Chapter 4
Neem Based Products

4.1 Introduction to Neem-Based Products

Technically, both the Sadao Thai and Sadao Tawai are the same species of tree. Yet, their uses are very different. Figures 4.1 and 4.2 give utilization flow charts for Sadao Thai and Sadao Tawai trees respectively. The reader should take note of the fact that the Environmental Benefits garnered from each sub-species are basically the same. The degree to which each of these types of Thai neem tree provide more or less of these benefits is a subject worthy of study, but it is beyond the scope of this study.

The following sections of this chapter describe and discuss some of the many different products that could potentially be produced from different parts of the neem tree. Almost every one of these products represents a potential forwarded linked industry. Moreover, each of these industries points back to the potentially large demand for raw materials from the neem tree.

Figure 4.1 Utilization Flow chart for the Sadao Thai Tree

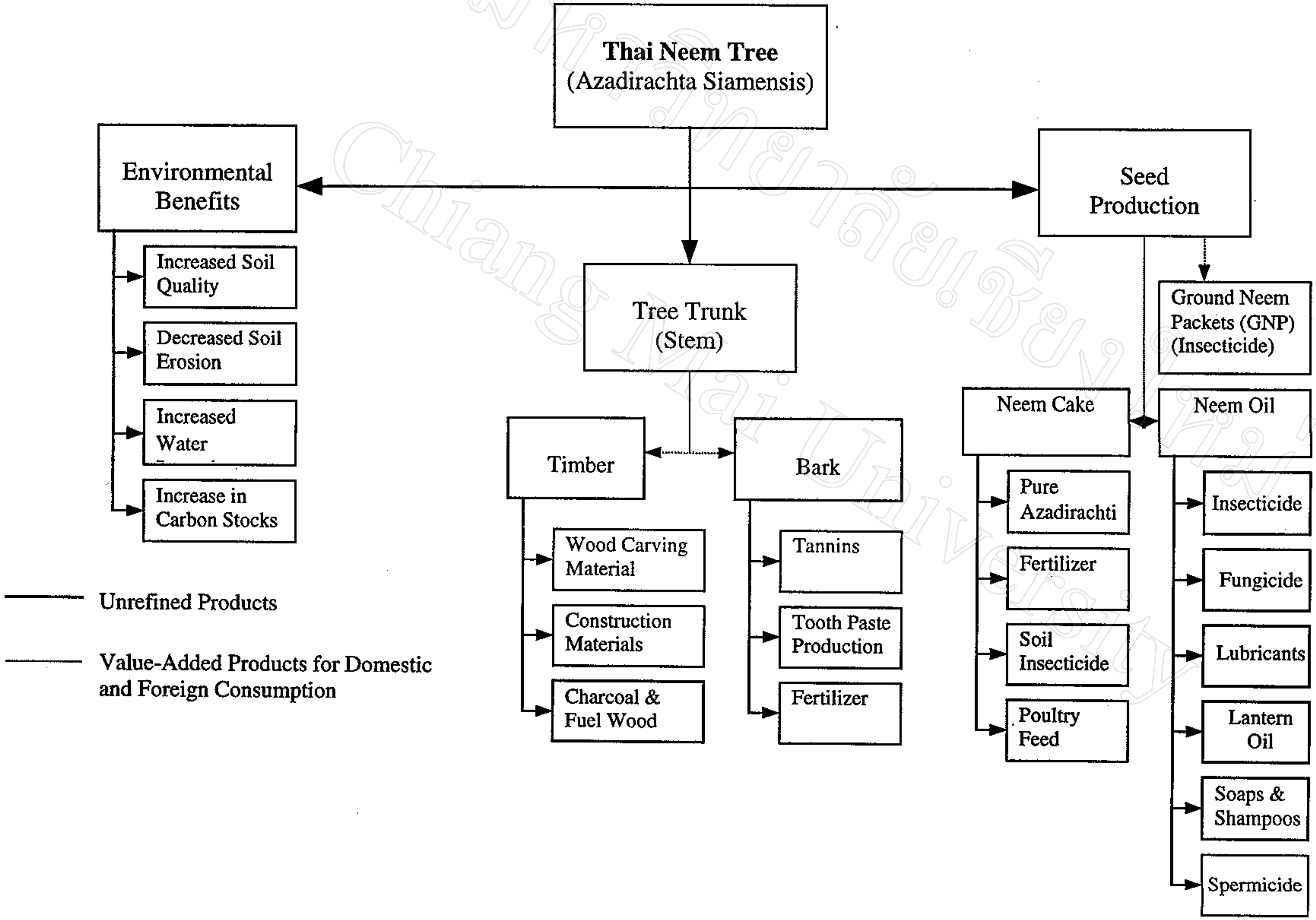
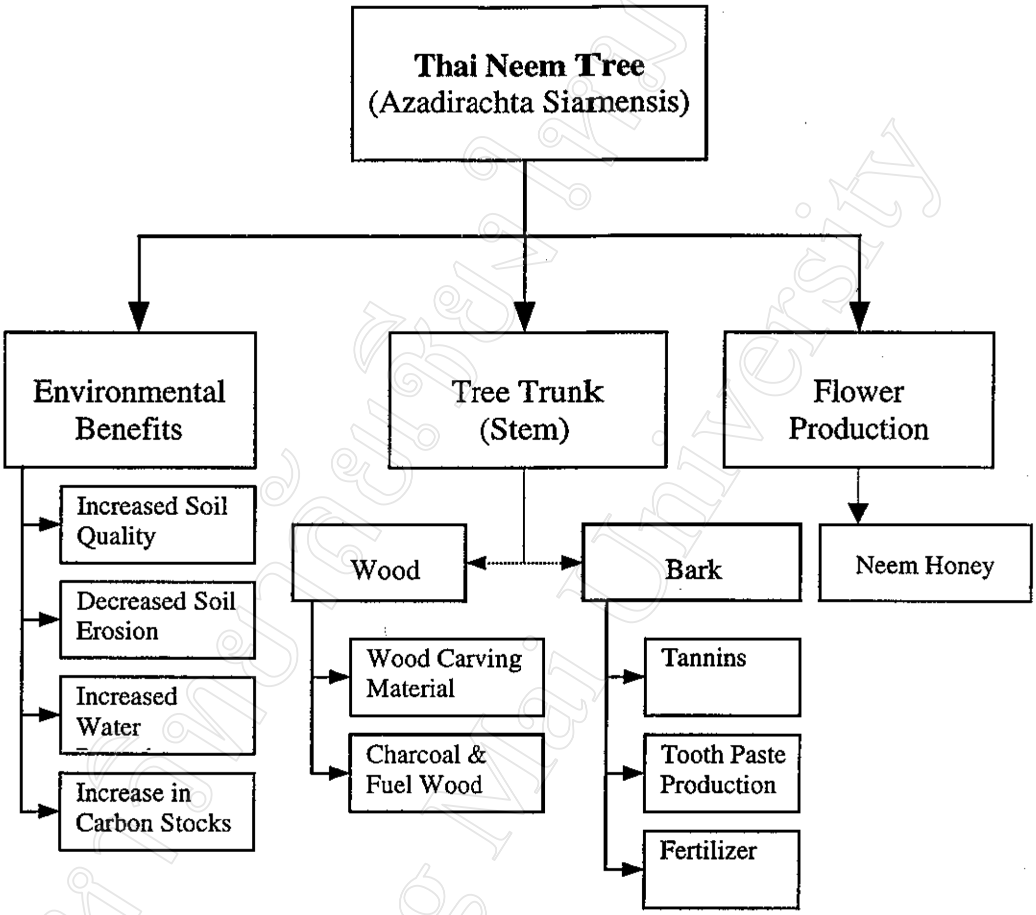


Figure 4.2 Utilization Flow chart for the Sadao Tawai Tree



4.2 Description of Sadao Thai Products

4.2.1 Neem Timber

In India, neem timber is used for the construction of furniture, door and window frames, carts, axles, yokes, naves and fellies, tool handles, agricultural implements such as plows, oil mills, cigar boxes, toys, drums, oars, building ships and boats, and building houses. The wood is also used for making fence posts, beams, and wood carvings (National Research Council, 1992; Kabra and Upadhyay, 1997; Schmutterer, 1995).

Neem is considered to be a moderately heavy hardwood having a density of 720-930 kg/m^3 at a moisture content of 12%. Neem timber is resistant to termite, powder-post beetle, woodworms and fungal attacks, and remains durable under exposed conditions (Lemmens et al, 1995). The wood is aromatic having a rather uneven and narrowly interlocked grain and a medium to coarse texture (Radwanski, 1977b). Neem wood is subject to only moderate shrinkage. From green to oven dry, the wood was found to shrink 4.5% radially and 6.2% tangentially (Lemmens et al, 1995).

Neem timber can be worked both by hand and machine, and turns on a lathe to a fair but not fine finish. It lends itself to carving, but does not take a high polish very well (Radwanski, 1977b). It is also easily sawn, worked, glued, and polished. Neem seasons well when sawn wet, but must be carefully dried as it will split and warp (Kabra and Upadhyay, 1997; National Research Council, 1992). Because it also splits easily when nailed, all holes must be prebored.

Tests conducted on neem trees planted in India and Sudan found the following mechanical properties at 12% moisture content (Lemmens et al, 1995):

Modulus of Rupture	=	79-99 N/mm^2
Modulus of Elasticity	=	6960-8765 N/mm^2
Compression Parallel to Grain	=	46-51 N/mm^2

The quality and usage's of neem timber can be closely compared to those of teak in many different respects. See Table 4.1.

Table 4.1 Properties of Neem Timber in Comparison to Teak

Properties	Quality Index	
	Teak	Neem
Weight	100	124
Strength (as Beam)	100	87
Stiffness (as Beam)	100	81
Suitability (as Post)	100	82
Shock Resistance	100	105
Shape Retention	100	77
Shear	100	129
Surface Hardness	100	131
Nail Holding Ability	100	144

Source: Kabra and Upadhyay, 1997.

Table 4.2 shows the comparisons in usage quality between Teak and Neem Excelsa *(Azadirachta excelsa)*. Neem Excelsa, or Sadao Chang as it is known in Thailand, is listed as a medium-weight hardwood and is not as strong or durable as regular neem (Lemmens et al, 1995). As such, regular neem, or Sadao Thai, should show similar if not better results than those given in Table 4.2 for Neem Excelsa.

Table 4.2 Usage Quality Index for Teak and Neem Excelsa

Usage		Teak (17 years old)	Neem Excelsa (10-11 Years Old)
1.	Square Pegs / Joints	Very Good	Good
2.	Small Piece Work	Poor	Poor
3.	Power Line Support Beam	Good	Poor
4.	Housing Lumber	Good	Very Good
5.	General Use	Good	Very Good
6.	Door Frame	Very Good	Very Good
7.	Window Frame	Very Good	Very Good
8.	Tongue and Groove	Very Good	Fair
9.	Parquet Flooring	Very Good	Good
10.	Wood Carving	Very Good	Very Good

Source: Office of Forest Promotion, 1993

All in all, the prospects for neem timber are very good as it could potentially be substituted for other types of wood presently being used in Thailand. This in itself would have several broad beneficial effects. First, it would prolong the life of or even invigorate industries such as furniture production and woods carving that have been relying on domestic hardwoods, which are rapidly diminishing in number and supply. Prolonging and invigorating these industries both supports and promotes domestic employment, which are both directly and indirectly related to them, and possibly exports as well. Second, by generating a new supply of timber, neem plantations could help ease some of the pressure off of natural forests and their tree populations thereby helping to preserve plant and animal species dependent on these natural forests.

Nevertheless, at present a domestic market for neem timber does not exist in Thailand. As shown by Tables 4.1 and 4.2 this is not because neem has inferior properties compared with other commercial timbers, but instead is simply due to the fact that it is not recognized as nor has it been promoted as a commercial timber species. Lemmens et al (1995) suggest the following reasons why minor commercial timbers, such as neem, have been grossly under-utilized:

- They are not readily identifiable in the field or in the market.
- They are not available in sufficient quantity for individual promotion.
- Their long-term supply is uncertain.
- Their physical and mechanical properties are not fully known.
- Practical solutions to processing and utilization problems are still lacking.
- There is a lack of specific market promotion.
- Methodologies to season and treat mixed consignments of species are lacking.

The suggestions above represent marketing problems that will have to be overcome in order to popularize the use of neem timber. However, Say's Law states that supply creates its own demand. A steady supply of neem timber emanating from hundreds or thousands of small and medium sized neem plantations should generate both a demand for the timber and solutions for the mentioned marketing problems.

4.2.2 Neem-Based Insecticides

4.2.2.1 Description of Neem's Insecticidal Properties

Over its evolution the neem tree has developed a cocktail of pesticidal agents that have served to protect it from a multitude of pests. Scientists have discovered more than sixty different chemical compounds in the leaves, bark, fruit, seeds, wood of the tree. The major pesticidal agents making up this cocktail are composed of three to four related compounds, but are backed up by 20 or more other compounds that are minor but nonetheless exhibit bioactivity in one form or another. These compounds mainly belong to a general class of chemicals called "triterpenes" and more specifically "limonoids" (National Research Council, 1992).

A great deal of research has been conducted on the insecticidal properties of the chemicals produced by the neem tree. To date, at least nine neem limonoid groups have been shown to affect a range of insect species, including some of the most deadly pests of agriculture and human health, in the following ways:

- Disrupting or inhibiting the development of eggs, larvae, or pupae;
- Blocking the molting of larvae or nymphs;
- Disrupting mating and sexual communication;
- Repelling larvae and adults;
- Deterring females from laying eggs;
- Sterilizing adults;
- Poisoning larvae and adults;
- Deterring feeding;
- Blocking the ability to "swallow" (i.e. reducing gut mobility);
- Disrupting or hampering metamorphosis at various stages; and
- Inhibiting the formation of chitin.

The best known and seemingly most significant of the limonoid groups, discovered thus far, are Azadirachtin, Salannin, Meliantriol, Nimbin and Nimbidin. Of these, azadirachtin was the first bioactive group of limonoids to be isolated from neem, and currently is considered to be neem's main agent for controlling insects (National Research Council, 1992). Because of this, the vast majority of research into the insecticidal potential of neem-based products has focused on azadirachtin. Moreover, at least seven different azadirachtin compounds (azadirachtin A, B, C, D, E, F and G) have been isolated, each showing the ability affect insects in one or more of the ways listed above. Most references to azadirachtin in the literature related to neem are referring to azadirachtin A, which is found in the highest concentrations in the Indian neem tree, *Azadirachta indica*. According to Dr. Klaus Ermel, the Thai neem tree, *Azadirachta siamensis*, does not maintain a very high level of azadirachtin A, but shows high levels of azadirachtin B instead.

Azadirachtin does not kill insects out right like synthetic insecticides. Instead it acts as an antifeedent and growth regulator. Azadirachtin's antifeedent properties dissuade insects from feeding on the tree or plants sprayed with this compound. For some insects that are not deterred from eating the tree or plants treated with azadirachtin, this chemical compound disrupts the insect's lifecycle by blocking the production and release of hormones vital for metamorphosis. The result is that the insect is not able to molt from stage to the next, or if it manages to molt, it emerges deformed in one form or another. This breaks the insect's life cycle and leads to population declines, because the insects are unable to reproduce (National Research Council, 1992). Meliantriol and Salannin also act as feeding inhibitors, while Nimbin and Nimbidin show antiviral properties (Kabra and Upadhyay, 1997; National Research Council, 1992).

These neem derivatives have been found to affect approximately 400 to 500 insect species belonging to the following genus's: Blattodea, Caelifera, Dermaptera, Diptera, Ensifera, Hetroptera, Hymenoptera, Isoptera, Lepidoptera, Phasmida, Phthiraptera, Siphonoptera, and Thysanoptera. They also shown bioactivity with one species of ostracod, and several species of mites and nematodes (Kabra and Upadhyay, 1997). Detailed descriptions of neem's bioefficacy for many of these genus's can be found in Schmutterer (1995) and in Singh (1996).

Unlike synthetic insecticides that are lethal to invertebrates and vertebrates alike, the hormone disrupting properties of neem extracts does not affect humans, livestock, or even insects that feed on other insects. Moreover, because the Limonoid compounds are highly complex, it is very unlikely that insects will be able to build up a resistance to them. As such, neem-based insecticides hold the potential for helping in controlling insect populations in a more environmentally friendly way.

4.2.2.2 Production of Neem-based Insecticides

Azadirachtin is more highly concentrated and accessible in neem seeds than in any other part of the tree. For this reason, production of neem-based insecticides centers on extracting azadirachtin and some of the other bioactive limonoids from the seeds. Presently, this extraction takes three major forms with each form expressing a different level of refinement.

The simplest and most widely promoted and employed form is to collect, grind or crush the neem seeds, and then extract them with water. Such steps are similar to making tea, but instead of using tea bags the farmer uses a ground neem packet (GNP). Generally, the GNP is steeped overnight in a barrel of water, and then applied to the crop the following day.

The next level up in complexity comes in the form of an aqueous solution of neem oil and water. Neem oil is derived from pressing the oil out of neem seeds. After being pressed out of the seeds, the neem oil is mixed with water or another aqueous solution and sprayed onto the crop. The level of refinement here depends on how the oil is pressed out of the seeds, and could represent anywhere from a simple oil mill to a high tech seed oil-processing unit. Need less to say this is at least one step beyond the level of the normal farmer.

The final form comes from chemically distilling off concentrated azadirachtin from either the neem oil or neem cake, which is the material left over after the oil has been pressed out of the seeds, using hexane, pentane, alcohol, etc. Obviously, this represents a refinement on a commercial level, and requires a high level of capital investment, which is beyond the capabilities of normal Thai farmers.

4.2.2.3 Domestic Market for Neem-Based Insecticides

A small market for neem-based insecticides does already exist in Thailand. A survey of the market in Chiang Mai found several brands and types of neem-based insecticides. The vast majority of the products found were in aqueous solution, although ground neem packets were available. However, the ground neem packets do not seem to be as popular, because they require more preparation than the products in aqueous form.

Because an in-depth survey of the producers and their retailers was not conducted for this thesis, an answer can not be given to the question of whether the present market for neem-based insecticides is growing, maintaining the same level, or diminishing. Nevertheless, government organizations on both the local and national level have been working hard to promote the use of neem-based insecticides by farmers due to the fact that these insecticides can be produced domestically and that they show few of the health hazards associated with synthetic insecticides.

4.2.2.4 The Economic Benefits of Using Neem-based Insecticides

The economic benefits from using neem-based insecticides could be very large and broad reaching for the economy as a whole for the following reasons. First, neem-based insecticides can be produced domestically thereby generating new jobs and forward and backward industrial linkages. Moreover, these domestically produced insecticides could be used to partially substitute imports of insecticides from foreign countries. And if the global demand for neem insecticides continues to grow, Thailand could also export neem-based insecticides as well. In any case, both of these scenarios would help to reduce the existing balance of payments deficit.

Second, the environmental and health costs associated with the over use of synthetic pesticides are causing unnecessary damage to the economy as a whole. Using neem-based insecticides could drastically reduce the amount of labor days lost and money spent on treating illnesses related to pesticide poisoning.

Third, because neem-based insecticides impact on the environment much less than regular insecticides do, they might be a prime option in the fight to control mosquito born diseases, such as drug resistant malaria, along Thailand's borders with Burma and Cambodia from spreading to other parts of the country. The Far Eastern Economic Review reported in its April 17, 1997 edition that the area along the Thai-Burmese near Mae Sot "has the world's highest concentration of multidrug-resistant malaria, but the same resistant strains have been reported in Cambodia, Burma, Laos, and as far away as Vietnam." These malaria strains pose a clear and present danger to the Thai people and economic growth in these regions. Several studies found that neem-based insecticides applied to wetland rice fields significantly reduced the mosquito population in and around these fields.

4.2.3 Neem-Based Fertilizers

Neem cake and to some extent neem leaves have demonstrated considerable potential as organic fertilizers. The composition of neem cake after being de-oiled varies widely, but the residue compositions are believed to remain in the following ranges:

Crude Protein	13-35 percent
Carbohydrate	26-50 percent
Crude Fiber	8-26 percent
Fat	2-13 percent
Ash	5-18 percent
Acid-Insoluble Ash	1-17 percent

It also contains higher levels of nitrogen, phosphorus, potassium, calcium, and magnesium than farmyard manure or sewage sludge (National Research Council, 1992).

Yet, its greatest potential as a fertilizer is the neem cake's ability to retard or inhibit soil bacteria from converting nitrogenous compounds into unusable nitrogen gas. According to Ketkar and Ketkar (1995), nitrogen is the primary limiting factor for increasing crop productivity. Whether or not farmers apply nitrogen to their crops to increase production depends upon its availability, cost, and the effectiveness of the source of nitrogen. Unfortunately, the efficiency of nitrogen is very low, especially in tropical agriculture due to nitrifying bacteria leaching it out of the soil. Splitting the application of nitrogen, placing nitrogen deep down in the soil, and using natural products, which can retard the nitrification process, can reduce the loss of nitrogen through leaching. When mixed with urea, neem cake can help reduce the amount of nitrogen needed for crop production while maintaining or increasing crop productivity by providing each plant a greater period of time to absorb the nitrogen in the urea.

The fact that using neem cake mixed with urea can decrease the amount of urea needed for crop production means that the country would not have to import as much nitrogen fertilizer. And provided that the neem cake / urea mixture could be made cheaply and in large enough quantities to meet domestic demand for it, farmers overall production costs could be decreased thereby increasing profits and possibly lowering domestic food costs.

Koul et al (1990) report that field trials with rice have demonstrated that various neem cake preparations (acetone extract of neem seed with urea, 100-200 kg N/ha; powdered neem cake with urea, 50-75 kg N/ha; and neem cake extract and neem mud balls with P_2O_5 + azobactor + urea, 50 kg N/ha) were very effective in increasing protein content and grain yield. In addition, they also report that field trials of neem cake blended with urea on lowland rice had also been very successful, results presented in Table 4.3, and that field experiments with neem had shown potential in increasing biological nitrogen fixation in wetland paddy fields by arresting the development of grazing invertebrates and nitrifying bacteria. This lead to a simultaneous increase in biological nitrogen fixation and decrease in nitrogen leaching.

Table 4.3 Effect of Neem Cake Blended Urea on the Yield of Lowland Rice

Treatment	Grain Yield (Tons/Hectare)		
	1977	1978	1979
Urea mixed with cake (at the rate of 30% by weight); basal application	4.1	4.1	4.7
Urea coated with cake (30% by weight using coal tar and kerosene); basal application	4.3	4.2	4.9
Incorporation of cake followed by urea application (basal)	4.1	2.9	3.3
Control	2.9	2.4	2.7

Source: Koul et al (1990)

Experiments using neem cake blended with urea have also shown benefits for paddy rice and sugarcane production. Ketkar and Ketkar (1995) provide the data given in Table 4.4.

Table 4.4 Results of Large-Scale Farm Trials Using De-oiled Neem Cake-Coated Urea (20% Urea)

Crop	Year of Trial	Number of Trials	Basic N application as urea (kg)	Yield increase (%)	Basic Yield Level (Tons/Hectare)
Sugar Cane	1981-82	7	880	15.1	101.060
Paddy	1980	42	220	19.8	4.159
Paddy	1982	64	220	27.7	4.316

Source: Ketkar and Ketkar (1995)

Because both paddy rice and sugarcane are major agricultural crops of Thailand, the potential economic benefits from using neem fertilizers can not be understated.

4.2.4 Other Neem-Based Products

4.2.4.1 Medicinals

In addition to the intense research being conducted into the potential of neem-based products for insecticide use, a great deal of scientific research is also being focused on the medicinal uses of the neem tree. Presently, research is being conducted into the possible uses of neem-based substances for fungicides, antibacterial agents, antiviral agents, analgesics (painkillers), antipyretics (fever reducers), anti-inflammatory agents, malaria treatment, and for birth control. Initial reviews of the scientific literature published on the use of neem-based medicinals can be found in Schmutterer (1995) and Singh et al (1996).

Traditionally, parts of the neem tree have been used medicinally for thousands of years by practitioners of Ayurveda and Unani, and more recently by practitioners of homeopathy (Ketkar and Ketkar, 1995). Medicinal properties have been especially ascribed to the leaves, fruit, and bark. The National Research Council (1992) reports that the most widely recognized and best-established medicinal uses for neem is founded on its qualifications as a general antiseptic being used to remedy a variety of skin diseases, septic sores, and infected burns. Decoctions made from the leaves are recommended for treating boils, ulcers, acne and eczema, while neem oil is applied to the skin to heal diseases such as scrofula, indolent ulcers, and ringworm (National Research Council, 1992).

Twigs from the neem tree have also traditionally been used for centuries as toothbrushes. The antiseptic nature of neem has been effective in preventing periodontal disease (National Research Council, 1992) and as a dentifrice, reported to heal gum inflammations and paradontosia (Koul et al, 1990). One application of this, has been the use of neem bark extracts in the production of toothpaste by German and Indian companies. With the interest in herb based products appearing to be on the rise in Thailand, neem-based toothpaste could be successfully marketed and sold here.

As neem-based medicinals become more accepted and popularized around the world, domestic industries devoted to producing neem-based medicines could be created and promoted in order to supply to both the domestic and international demand. As with neem-based pesticides, this would benefit the national economy of Thailand by reducing imports and increasing exports.

4.2.4.2 Cosmetics

Neem's potential for treating skin related ailments has lead to the development of neem-based cosmetics such as hand and body lotions, facial moisturizing lotions, massage oils, shampoos and conditioners, and a large number of different soaps. A recent search of the Internet found nine different companies advertising neem-based products. The names and addresses of these companies is given in Appendix A. Eight of these companies advertised at least one of the cosmetic products mentioned above.

Eight companies worldwide does not seem like a large number. Yet, because the Internet is still a new media for advertising, it is difficult to say exactly how many companies world wide are producing and marketing neem-based cosmetics. Nevertheless, a search of the Internet a little over a year ago for companies selling neem-based products found only two companies. Thus, at least the number of companies advertising their products over the Internet has greatly increased showing there is an increasing demand for neem-based cosmetics. As the global market for neem-based products continues to increase, it will eventually expand into Thailand creating domestic demand.

4.2.4.3 Soaps and Detergents

In India most of the oil pressed from neem seeds is sold to soap manufactures that use the neem oil in its crude form to produce coarse laundry detergents (National Research Council, 1992; Kabra and Upadhyay, 1997). Neem oil in its crude form is brownish yellow and has an unpleasant odor and bitter taste due to the presence of sulfur compounds. These compounds hinder hydrogenation and must be refined off using distillative deacidification. After being refined, the residual oil is free of the offensive odor and is ready to be converted in fatty acids by using the normal methods of splitting and distillation. These fatty acids can be used to produce top-quality toilet and laundry detergents (Ketkar and Ketkar, 1995).

4.3 Sadao Tawai Products

4.3.1 Flowers

The flower of the Sadao Tawai tree is the tree's primary product. The flowers are picked from the tree and consumed as a vegetable side dish. This paper makes the assumption that the vast majority of the flowers collected are eaten domestically. However, at least a small percentage are canned and exported. Figure 4.3 shows the label from a can of First World canned neem flowers found in an Oriental Market in East Lansing, Michigan USA. However, information relating to the quantity of neem flowers canned and exported by this company cannot be defined because all attempts to contact this company were unsuccessful.

Figure 4.3 Label for First World Canned Neem Flowers

Neem wood produces high quality charcoal, because it has an energy level of 20,830 kJ/kg (Lemmens et al, 1995) Koul et al (1990) state that in Nigeria charcoal made from neem wood is said to have a caloric value just slightly less than Enugu coal mined in Nigeria, but no specific data or literature references were provided. Schmutterer (1995) reports that the smoke from neem wood is believed to drive away mosquitoes.

The use of neem wood for firewood or for making charcoal has positively effected forest environments in Africa, because its use has taken the pressure off of other local tree populations. Provided a large enough supply could be created to meet the fuelwood demands of local markets, charcoal make from Thai neem could provide the same benefits for the Thai environment as it has for the environments of many African countries.

4.3.3 Honey

The National Research Council (1992) report that neem honey demands premium prices in some parts of Asia, and that people in these areas plant neem trees in order to promote apiculture. Although neem honey does not appear to very prevalent in Thailand, whether intentionally or not, the fact that others place a value on it could be mean that neem honey could be produced here in Thailand and then exported. The Sadao Tawai tree seems ideally suited for apiculture since it produce a large abundance of flowers over an extended period of time.