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World Distribution and Trade in Neem Products with Reference to their Potential in China

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Abstract

Neem is regarded as a promising tree species which can be utilized in various ways to benefit agricultural communities throughout the world. Scientists and entrepreneurs are paying considerable attention to its potential value as a source of biopesticides through extracts from neem seeds, bark, and wood. Azadirachtin the most important active compound from neem seeds and other plant parts has natural insecticidal properties and may be a potential substitute for synthetic pesticides which are widely used in crop production in China. However the **distribution** of neem trees among major producing countries, the **trade** in neem products on the world market, and potential supplies of azadirachtin for China are not widely known, a topic which will be addressed in this paper.

INTRODUCTION

In the past two decades, at least six international conferences have been held to discuss issues on neem. Since the first neem conference was held at Rottach- Egern, Germany in 1980, neem has been attracting the attention of more and more scientists in relevant areas as well as businesses. Neem is regarded as a wonder tree because of its benefits and potential benefits to human beings and the environment through its various parts.

NEEM – SOURCE OF BIOPESTICIDES AND OTHER PRODUCTS

Native to India and Burma, neem whose common botanical name is *Azadirachta indica*, is a member of the mahogany family. Neem has long been revered by ancient Indian people and is entitled “village drugstore”. It is a tall (up to 30 meters) ever – green tree, sometimes spreading like an oak, that bears masses of honey – scented white flowers that develop into bunches of small fruit. Its complex foliage resembles that of walnut or ash, and its swollen fruits look much like olives. Normally it starts fruiting after 3 – 5 years, and it can survive for up to 200 or 300 years. It is seldom leafless, and the shade it imparts throughout the year is a major reason why it is prized in India.

According to the publications of Neem Foundation and other organizations, the major benefits of neem and neem products as known so far can be categorized as follows:

1. Excellent source of pesticides

Neem contains 40 different active compounds called liminoids. The main active ingredient of neem seed is *Azadirachtin*. It exhibits antifeedant, insect repellent and insect sterilization properties. Insects treated with *Azadirachtin* during the larval and pupal stages, comprising 60 – 70 percent of their lives, generally die within 3 – 14 days. Unlike chemical insecticides, it works on the insect’s hormonal system, not on the digestive or nervous system, and it is claimed that this does not lead to development of resistance in future generations. Because azadirachtin had a multi-modal action, it is unlikely that an insect species would develop resistance based on one mode of action. This is in contrast to most synthetic pesticides with operate on the insect’s nervous system and resistance to one chemical leads to resistance to all others with the same reaction pathway..

2. Materials for pharmaceuticals and toiletries

Neem fruits, seed oil, leaves, bark and roots have various uses such as general antiseptics, antimicrobials, as a treatment of urinary disorders, diarrhoea, fever, bronchitis, skin infections, septic sores, infected burns, hypertension, and inflammatory diseases. Neem leaf extracts and teas are reputed to treat malaria. Neem

twigs are used daily by millions in Bangladesh, India and Pakistan as disposable toothbrushes. Neem toothpastes and powders are reputed as effective dentifrice products.

The most common use of neem oil is for soap production, a relatively low value use. Such medicated soaps with neem odour are proved to have very effective germicidal properties. Neem is also becoming a popular beauty aid. Quite a few companies are using neem oil and leaves for production of cosmetics like facial creams, nail polish, nail oils, shampoos and conditioners etc. Neem oil is also a very effective mosquito repellent (work reported by Sharma from India). One of the largest potential markets for azadiractin, because it has low mammalian toxicity, is in the treatment of head lice.

3. Neem for fertilizer management

Indian farmers have traditionally used de-oiled neem cake as a fertilizer and soil amendment in their fields. The dual activity of neem cake as fertilizer and pest repellent has made it a favored input. Neem cake is a by-product of oil extraction and since it represents 70% of the original seed by weight or volume, it can become a disposal problem if not sold or distributed immediately after the oil is extracted.

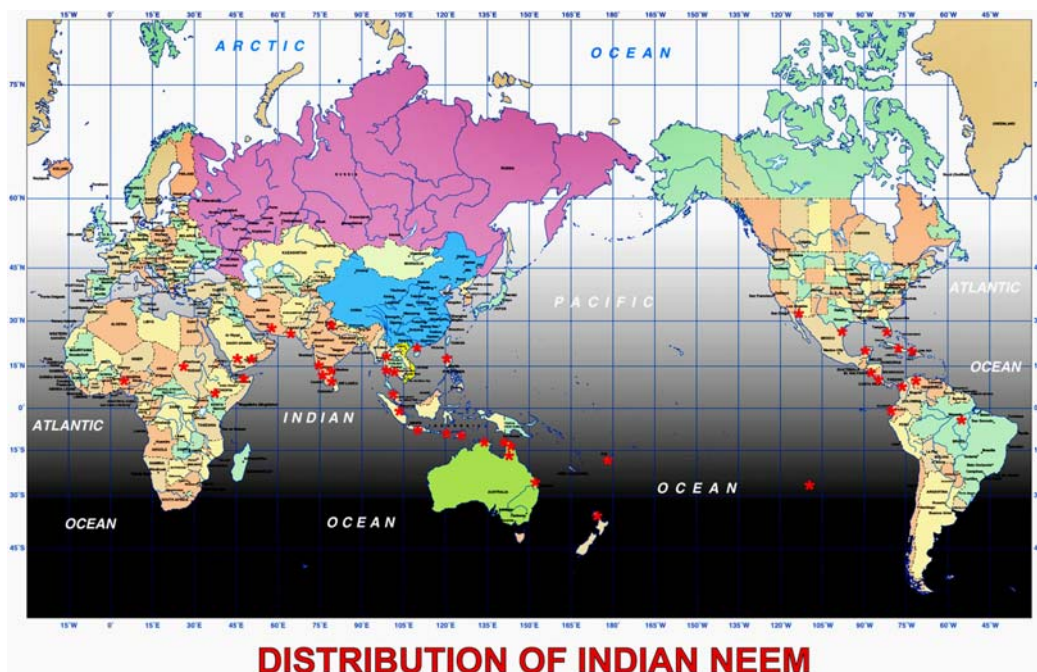
Neem leaves have also been used to enrich the soil but they can only be used in high-value areas such as nurseries.

4. Neem in reforestation and agroforestry

Neem is a very valuable forestry species in India and Africa and is also becoming popular in tropical America, the Middle East countries, and in Australia. Being a hardy, multipurpose tree, it is ideal for reforestation programs and for rehabilitating degraded, semiarid and arid lands.

DISTRIBUTION

Neem is a tropical tree with wide adaptability and is especially suited to semi- arid conditions. Currently it is grown in many Asian countries and in the tropical regions of the western hemisphere. A map showing distribution of neem in the main countries around the world is attached.



According to the Report of an Ad Hoc Panel of the Board on Science and Technology for International Development National Research Council (1992), neem has been planted in many parts of Asia, Africa and some other areas of the world. However over 60% of the entire neem population is in India (Neem Foundation, 1997). Excerpts from the report on neem distribution are as follows:

Asia: India, Burma, Thailand, Bangladesh, Cambodia, Indonesia, Iran, Malaysia, Nepal, Pakistan, Sri Lanka and Vietnam are reported as having planted neem trees.

India: neem grows wild in dry forests and it is also cultivated in all but the highest, coldest parts of the country. It thrives best in the drier zones of the northwest, and a large number of trees are found in the state of Uttar Pradesh. It is commonly planted as a roadside tree to form shady avenues. It is estimated that there are around 18 millions neem trees in India. It could be helpful to compare the climate and growing conditions in India to the parts of China where neem production is planned.

Burma: although Burma is one of the main countries where neem is native, not much about its neem trees has been recorded. Nonetheless, it is a significant producer of neem seed (up to 20 000t is currently awaiting export) and a pilot factory was established in Mandalay to produce a 1%-azadirachtin product by methanol extraction with the help of a German aid project. However, the pilot factory failed when funding from the aid project ceased 4 or 5 years ago. The product produced was cheap but variable and unstable.

Indonesia: Java has a large number of widely spread neem trees of the “indica”

species. Bali, Lombok, and Surabaya have neem forests of considerable size while there are plantations on some of the other islands. There are trial plantations of the “excelsa” variety in Sumatra for seed and timber production.

Pakistan: Neem is fairly widespread in the country south of Lahore. In many cities giant neem trees, more than 100 years old and more than 30 m tall stand along roadsides.

Philippines: The “excelsa” variety, also called Philippine neem, is native to the Philippines but it was cut down in the 1920s for making piano frames. It is a variety suited to a high-rainfall environment. In 1978, scientists working at the International Rice Research Institute (IRRI) including Ramesh Saxena used neem as a control for insects in rice. By 1990, however, IRRI had distributed more than 120 000 seedlings and the tree was growing on at least eight islands. In spite of government support, a potential market for the product, and other advantages such as cheap labour, there has been no development of a neem industry in the Philippines. It is pertinent to ask how and why China will be different. Wide scale plantings for fuelwood and potential pesticide production had also been undertaken by private and governmental agencies.

Saudi Arabia: Neem was introduced into this country more than 40 years ago, and has acclimatised remarkably well to the hot and arid conditions. In the plains where the Prophet Muhammad is said to have delivered his farewell sermon some 1400 years ago, about 50,000 trees were planted in early 1990’s to provide shade to the 2 million Muslim pilgrims who camp there annually for the hajj.

Thailand: Thailand has all three varieties of neem (“Indian” neem *Azadirachta indica*, Philippine neem *Azadirachta excelsa*, as well as their own species (*Azadirachta siamensis*). although they grow in different regions. There is little overlap which means that the species have strong agronomic preferences, a matter that has important implications for plantings in China. Both *A. indica* and *A. siamensis* are smaller and slower growing than *A. excelsa*. It is one of the fastest growing trees in the world. At Ratchaburi, on arid rock outcroppings, 200 000 specimens averaged 11 m tall only 6 years after planting.

Africa

Indian immigrants introduced neem to Mauritius and may also have taken it to continental Africa. It is now widely cultivated in Mauritania, Senegal, The Gambia, Guinea, Ivory Coast, Ghana, Burkina Faso, Mali, Benin, Niger, Nigeria, Togo, Cameroon, Chad, Ethiopia, Sudan, Somalia, Kenya, Tanzania, and Mozambique.

Senegal

Because of tree planting programs of the Forestry Department and of the local people, Senegal probably has more neem trees than any other African country. The tree

dominates towns and villages all over the country. It is used for shade and for firewood, and it has had very beneficial ecological consequences, including the saving of many indigenous trees that would, in its absence, have been felled for fuel.

The original commercial pesticide derived from neem (Margosan-O) was developed by Robert Larson from seed imported from Senegal. When he sold his company to the WR Grace Corporation, they tried to import neem seed from Senegal but changed to India as their source of supply. The reasons why this change occurred are interesting. There was plenty of seed available, a network of traders in place, and cheap labour for harvesting yet the venture failed because of unreliability and corruption which made the price too variable. It also meant that no one would invest in an extraction plant in Senegal. Again the lessons for establishing an industry in China are obvious.

Ghana

Neem has been growing on the plains near Ghana's capital, Accra, since the 1920s. The trees have naturalized, and their spread has been boosted by birds and bats that feed on the fruits and spit out the seeds while sitting in the branches. Neem is now scattered all over the area, and has become Ghana's major source of firewood.

Niger

At the beginning of the nineteenth century, the Majjia Valley in central Niger was heavily wooded. But it is located in the southern Sahel, an area with highly variable and low rainfall (400 – 600 mm a year). The growing population – with a relentless appetite for fuelwood, fodder, and construction materials – left it bare. By the drought years of the early 1970s, wind erosion was blowing away nearly 20 tons of topsoil per hectare per year. In 1975, the American relief agency CARE began planting neem windbreaks. By 1987, some 560 km of double rows of neem were established and more than 3000 hectares of cropland protected.

Nigeria

Neem is common, especially in towns and villages, in the northern regions. Sometimes it is planted in large numbers along roadsides.

Mali

Neem is part of the scene along the Niger river as far north as Timbuktu. Many of the trees are pollarded (at about 2 m height) to provide forage to cattle and goats.

Sudan

Sudan was one of the first African countries to get neem. Today, the trees are widespread along the Blue and White Nile rivers, in irrigation schemes, and in towns and villages.

The AMERICAS

Apparently, it was immigrants from India who introduced neem to several Caribbean nations. The tree is now grown as a medical plant in Suriname, Guyana, Trinidad and Tobago, Barbados, Jamaica, and elsewhere. More recent neem plantings are also found in St. Lucia, Antigua, Dominican Republic, Mexico, Belize, Guatemala, Honduras, Nicaragua, Bolivia, Ecuador, and Brazil. In most of these nations, however, the plantings are small, scattered, and exploratory. Only in Haiti, the Dominican Republic, and Nicaragua have large numbers of neem trees been planted so far.

Haiti

In the past decade or so, neem has been widely planted in Haiti. In fact, this tree is now one of the leading species for reforesting the much-denuded land in this country. For example, one project funded by USAID has planted 200 000 neem trees as part of a road beautification program using seeds imported from Africa in the late 1970s. Later neem became a popular species for planting in other reafforestation schemes. The trees have grown so well that today neem seed is becoming a Haitian export. Approximately 40 tonnes were processed for azadirachtin by an American company in 1990. However, this represents an enormous waste. The trees planted in Haiti are now 18 years old but there is very little production from them. Only a small income has been received for a very large outlay. Still there is confidence in the industry and USAID will apparently provide up to \$US5 million for the industry as soon as proper elections are held.

United States

Because the tree is a tropical species, it probably cannot be grown economically in the continental United States beyond South Florida. In South Florida, however, there are a small number (around 50) neem trees. And in 1989 the Hawaii State Senate passed a resolution supporting research and development of this “wonder tree”.

Dominican Republic

In 1987, some organizations in the Dominican Republic started a joint project to promote and disseminate the use of local, home-made insecticides from neem. Since then more than 400 000 neem trees have been planted in the country.

Nicaragua

Use of insecticides produced from neem is becoming a real alternative for the management of pests in vegetable crops grown by small farmers in Nicaragua. There are 125 000 neem trees planted in Nicaragua.

The Pacific

Nineteenth century immigrants carried the tree from India to Fiji, and it has since spread to other islands in the South Pacific, even to Easter Island, which is hardly known as a place for trees. In Papua New Guinea, neem was introduced at the beginning of the 1980s, mainly in the Port Moresby area.

Australia

Neem had been introduced to Australia in small numbers on several occasions. It is believed that the tree first arrived on this continent in the waning years of the Makassar Trade between North Australian Aborigines and East Indies Islanders from what is now Eastern Indonesia. This trade, which legally ended in 1903, brought many tropical staples to North Australia as well as neem seed. Two generations later, former members of the Imperial Armed Forces who had become familiar with neem during World War II as a remedy for malaria took neem with them from Southeast Asia. More recently, neem was brought to Australia for aesthetic reasons, such as roadside trees at the RAAF Base at Darwin after Cyclone Tracy (1975) or for mine rehabilitation, notably by Comalco on their bauxite mine at Weipa near Cape York in 1968 – 1970 (Bosselmann, 1993). In total, over 2 500 neem trees have been planted in Weipa as part of a mine regeneration trial (Warren 1996). Some 400 neem trees were planted on a research station near Ayr, belonging to the Queensland Department of Primary Industries, but they have now been removed. About 120 neem trees were planted at Cleveland in early 1988 (Bosselmann, 1993). It is reported in total “some 80,000 neem trees so far have been planted across the dry, and semi – dry tropical north of Queensland” (Friend 1996) but there is only one significant plantation at this stage with 8 000 trees. The rest are scattered and not really able to be harvested. In the later half of 2000, Plantation Developments Pty Ltd launched a neem plantation project by inviting investors to apply for participation. The project land is comprised of both the Georgetown and Lakeland properties. The Georgetown property (91.64 ha) is situated beside the Gilbert River, approximately 330 km southwest of the city of Cairns. The Lakeland property (310.2 ha) is located at Lakeland between Mareeba and Cooktown, North Queensland. The project has a life of approximately twelve years. Investment in the project is achieved by applying for one or more woodlots each of 0.3 hectares on part of the land for the purpose of farming neem trees. A minimum of 120 trees will be grown on each woodlot. Despite a lot of interest, it will be many years before a commercial neem industry is established in Australia because it is so uncompetitive with other locations.

NEEM PRODUCTS TRADED IN THE WORLD MARKET

Parts of the neem tree are being processed into various products for sale in the world market. The following is the introduction of a few leading producers of neem products in India, the United States and Australia.

Neem Oil in India The neem trees occurring throughout India represent a large, although very scattered, resource. Already, neem oil is a common commodity traded freely in the markets, but much more could be produced. It has been estimated that India's neem trees bear about 3.5 million tonnes of kernels each year and that, in principle, about 700 000 tons of oil might be recoverable. The annual production in the late 1980s was only around 150 000 tons. (About 34 tonnes of neem oil were

exported in 1990 valued at 300 000 rupees, worth about 21 000 US dollars.)

The Calcutta Chemical Company, India started to make soap from neem oil in 1920 and, in 1929, neem toothpaste was launched. **Sunida Exports** is making various varieties of neem products such as neem soaps, food supplements, agricultural products and veterinary products. **Plasma Power P Ltd** is another Indian company making speciality neem products mainly of neem oils, neem leaf granules (priced at US \$1.8 per kg), neem bark powders (US \$1.26/kg), soap nut powders (US \$4.68/kg), and neem cake. Plasma neem oils and other products are used not just in India, but in other countries of the world such as New Zealand, The Netherlands, Hawaii, United Kingdom, Switzerland, Panama, and so on.

Thermo Trilogy Corporation of USA. The first commercial use of a neem seed extract for non-food use was approved by the U.S. EPA in 1985 (Walter 1996). Vikwood Botanical introduced a product called Margosan-O for use on trees and shrubs to control leafminers and gypsy moths. In 1988, W.R. Grace purchased the patent, registration and technology for Margosan-O, and changed the formulation in 1990 before introducing it into the greenhouse industry. In 1993, Grace received approval by the U.S. EPA for use of azadirachtin on food crops and introduced NEEMIX (0.25% azadirachtin) in Florida. Simultaneously, in collaboration with an Indian partner, they started up the world's largest azadirachtin plant in Tumkur, India. NEEMIX found good acceptance in the citrus and vegetable markets for control of such pests as armyworms, leafminers and aphids. In 1994, Grace obtained registration for a 4.5% azadirachtin formulation and introduced NEEMIX 4.5 to the agricultural market. The 4.5% formulation, being 18 times more concentrated than the 0.25% insecticide, reduced the difficulty of handling large volumes of material and simplified package disposal. In 1996, Grace sold the Biopesticide Group to Thermo Ecotek, which formed a new company, Thermo Trilogy, to market and develop biopesticides. Margosan-O was renamed NEEMAZAD. At present Thermo Trilogy Corporation is manufacturing at least three neem products. Trilogy, one of the major products of the company, is a broad spectrum fungicide of certain diseases and mites. Its active ingredient is clarified Hydrophobic Extract of Neem oil (5.46 lb per US gallon), and major target pests are alternaria, greasy spot, postbloom fruit drop, mildews and mites. Trilogy can be used on vegetables, fruits, nuts, melons, and agronomic crops.

Agro Logistic Systems, Inc. of USA is also producing neem-based products including the following three products:

AGRONEEM is a unique formulation containing azadirachtin (0.15%) as the active ingredient. It also contains 15% neem biomass (neem lipids), thus utilizing the complete spectrum of neem's potential as a pest management tool. It attacks insects at different stages of growth as anti-feedant, insect repellent, growth regulator and insecticide. It is non-toxic and does not harm the workers. It is bio-degradable and

protects the environment. It is compatible with most commonly used fertilizers, fungicides and insecticides. It is registered with the US EPA.

AGRONEEM from Agro Logistic Systems, Inc. is packed in a 32 oz. (One quart) plastic bottle. Case pack is 10 bottles. Order in case pack or multiples. List Price is currently \$400.00 per case.

NEEM CAKE is a soil supplement containing nutrients NPK, which loosens up the soil structure and makes the soil more receptive to nutrient uptake. In many countries around the world, it is routinely applied to the soil for the control of soil borne nematodes.

NEEMCAKE for sale by Agro Logistic Systems, Inc. is packed in 50 lb. bags. Pallet pack is 12 bags or 600 lbs. List price \$300.00 per pallet (12 bags).

AGROMORE FOLIAR, used as plant food, booster and plant growth promoter to increase crop yields, is advertised as a Phosphorous rich foliar fertilizer with added Magnesium and Zinc. The leaves absorb the nutrients rapidly, thus helping in the process of photosynthesis.

AGROMORE FOLIAR is packed in 8 oz. bottles. Case pack is 12 bottles. List price is \$192.00 per case (12 bottles).

NeemAura Naturals, who have just introduced the world's first certified organically grown neem leaf, and pure wild – crafted neem oil, has its own farm growing neem trees. Its neem products include:

Toothpaste: US\$2.95 each, 3.5 oz

Wild – Craft Neem Oil: US\$10.95, 1 oz. Bottle

Certified Organic Neem Leaf: US\$12.00, 1/4 pound Bag

Neem Cream: US\$18.95 each, 2 oz.

Hand & Body Lotion: US\$11.95 each, 8 oz.

Neem Herbal Spray: US\$8.95 each, 4 oz.

Organic Neem Leaf Extract: US\$12.95 each, 1 oz.

Neem Soap: US\$4.95 per bar, 3.5 oz.

BioNeem located in New South Wales, Australia is manufacturing neem oil products. Over the past four years, it used only neem seed oil on its farm and achieved very good results against a broad spectrum of pests. BioNeem is claimed to be a highly concentrated emulsified neem oil which contains a minimum of 3000 ppm of Neem's main active compounds. Currently BioNeem price is as follows: 100 ml bottle \$13 (packing and handling included), 1 litre bottle \$50 (P & H included), 5 litre bottle \$154 + P & H.

Neem Co-op was formed in 1996 in Northern NSW, Australia. It is manufacturing or importing and selling a broad range of neem products. Some of them are listed with size and price as follows:

Neem Facial Moisturing Lotion	125 ml	AU\$15
Neem Shampoo for All Hair Types	250 ml	AU\$9.8
Neem Soaps	100 gm	AU\$3.6
Cold Pressed Neem Oil	25 ml	AU\$4.9
Neem Toothpaste	100gm	AU\$3.9
Neem Seedling	5 + cm	AU\$3.0
Advanced Seedling	20 + cm	AU\$8.0
Neem Tree	60 + cm	AU\$12.0
Neem Tree	1 m +	AU\$18.0
Neem Meal Cake	2 kg	AU\$4.0

Information about the content of neem extracts in these various products is known so it is possible to estimate how much of the original seed is included in any of these products and calculate the potential returns to the producers. The economics of some of these products are highly questionable. If we use some of the Agro Logistics products as an example, we can show that they are not likely to be commercially viable at the prices currently advertised.

Agroneem is an emulsified neem oil with 0.15% aza as the natural azadirachtin content. It is packed in 1 litre (quart) bottles and sold at a price of \$71.40 (\$US40) while an Australian market study showed that a price of \$15-18 per litre was an acceptable price. Certainly no commercial farmer would buy it at \$71.40 per litre! With an application of 2 to 3 litres per hectare, the cost is prohibitive.

If we assume 22% recovery of oil from the neem seed, about 220 litres of oil is obtained per tonne of seed. With a mixture of 70% oil: 30% emulsifiers, it is possible to extend the amount of oil to 314 l of neem oil per tonne of seed, giving a gross return of over \$22 400 per tonne. This is not realistic.

NEEMCAKE is currently advertised at \$US1 125 per tonne or AUD2 008. Market research conducted by Neem Extracts Australia showed that a price of \$600-700 per tonne was possible with a sales figure around 1 700 tonnes per year. A price of three times this level is just not believable.

The product like AGROMORE FOLIAR is described as it is to avoid regulatory controls. As such, these products sell very poorly.

Thus the claims of current marketers of neem products need to be carefully examined and proper market evaluation studies need to be carried out before any large-scale investments are made. The common thread linking all of the ventures that have failed commercially when trying to produce and market neem products has been their

inattention to economic considerations.

In summary, the main market for neem products, \$US125 million sales per year by Thermo Trilogy, is to conventional farmers in the United States. There is no proof about its widespread use in organic agriculture at this stage, only anecdotal comments. There also seems to be a specialty market for limited quantities of products for which unrealistically high prices are paid.

NEEM POTENTIAL IN CHINA

From 1980, the agricultural areas attacked by crop diseases and insect pests has been increasing each year in China, and the damage to agricultural output has become more severe. It is estimated that the loss of grains and cotton caused by crop diseases and insect pests amounts to 16 million tonnes and 300 000 tonnes respectively although around 250 000 tonnes of farm chemicals are applied in China each year. Chinese central and local Governments have noticed that the current synthetic chemicals which are used by most farmers have caused many problems such as the growing resistance from pests, the damage to the environment, and toxicity to humans and animals. Therefore the introduction of new chemicals, especially biological chemicals, is being paid greater attention by research, government, and business organizations.

From 1986 China started to introduce neem trees on an experimental scale. The first place testing the plantation of neem was in Wanning county of Hainan province. Unfortunately, almost no tree can be found there at present because of the side effect of rapid economic development. In 1997, a Shenzhen based company developed a neem product with 0.3% azadiractin for the first time in China and this product achieved registration by the Ministry of Agriculture of China. This new product was also regarded as a high-tech product by other relevant ministries. Unfortunately, this company went bankrupt because of other reasons. In 1995, a research institute named Luxi Biological Resources Development Institute in Dehong Prefecture of Yunnan province began the introduction of neem trees with great enthusiasm. The neem seeds were from India, Thailand and Burma. In 1999, The Institute cultured more than 1 million seedlings for plantations in this area and other prefectures. Its initial progress in this regard has attracted the support from governmental organizations and businesses. The provincial government is giving support in finance and policy through its cooperation with another new company so as to set up a processing factory for neem named Yunnan Guangming Neem Development Company (YGND). The new company plans to produce 2.8 million seedlings annually, and to plant 3 300 hectares of neem trees every year in the next five years. To fulfill this plan, \$US 2.8 million of funds have to be raised and put into the program. Currently an Australian company is holding discussions with YGND in regard to establishing a joint venture for extracting azadiractin and manufacturing pesticides in Yunnan province.

Two other companies based in Yunnan and Hainan respectively are also very

interested in setting up processing factories. Xinlian Eco-Science & Technology Company is raising funds amounting to around \$US 7 million for the production capacity of 670,000 litres of 0.3% azadiractin preparation and 250 tonnes of neem oil each year.

An international workshop on the production and utilization of neem will be held in Yunnan province of China in February 2001. In the near future, China may be one of the most important countries for neem plantations and for the production of neem products in the world. China will benefit from neem's application in various ways such as:

- Biopesticides for crops, especially for greenhouse industries, for example in Shandong province which is the largest production base for vegetables in the country. The application of neem pesticides will be conducive to the export of vegetables which are recognizably "green" and free of synthetic pesticide residues.
- Poverty-alleviation in rural and remote areas. Farmers planting neem trees can obtain income from the sales of neem leaves, seeds and the timber might be used as a source of woodchips.
- The beneficial impacts on environment. Since neem pesticide has low mammalian toxicity and low impact on beneficial insects, it will be much safer to apply neem pesticides than synthetic products. In addition, in hot and arid regions like Yunnan province, it can be demonstrated that the neem tree is one of the most appropriate trees suited to these environmental conditions.
- Potential impact on population control. In India and the United States, trials show that neem extracts have effectively achieved contraception without apparent side-effects. There is no doubt that this result will be a good news to China since population control is still a severe challenge in this new century, and rural people could presumably afford to buy the neem contraceptives which had a cheap source.

CONCLUSION

In this paper, we have discussed the value of neem and neem products as a **source of bio-pesticides, as raw materials for pharmaceuticals and toiletries, for fertilizer management, and in reforestation and agroforestry.**

Neem contains 40 different active compounds called liminoids which exhibit antifeedant, insect repellent, and insect sterilization properties. A lot of technical research into the effectiveness of azadirachtin as a pesticide has been reported but much more study of the economics of using this chemical as an alternative to synthetic pesticides needs to be carried out.

There needs to be an objective study undertaken to determine the potential market

size for antiseptics, cosmetics, mosquito and malarial control products, and germicidal soaps based on neem products. Some of these products represent opportunities for high-valued products, eg. malarial control while others are for low-valued products like soap. It would be quite helpful to know how much neem products are needed to satisfy each of these potential markets. In other words, how many neem trees need to be planted to satisfy these outlets? China is in a favourable position to supply much of this material for the local and world market if it can establish a successful neem industry.

Neem cake, the residue left after oil extraction, has traditionally been used as a soil amendment. This bulky product represents 70% of the original seed weight and can become a disposal problem unless proper measures are taken to distribute or sell it as soon as the oil has been extracted. Neem leaves have also been used to enrich the soil and control soil borne organisms but they can only be used in high-value applications such as nurseries. Current prices for dry neem leaves in the United States are around \$US5.80 per kg which raises the question whether Chinese farmers could afford to pay such prices or whether any future industry would earn more income by exporting the product.

Neem is a very valuable forestry species in India and Africa and is also becoming popular in tropical America, the Middle East countries, and in Australia. Being a hardy, multipurpose tree, it is ideal for reforestation programs and for rehabilitating degraded, semiarid and arid lands. There are serious research issues to be addressed to assess whether tree plantations planted for re-afforestation should be treated like a crop and harvested regularly or retained. For example, what is the economic and environmental value of stabilising degraded land in the upper reaches of major Chinese rivers and the reduction of flooding in the lower reaches?

Research to be conducted over the next two years will focus on:

- Economic evaluation of the establishment and development of neem plantations in south China for example in Yunnan province.
- Economic feasibility of establishing an extraction and formulation plant for neem pesticides in China including issues of capital structure and access to intellectual property.
- Continuing assessment of the technical efficiency of azadiractin and other neem derivatives for pest control in crops typically grown in China eg. cotton, vegetable, fruit crops.
- Evaluation of the market potential for neem based products in the United States and Australia and as replacements for synthetic pesticides used in traditional farming systems in China.

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