

After harvest the seeds were dried in the sun until they have a moisture content of 20%. Twice a week Copinim sends a car to collect the neem seeds from fixed collection points where the collectors are paid in cash. The average distance to the neem plants was approx. 50 km.

At the neem processing plant Copinim dried the neem seeds with an electric dryer to reduce the moisture content to 8 - 9%. This resulted in a weight loss of 30% which results in a price 12 cordoba (US$ 1) for 1 kg seed. The dried neem seeds are filled into bags and stored in a hall.

According to Copinim there is no shortage of raw material in Nicaragua. It is calculated that each of the 2 million trees can yield 4 kg fruit which come to 8 million kg of fruit or 1,000 tonnes of seeds. In 1999 the manufacturers in Nicaragua processed approx. 25 tons of seed, which is about 2.5% of the potential total.

Until 1998 the NGO Copinim ran its own wet processing unit (see Chapter II), which however has stopped working because it was not profitable. Since 1999 this manufacturer of neem pesticides has been buying washed and pre-dried neem seeds for an average price of 7.5 cordoba from the farmers in the regions La Trinidad/Carazo, Leon and Los Brasiles. In 1999 Copinim bought 9 tonnes of neem seeds, whereas in 1998 it purchased 14 tonnes.

Generally the volume of raw material purchased by Copinim is decreasing, which is due to a lack of investment capital for purchasing the seeds, not to a lack of demand for the final products. According to the directors, the whole of the 1999 harvest has been sold, while in 1997/98 some problems occurred in selling the oil to the USA. The US Environmental Protection Agency (EPA) did not allow the import of neem oil intended for shampoo manufacture because the oil did not fulfil the quality criteria for cosmetics in the US.

4.4.3.2 Processing activities

Manufacture of formulated neem oil

Decortication of 400 kg neem seeds results in 200 kg of neem kernels.

Pressing 200 kg neem kernels results in approx. 50 l neem oil and 150 kg neem cake.

50 litres of raw oil + 20% emulsifiers results in 60 litres of formulated neem oil, type "CE 80".

The neem oil is bottled in containers of 1 l and 20 l.

Recommended application is 4 - 10 ml/l oil in water, depending on the occurrence of pests.

Manufacturing of neem cake (Torta de Nim, 0.3% WP)

From 400 kg neem seeds, 150 kg neem cake is left over. This is milled with a hammer mill and packed in 2 kg or 20 kg bags.

Recommended application is 25 g/l water. According to the manufacturer the cake has an azadirachtin content of 0.3%.

Manufacture of alcoholic neem extract (Nim Action 0.4 SL)

200 kg neem cake is mixed with 100 l alcohol for 8 h in a mechanical stirring unit. The extract is filtered and the filtrate mixed with emulsifiers.

1 l Nim Action 0.4 SL consists of 1% emulsifiers, 79% alcoholic extract and up to

20% neem oil. According to Copinim the azadirachtin content is 0.4%.

The product is bottled in 1 l and 20 l units.

Manufacture of neem paste (Pasta Nim)

The neem paste is a by-product of the oil manufacture and is basically the sediment remaining after the neem oil is filtered. The pomade is filled in 125 g units.

All Copinim's neem products are registered by "Sanidad Vegetal".

Quality control

The raw material and products are checked for cleanliness, contamination with fungi and correct packing and bottling. There is no laboratory in Nicaragua which is able to check the azadirachtin content.

4.4.4 Economical assessment of COPINIM's processing plant in Nicaragua

4.4.4.1 Technical and economic description of the neem processing plant

The following products are manufactured and offered by Copinim, Nicaragua:

Table 51: Neem products offered by Copinim, Nicaragua

Neem bases pesticides	Unit	Price/unit in C$
Neem alcoholic extract (Nim action 04 SL)	1 l	120

Formulated neem oil, CE 80	1 l	110
Neem cake (Torta de Nim)	2 kg	60 (or 30/kg)
Veterinary products		
Neem paste	125 g	15

Key data

The plant is based in Managua, Los Brasiles km 15 carr. Nueva a Leon, Nicaragua.

The site is comprises 28,000 sq m, of which 2,000 sq m is covered with a roof.

The building has a size of 150 sq m and includes an office, store room, sales room and processing unit.

Owner: the area and building was given to Cieets by a German NGO on condition that *COPINIM Cooperativa de Produccion de Insecticidas Nim,* (Copinim) is allowed to use them. It is unclear whether the processing unit belongs to the NGO Cieets or to Copinim.

Staff:

In November 1999 two permanent staff were employed by the plant.

Other labourers are employed according to the need.

Invested capital:

Copinim owns the following machinery:

3 depulpers, capacity: 250 kg/h, value:	US$ 3,000
1 pump, value:	US$ 2,000
1 dryer, capacity: 30 kg/h, value:	US$ 6,500
4 small depulpers, capacity: 60 kg/h, value:	US$ 2,000
1 thresher IMEF, capacity: 60 kg/h, value:	US$ 1,000
1 thresher "Hans Ulrich", value:	US$ 500
1 thresher, capacity: 50 kg/h, value:	US$ 700
1 hammer mill, capacity: 100 kg/h, value:	US$ 1,500
600 drying sieves, value:	US$ 2,000
1 fine sieve (1.5 mm), value:	US$ 400
1 Monfort oil expeller, capacity: 2.5 l/h, value:	US$ 4,000
1 stirring unit, capacity: 150 l, value:	US$ 200
1 van "KIA", value:	US$ 2,000
1 bus, value:	US$ 3,000

Capacity

A description of the processing steps (including wet depulping process) of Copinim's neem plant:

Table 52: Processing steps and capacity of Copinim's neem plant

Process	Potential capacity of	Capacity	Potential capacity of	Real

	the machinery	used in 1998	1 labour/staff	capacity in 1998
Selection of fruits	8 tonnes/day	3 tonnes/day	150 kg/day	150 kg/day
Fruits after -ripening	6 tonnes/day	3 tonnes/day	6 tonnes/day	3 tonnes/day
Depulping	10 tonnes/day	5 tonnes/day	1.5 tonnes/day	1.5 tonnes/day
Washing	5 tonnes/day	2 tonnes/day	1.5 tonnes/day	1.5 tonnes/day
Drying	1.5 tonnes/day	0.8 tonnes/day	0.4 tonnes/day	0.4 tonnes/day
Threshing	1 Ton/day	0.5 tonnes/day	0.5 tonnes/day	0.5 tonnes/day
Grinding	1 Ton/day	0.3 tonnes/day	0.5 tonnes/day	0.5 tonnes/day
Formulating oil	300 l/Day	300 l/day	150 l/day	150 l/day
Alcoholic extraction	100 l/Day	100 l/day	100 l/day	100 l/day

Oil pressing is carried out by another company which charges Copinim per unit.

The technology applied and quality of the neem pesticides match the requirements

of the local market.

Constraints

An analysis of neem processing in Nicaragua revealed the following constraints:

- **Copinim is not able to perform any azadirachtin analysis**
- **The capacity of the oil expeller is not sufficient.**
- **The alcoholic extraction of the neem cake is not optimal.**
- **Marketing and distribution are not effective enough.**

4.4.4.2 Production costs at COPINIM's neem processing plant

Production and maintenance costs

The following table (51) provides an overview on the production and maintenance costs calculated on different volumes processed:

Table 53: Production and maintenance costs for different volumes processed by Copinim:

Activity	Based on 10 t neem seeds (US$)	Based on 75 t neem seeds (US$)
Drying neem seeds	10,000	75,000
Direct labour	1,500	4,771
Indirect labour	3,200	9,513
Power	500	689

Depreciation of machinery	8,619	8,619
Maintenance	1,382	1,382
Others	1,890	2,660
Total costs of production	**27,091**	**93,425**
Operating costs, administration and sales		
Wages	9,500	13,169
Assurances	1,270	1,773
Water, power, telephone	641	641
Stationery	683	683
Representation	356	356
Depreciation	308	308
Taxes	0	2,600
Other costs	1,000	1,600
Total operating costs	**13,758**	**21,370**
Interest/repayment of credit	2,000	4,780
Total expenditure	42,849	119,575

External costs

A large amount of energy is needed for drying the neem seeds, and therefore Copinim is currently setting up a solar drying unit costing US$ 5000.

Wet processing of neem requires large amounts of water. Neem pulp and waste water could produce environmental damage if they are not treated appropriately.

Cash flow

If 10 t raw material is processed by Copinim the following income can be generated:

Table 54: Calculation based on processing 10 t of neem seeds in Nicaragua

Investment	Value of the investment (US$)	Annual depreciation (US$)
Building	75,431.89	3,771.55
3 depulpers	3,000	600
Washing unit	2,000	400
Dryer	6,500	928.57
4 small depulpers	2,000	666.67
1 thresher/decorticator IMEP	1,000	333.33
1 thresher "Hans Ulrich"	500	250
1 thresher, national brand	700	100
1 hammer mill	1,500	500
600 drying sieves	2,000	400
1 fine sieve	400	100

Oil expeller	4,000	1,333
1 packing unit	250	125
1 small transporter	2,000	500
1 small bus	3,000	600
Equipment and tools	2,000	500
Total	106,781.89	11,108.12

In 1999 about 50% of the total capacity was used by Copinim. This is not enough to cover the costs. Given that neem is processed all year the current amount of raw material could be increase from 9 t/annually to 200 t/annually.

Calculation of cash flow:

1,250 l formulated oil	US$ 12,500
1,875 l alcoholic extract	US$ 20,625
total turnover	US$ 33,125 minus costs
results in a loss	- US$ 9,724

In 1999 the loss was concealed, because the depreciation was not included in the calculation and the wages were not paid as agreed.

Theoretically it is possible to cover the loss by increasing the prices:

A 25% price increase brings in	US$ 8,281.25
The remaining loss is	US$ 1,442.75

One further option is to increase production to 75 t neem seeds, which can easily be processed by the current plant. This would result in an increased

turnover of	US$ 133,071
costs	US$ 119,576
preliminary profit	US$ 13,495

Production cost per unit if retail prices increased

This results in a cost calculation such as that for the unit of NimCE 80/(Table 55).

Table 55: Cost analysis for single product unit of formulated neem oil (Nim CE 80)

Ingredients/process	Total costs (US$)	%
Neem seeds with shell	7.71	59.06
Emulsifiers	1.50	12.59
Labour costs/extraction 0.115 d.h.	0.55	4.47
Labour costs/formulation 0.0066 d.h.	0.06	0.48
Indirect costs		
Labour 0,36 d.h.	2.76	17.51
Power supply	0.005	0.41
Maintenance	0.04	0.34
Depreciation	0.63	5.16
Assurance	0.03	0.027

Assurance	0.05	0.027
Total production costs	13.315	100

(d.h. = labour force day)

Retail price for 1 l formulated neem oil would be between 9.5 and 10 US dollars.

In addition to this, a further product of 3 kg neem cake is left for producing ground neem cake or alcoholic extract.

The following table (Table 56) provides the cost analysis for 1 kg ground neem cake.

Table 56: Cost analysis for 1 kg ground neem cake

Direct costs	Total costs (US$)	%
Raw material: ground neem cake	0	86.08 (calculated)
Labour 0.057 d.h.	0.27	2.96
Labour, administration, sale 0.18 d.h.	0.855	9.35
Power	0.013	0.14
Maintenance	0.069	0.75
Depreciation	0.052	0.14
Total	1.259	100

The retail price for 1 kg neem cake would be US$ 2.5, which results in a profit of

US$ 1.241/kg, or with 3 kg units US$ 3.723.

The loss of US$ 3.315/l formulated neem oil should be covered by US$ 3723 from the cake production, which results in an overall profit of US$ 0.41.

This calculated raw profit is too low for sustainable production.

Another possibility is to use the cake for production of alcoholic extract. The consequences of this calculation can be taken from the chapter "Recommendations", see below.

4.4.5 Market potential for neem pesticides in Nicaragua

4.4.5.1 Marketing of neem pesticides to date

As in the Dominican Republic there is also a potential market for neem products in Nicaragua, especially for agricultural produce designated for export (mainly fruits) and crops which are cultivated according to certified biological farming methods.

In general the market in Nicaragua is not as well developed as in the Dominican Republic. Still farmers have tried with assistance of NGOs to apply neem products crops which are designated for local consumption such as maize, rice, beans, millet and cassava. This seems to be not economical, however, if the farmers do not apply home-made neem extracts or get them subsidised from NGOs. The price for neem-based pesticides cannot compete with synthetic insecticides if external costs are not taken into consideration.

In Nicaragua the sale and distribution of neem pesticides are carried out by the

conventional agricultural supply outlets. However, this is not effectively organised. An additional marketing analysis is needed to investigate how this system can be improved and the marketing can be intensified.

4.4.5.2 Market potential

General data on agriculture in Nicaragua:

Nicaragua has a population of about 4.5 million, of which 22.4% work in the agricultural sector.

The neoliberal agricultural policy since the beginning 1990s has led to a concentration of large-scale farms which are dominating agricultural production, although Nicaragua still has more equal land distribution than other Latin American countries. The number of agricultural cooperatives has declined by 50% within the last decade (from 3000 to 1500).

Small farmers receive only marginal agricultural extension from the government, but a range of NGOs are working with farmers. Government policy is mainly promoting agricultural production for export. It is very difficult for small farmers and cooperatives to get access to credit provided by the government to boost the agricultural sector, so that the main beneficiaries are large-scale farmers.

Production according to organic farming principles is increasing, which however mainly refers to the cash crops such as coffee. Production of vegetables in Nicaragua is comparatively insignificant, even for export. The major vegetables grown are tomato, cabbage and other brassicas, onion, capsicum and carrots (see Table 57).

Table 57: Agricultural production in Nicaragua in 1998/99 (selected crops)

Crop species	Production volume in t	Cultivated area in ha
Agricultural export		924,355
Coffee	5,985.3	91,650
Sesame	3,287	18,050
Tobacco	2,185	2,115
Local consumption		
Rice	182,270	958,800
Beans	155,956	250,560
Maize	320,862	318,990
Sorghum	57,522	55,765
Soya	28,272	20,868

The application of insecticides in Nicaraguan farming systems is very common. Pesticides are imported by a few large importers and distributed to 226 smaller retailers. These in turn employ merchandisers who sell the pesticides on the market or offer them going from house to house. The agricultural supply traders provide credit for the farmers and advise them how to use the products.

Neem and other biological agents are distributed via the conventional agricultural supply channels. Additionally NGOs, government administration offices, farmers' associations and cooperatives are also selling agro-chemicals. Therefore it is difficult for the MoA to control the pesticide market on all levels.

Table 58 gives some indications of the costs of pesticide application as a share of the total production costs in Nicaragua according to Appel & Beck (1991).

Table 58: Costs of pest control in selected crops (according to Appel & Beck, 1991)

Crops	Costs of pesticide application in US$	% share of total production costs
Cotton	721.57	64.4
Industrial tomato production	766.78	45.0
Cabbage	572.07	44.3
Beans	132.57	39.6
Tobacco	1520.79	37.3
Maize	154.6	32.9
Rice	267.46	26.9
Maize, traditional	43.39	26.5
Sesame	103	20.2
Beans (traditional)	17.63	10.6
Beans, traditional	17.87	9
coffee, (traditional)	10.21	5.1

Source: Beck (1997)

To regulate the introduction, use and application of pesticides in Nicaragua the following regulations exist:

1. **"El Reglamento sobre importacion, Distribucion y uso de productos Quimicos y Quimico Biologicos para la industria Agropecuaria (1960) facula al Ministerio de Agriculura y Ganaderia (MAG), extender certificados de aprobacion para la importacion, fabricacion y venta de productos para uso agropecuario".**

2. **Registro de Agroquimicos y Sustancias afines (1993).**

3. **Comision de Agroquimicos (1993).**

The responsible national authority is the "Departemento de Registro y Control de Agroquimicos de la Direccion de Sanidad Vegetal", which is in charge of importing and trading of pesticides.

The following table (59) provides the value of imported insecticides in Nicaragua.

Table 59: Import of selected agrochemicals from 1996-1998

Product	1996 (in 1000 US$)	1997 (in 1000 US$)	1998 (in 1000 US$)
Insecticide	4,955.57	5,827.85	8,174.86
Others	243.06	557.63	170.99
Total	41,394.81	49,527.92	53,526.88

Source: Banco Central DGPSA - AG

No pesticides other than neem-based pesticides are manufactured in Nicaragua.

In 1999 Copinim and the newly created venture IOSA were offering neem products, and only low quantities of neem pesticides were imported.

The following table (60) provides information on products offered by Copinim and their prices.

Table 60: Products offered by Copinim and their prices

Product/unit	Price (cordoba)	Application recommendations
Torta Nim, price 1 kg	30	25 g/l water, 0.3% azadirachtin
Nim-Action O.4 SL, Price 1 l	120	4-6 ml/l water, 0.4% azadirachtin
• Aceite de Nim C E 80, price 1 l	110	4-10 ml/l water
• Pasta Nim, 125 g	15	Treatment of sores and injures of animals

All products of Copinim have been registered in Nicaragua. Copinim is exporting to other countries in central America and has good chances of having the products registered.

4.4.5.3 Further neem manufacturers in Nicaragua

Neem-processing plant of *Investigaciones Organicas, S.A.* (IOSA), Nicaragua

Beside the neem-processing plant of Copinim, a second plant is currently under construction by the Donald Spencer Group, called IOSA: *Investigaciones Organicas S.A.* Managua, Carr. Nueva a Leon km 13.5.

IOSA is a new company which started in the neem business in 1999 and bought about 20 t of neem fruits to be processed in its own production plant. A large neem tree plantation at "Los Brasiles", a 50 ha plantation was given back from Copinim to the former owner, Donald Spencer, who is selling the neem kernels to IOSA.

IOSA is owned by a shareholder company which is directed by Dr. K. Gruber, who formerly assisted Copinim. The company has two further members and is located in the building of the Spencer Group. The group invested about US$ 80 000 in machinery, while the building and plantation was already available.

Nothing can be said about the staff numbers and capacity utilisation, since the production will start in June 2000 with the neem harvest in Los Brasiles and Malpaisilla. It is intended to offer ground neem seeds, raw neem oil, formulated neem oil, neem cake and neem paste and to register all products.

UNI-Leon has an extraction plant for perfume available and is producing alcoholic neem extracts on request

A private chemist called Freddy Soza is producing alcoholic neem extract under the brand "Organ Nim", which consists of an alcoholic solvent and ground neem seeds.

The two latter manufacturers have not registered their products and do not supply

the market continuously.

The total amount of neem production in 1998 in Nicaragua was about 5000 kg of neem products.

The customers can be divided into four groups:

- Export, mainly El Salvador: approx. 30%
- NGOs: approx. 40%
- Agricultural supply trading: 20%
- Farmers: 10%

It is estimated that about 100 - 200 Nicaraguan farmers apply neem pesticides frequently.

Some interesting experiments in cooperation between manufacturers of neem pesticides and farmers failed due to financial and organisational deficits. For such ventures it is necessary that the partners have sufficient capital, and also economic knowledge.

Now that the Spencer Group is engaged in neem processing and marketing, new perspectives have opened up for neem products in Nicaragua since the group possesses its own plantations and sufficient capital to invest in the production, and is also well organised.

4.4.5.4 Analysis of the economic production with and without the use of neem pesticides

Leupolz (1995) investigated the economic relationship between the application of NKWE and synthetic pesticides in crops such as maize, millet, beans and cassava, and found that with the exception of cassava the short-term profit from application of synthetic pesticides was higher than with NKWE under the given conditions in 1994. At that time neem kernels were subsidised and supplied 50% cheaper than today.

A main advantage for the farmers applying NKWE was that they received additional permanent advice from the NGO and could optimise the total production system. It was also revealed that inputs and yields were optimised by the farmers applying less synthetic pesticides than recommended by rural development banks.

No information on trials is available concerning the actual price and cropping conditions and which compare IPM systems with and without pesticides. Therefore for a rough approach the mere cost for pesticides competing with neem are compared below (see Table 61). The following is discussing insecticides, which can be substituted by neem.

Nicaraguan neem pesticides can effectively control aphids, lepidopterous pests and white fly. There exist also a fair efficacy against heteropterous pests.

Table 61: Price comparison of pesticides competing with neem, and target pests

Product	Aphids	Heteroptera	Lepidoptera	Whitefly	Approx. price/l or kg (US$)
Neem seeds	X	X	X	X	1.88
Neem cake	X	X	X	X	1.56

Formulated Neem oil	X	X	x	X	8.13
Alcoholic neem extract	X	X	X	X	10
Decis	X	X	X		17.65
Diazion	X	X	X		12.94
Dipel			X		18
Javelin			X		27.94
Lorsban	X	X	X		9.71
Malathion	X	X	X		3.92
Turcide			X		19.00
Eviset				X	20.38
Thiodan				X	11.88
Monitor			X		10.00
Lannate			X		22.00
Tamaron			X		10.00
M.T.D. 600			X		5.00
Pegasus				X	75.25
Danitol				X	32.81
Thionex				X	11.00
Eviset				X	20.38

4.4.5.5 Market growth potential and substitution possibilities in Nicaragua

In the Dominican Republic and in Nicaragua the market requires a product which is characterised by good quality and easy handling. In addition the packing should be stable and provide sufficient protection against humidity, and should contain a description of how to apply the product, provide information on the toxicity and protection needed, as well as a registration number.

The neem manufacturers in the Dominican Republic and Nicaragua fulfil these requirements

In both countries there are economical constraints on neem pesticides. There are no government promotion programmes to assist neem manufacture and use. While on the one hand the import of pesticides is free of tax in the Dominican Republic, tax has to be paid for the import of neem raw material for manufacturing neem pesticides.

On the other hand no constraints or conditions hinder investment in manufacturing neem pesticides. In general any sort of foreign investment is most welcome and supported.

One of the unfavourable frame conditions is that no national certified or recognised laboratory is able to carry out analysis of azadirachtin content which has so far been carried out in laboratories abroad.

Although being part of the conventional pesticide distribution system, marketing and distribution of neem products have not been effectively organised so far, and

can and must be considerably improved.

Both neem manufacturers, Copinim and IOSA, must find strategic partners such as the conventional agricultural supply services which have more motivation and interest in selling the products.

Copinim has a further problem: it cannot supply the market constantly with the required product volume. This constraint has to be overcome.

Customers of Copinim so far have been exporters of agricultural produce, NGOs, organic farmers and research institutes.

Up to 1999 neem products were of marginal importance. Due to the MRL regulations (see Chapter II) an increasing market potential can be expected for those farmers who are producing for export.

A marketing strategy should focus firstly on the substitution of more expensive biological or selective synthetic pesticides.

A further market which could be expanded is organic farming, where hardly any alternative control measures exist which are effective as neem. In Nicaragua the main crops are cotton, coffee, cocoa, maize, rice, sesame, soya and to a certain extent tomatoes, but only a few vegetables.

BCS-Control (the local certification organisation for organic farming) is accepting the application of neem product in certified organic farming systems.

4.4.6 ''Lessons learnt'', recommendations and development strategies

In the past it was attempted to set up a strategic partnership between the collectors/farmers and Copinim, and to integrate farmers' associations as investors in neem production and processing. This concept failed - as in the Dominican Republic - due to the poverty of the farmers. Farmers accept planting neem trees and to a certain extent they process the seeds if they get a fixed price for pre-dried seeds (in 1999: US$ 0.63/kg, which comes to US$ 1/kg of seeds with a moisture content of 8%).

NGOs are good customers and strategic partners for neem processing but not good as co-investors, since their aim is not to maximise the profit.

It is questionable whether international investors would invest in small industrial neem processing in developing countries since turnover and profit margin are limited. Only small ventures from industrial countries with social and ecological intentions might be interested, but these often have capital restrictions or no contact with a suitable partner in developing countries.

For making neem processing in Nicaragua more profitable and successful the following recommendations should be considered:

- **Increasing of the product price**
- **Increasing the total production to enhance capacity utilisation of the plants**

The minimum processing volume for processing neem as a profitable venture is about 75 t of neem seeds. Since currently not even this capacity is fully used it seems that small industrial processing is preferred to large-scale processing to

minimise the risk. The reasons for not using the full capacity of the neem processing plants in Nicaragua and the Dominican Republic are, however, the lack of investment capacity and organisational issues.

Additionally, the costs of raw materials have to be reduced, which can be achieved, e.g. by importing cheaper neem oil from abroad.

National investors, on the other hand, are prepared to go into neem processing if they have raw material available for processing (as the Spencer Group) or see a chance for selling the products.

Copinim has identified 7 areas for investment:

- Purchase an oil expeller with a capacity of 100 l oil/day
- Laboratory for quality control (analysis of azadirachtin)
- Solar drying
- Raw material
- Advertising
- Training in economics and optimising the techniques
- Product development

In the long run decorticating and packing units have to be improved, along with storage rooms and offices.

Development strategies

Neem-based products have to match farmers' expectations of pesticides. Farmers expect that an insecticide should be cheap, permanently available, easy to apply,

show fast action and save labour. Neem pesticides could not fulfil all these ideal characteristics. The poorer the farmers are, the less important they consider aspects such as ecology and health.

Neem products cannot successfully compete with cheap broad-spectrum insecticides which are applied on staple crops. Normally farmers with low income are not prepared to use relatively expensive neem pesticides even if they recognise the impacts of synthetic insecticides on health and soil fertility.

Subsistence farmers tend to accept neem pesticides only if they get them free or - if no alternatives are available - they can produce them themselves. Those farmers collecting and processing neem fruits to be sold for pesticide production are using synthetic pesticides because neem is too expensive and because the additional value of cropping (IPM) systems with neem are not obvious to them.

Prospective customers for neem-based pesticides in conventional agriculture are farmers with a medium or higher level of education, who are able to calculate the economic benefits of integrated pest control.

This group is taking part in the development of IPM concepts because they have severe problems with resistant pests or pesticide residue levels on their crops are too high.

Therefore the marketing strategy should be to convince export producers of the properties and advantages of neem pesticides. Wide application of IPM principles in Nicaragua will lead to a stronger demand for neem pesticides. A higher production volume will decrease the price for the pesticides and subsequently

increase the market share.

Further biocontrol or biotechnical control strategies are needed for organic farming systems.

Although the properties of neem pesticides are the best advertisement concepts should be worked out which clearly reveal the positive medium-term and long-term impacts of neem. This should be demonstrated and advertised to the farmers.

In addition, the farmers should have easy access to neem pesticides. Therefore it is important to integrate neem pesticides and products into the conventional agricultural supply trading on large scale.

Small enterprises are producing neem pesticides in small volumes more cheaply and are more flexible in responding to market demand than large-scale industrial neem manufacturers. Small industrial neem processing ventures are therefore a good opportunity and are of special importance for developing countries.

Technical cooperation (TC) organisations should therefore assist such forms of production.

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4.4.8 Units

1 Quintal, qq = 47.5 kg
1 libra, lb 475 g
1 manzana, mz 0.7050 ha
1 tarea, ta = 628.1 sq m

Currencies:

cordoba:	12 C$	= US$ 1	(as of Nov. 1999)
Dominican peso:	16 RD-$	= US$ 1	(as of Nov. 1999)
cordoba:	1 C$	= DM 0.27	(as of Jan. 93)
Dominican peso:	1 RD-$	= DM 0.13	(as of Jan. 1993)
US Dollar:	US$	= DM 1.86	(as of Nov. 1999)

Neem products:

NSWE:	aqueous extract of neem seed
Nim-PSM:	Neem pesticide

Costs of selected pesticides for controlling aphids:

Product name	Price/kg or l	Dosage/ha	Cost/ha
ACE-Nim EC	130 pesos	5 l	650 pesos
Semilla Molida	30 pesos	30 kg	900 pesos
Torta Molida	25 pesos	30 kg	750 pesos
Diazinon	210 pesos	1 l	210 pesos
Ekatin	155 pesos	1 l	155 pesos
Monitor	140 pesos	1 l	140 pesos
M.T.D. 600	140 pesos	1 l	140 pesos
	304 pesos	0.75 kg	228 pesos

Costs of selected pesticides for controlling whiteflies:

Product	Price/kg or 1	Dosage/ha	Cost/ha
ACE-Nim EC	130 pesos	3.75 l	487.5 pesos
Semilla Molida	30 pesos	22.5 kg	675 pesos
Torta Molida	25 pesos	22.5 kg	562.5 pesos
Tiodan	190 pesos	1 l	190 pesos
Evicet	326 pesos	0.5 libra	163 pesos
Thionex	175 pesos	1 l	175 pesos
Danitol	525 pesos	0.75 l	393.75 pesos

Pegasus	1204 pesos	0.75 l	903 pesos