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STUDY ON THE PRODUCTION POSSIBILITIES OF BOTANICAL PESTICIDES IN DEVELOPING AFRICAN COUNTRIES*

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* The views expressed in this paper are those of the author and do not necessarily reflect the views of the Secretariat of UNIDO. Mention of firm names and commercial products does not imply the endorsement of UNIDO. This document has not been edited.

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ABSTRACT

In accordance with the conclusions of a previous meeting, in Hungary (1), the purpose of this study is to review and assess the statistical and technical trends, as well as the possibilities for the industrial production of botanical pesticides in African countries, which may offer a practical alternative for the pesticide industry in the future.

The information available is grouped into 5 main parts:

I. The main problems (especially the food situation, crop losses) in developing countries.

II. Basic information on the economy, geographical climatic zones, and main products of the African countries.

III. Summary of the most important potential pesticides of biological origin, based on literature search.

IV. Main criteria for the establishment of a pesticide industry based on domestic plants.

V. Summary highlighting the importance of international co-operation and guidance for the new strategy.

I. Introduction

One of the greatest challenges facing the world is to produce enough food for the growing population, which is expected to amount to six billion people by the year 2000. The situation is particularly critical in some developing countries, where agricultural production is barely adequate to meet even current needs; moreover, the rate of food production is slowing down in relation to population growth.

Statistics show that in the developing countries the index of food production per capita basis was the same in 1980 as in 1970 (2). This is in sharp contrast with the situation in the developed countries, where during the same period food production increased by about 11 % on a per capita basis.

The world food situation is aggravated by the fact that approximately one-third of the global food production is estimated to be destroyed annually by weeds and various species of pests or diseases. Highest losses occur in the developing countries of Asia and Africa (see Tables 1-2).

As a consequence of the vast disparities among countries in their ability to produce and pay for food and to exploit modern production technology, scientists are coming under increasing pressure to investigate alternative plant and crop protection technologies to alleviate food problems and to improve the standard of living in developing countries in the 21st century.

Like with most biologically active substances, the use of pesticides is not without drawbacks: there can be unforeseen side effects, such as toxicity to non target organisms. including human health hazards, development of resistance of pests to the agent used, environmental contamination, etc.

Also, unsatisfactory manufacturing and transport practices or inappropriate use might lead even to disaster.
In developing countries further problems are due to the high prices, improper storage conditions, non availability of suitable application equipment and lack of technical training to ensure the effective and safe use of pesticides.
For that very reason, it is inevitable to develop new technologies to increase the efficiency of production, to protect crops from a host of field and storage pests, and to minimize environmental contamination, toxicity and costs.
It follows from the above mentioned facts that each activity in pesticide industry and practice must be strictly regulated. Further, pesticide demand is decisively determined by geographical and climatic conditions, crop structure, level of development of the agriculture, and the size of cultivated land.

At present, over 4000 formulated pesticides products are available on the market (5). Organic chemicals account for the vast majority of the active ingredients in these preparations.
The about 800 organic compounds useed are produced predominantly by chemical synthesis.
The industrial production of pesticide chemicals is limited to industrialized countries (the top 40 countries control more than 70 % of the world market), however, the formulation industry is widespread.
Most of the production and trade data for developing countries are incomplete; however, in Table 3 an attempt has been made to collect the most important production and trade data of the African countries, based on the available information up to 1985. Their own production covered 28 % of their global demand; 72 % of the consumption was imported from developed countries in 1985. At the same time, the total demand of developing regions represented

more than 30% of the world-wide consumption, and 25% of these was imported.

Table 3 shows the quantities of pesticide chemicals (thousands of tons) consumed in North Africa and Tropical Africa at CIF import prices (millions of dollars); the total production of pesticide preparations (thousands of tons) and the A, B, C types of trend analysis of pesticide projections for 1990 and 2000 (thousand tons of active ingredients) are listed.

(A was analysed using a linear regression model on data for the period 1975-1984; B and C were estimated by need model, which forecasts a continuous increase in demand for pesticides based on agricultural growth in these countries)(6).

Table 4-5 show (5) the share of total pesticides consumption in Africa; in 1985, insecticides consumption was estimated about 59 %, fungicides 39 %, and less than 2 % of herbicides.

These facts and most market surveys, which suggest the increase of future demand in developing countries, indicate immediate priorities of own production in developing countries.

II. Classification of African countries according to economy, geographical and climatic zones and crop structures

Developing countries can be classified into three groups according to the stage of development of their pesticide industry:

1. The majority of these countries neither make nor formulate pesticides; they rely on imports of finished products. However, many of them have a potentially large pesticide market, and with guidance and support they would be able to set up facilities.

2. Many countries, as a consequence of using considerable quantities of pesticides, possess formulating capacity for the imported active ingredients, and for packaging and labelling the finished products, mainly for their local markets. (This activity is limited by the fact that active ingredients are scarcely available in the open international market, even after the product patent has expired).

3. Relatively few of the developing countries have a basic chemical industry. These countries are capable of undertaking pesticide production either on their own, or with technological and/or financial assistance. In this countries the further increase of modern agrochemical cultivation techniques and the local production of pesticides have indisputably great importance.

Table 6 shows the classification of African countries according to their manufacturing possibilities.

Taking into consideration the cost and time factors of developement of a new compound (USD 5-25 million and 10-12 years), including the availability of specially trained manpower, efficient machinery and equipment maintenance service, etc., so it is quite likely that there is no chance even for partly industrialized countries to develop a new compound within reasonable time. The expenses could only be recovered by selling the product all over the world, which would require an efficiently operating international marketing organization.

Only such a project can be attractive for these countries, which is technically feasible, economically acceptable in the start-up period, and profitable in the long run. The project can be facilitated by non-tariff co-operation strategies (joint venture, long-term technical co-operation, etc.).

Certain pesticides of plant origin can provide a promising alternative agrochemical future for partly industrialized countries which might then become potential exporters for other African or even for developed countries.

Since all species of pests (insects), diseases (fungi) and weeds have characteristic environmental requirements (temperature, rainfall, soil types), the level of infections caused by them varies according to geographical and climatic zones.

The spread of some weeds is largely determined by soil types. In regions with arid and eroded sandy soil, weed control is insignificant, whereas climatic conditions highly influence the extent of the pests, consequently the pesticide consumption in both quantity and quality (insecticides, fungicides, or herbicides).

Infestation by insects is significantly higher in regions with rainy and warm climates than in the areas with cold and rainy weather, or under dry continental or desert climatic conditions.

It must be noted, however, that not more than 30 dangerous pests, diseases and weeds are responsible for most of the losses in yield in almost all geographical zones of the world; actually those pests, which can adapt themselves to changing environmental conditions.

Plant growth fundamentally influencing soil is a living medium under permanent transformation, affected by external environmental factors. The soil types and climatic conditions are in close relationship; climatic influence has affected soil formation for millions of years and the current phenomena of soil formation and erosion had been induced by climatic factors.
Characteristic associations of plants may be attributed to the types of soil and the climatic conditions. Almost all plants require definite factors for their living conditions, such as favourable soil, optimal temperature, hours of sunshine and, most important, rainfall (zone of conifers, zone of deciduous plants, forests, grasslands, deserts, etc.). The above ecological factors are of great importance in the success of plant production, which can be modified to a limited extent by proper agricultural policy suiting the given country. The essential task of agriculture is to regulate and shift these factors in favourable directions by means of applying fertilizers, proper tillage and mechanical treatment, by the careful selection of appropriate plant species and plant protection.

The main climatic zones in which most African countries can be ranged are the mediterranean and tropical zones. The latter can be devided into two sub-regions with typical pests and diseases: the tropical arid and the wet zones. The number of local pests and the level of damage in these regions are high.

Tropical wet zone

In this zone there are two seasons; a hot rainy summer is followed by a cold, dry "winter". Most plants have two seasons annually while major pests attacking all the year round, the insect generations follow each other without diapause. The most serious loss is thus caused by insects; of course, the humid warm weather is optimal also for fungal diseases and for continuous infections. The presence of weeds is of secondary importance.

The major crops are rice, sugarcane, cotton, tropical fruits, wheat, millet.

Pesticide consumption is highest in insecticides, and in lower quantities of fungicides; weed control is than mechanically (see Tables 4-5).

Tropical arid zone: characteristic for Central Africa.

The two specific seasons are the very hot dry summer and temperate "winter" with low volumes of rainfall.

In this zone, agricultural production is restricted (due to irrigation problems) and only certain plant species can be grown (millet, sorghum).

The occurrence and the number of species of pests and diseases are much lower than in the wet zone; insects are mostly in diapause during the dry summer period. However, high population of insects frequently occur over the area (locust invasion). The occurrence of fungal diseases is more limited and only some species can be found (e.g. fusarium).

In spite of these factors, the extent of the damages caused is still the highest as compared with the other zones. Obviously, pesticide consumption is restricted to the use of insecticides.

Fungicides are used according to the actual level of agriculture. Besides millet and sorghum, in some areas tropical fruits and cotton can also be grown.

Mediterranean zone

The characteristic seasons are a warm and dry summer and a cold winter, with moderate rainfall, without frost. The number of sunny hours is high, but less than that in the tropical zones. The lowest temperature is -1 - -5 ^{0}C, but it occurs rarely.
This zone is favourable for the spread of fungi, but attacks by insects and weeds are not less important. During the warm and dry summer periods the insects are in diapause, thus the infestation level decreases.

Crop structure

Without going into details of the crop structure in African countries, Table 7 shows the most important crops of these countries, in both government and in farm management. General information on crop stucture is summarised in the study of "Cost Effectiveness of Pesticide Production and Application in Developing Countries" (9).

III. Potential plant species containing botanical pesticides

III. a Historical overview of plants containing pest control materials

It was soon and readily recognized that many botanical species possess selective action against a number of pests; some of them have been used as botanical pest control materials in many parts of the world (Azadiracta indica: to reduce damage in storage; Tagetes erecta: to protect vegetables from certain insects and nematodes; Gripha utan: to reduce rodent damage, etc.).

Based on an examination of some published reviews, Ahmed et al. (10) compiled a list of more than 2000 plant species reported to possess pest control properties for a wide variety of pest and diseases (see Table 8). In Table 13 is given a more detailed list of plant species having pest control properties (56-87)

A number of these plants have been recommended for exploration because many of them have potential priority to chemicals, such as a fairly broad spectrum of control and short period of activity; they are more readily biodegradable than synthetic products, so they have relatively lower toxicity and are less harmful to the environment and the consumer.

There is one more not negligible fact, the waste of certain plant extraction process could be used as potential natural fertilizers to contribute to higher crop yields.

Since traditionally big commercial firms generally devote their activity to the investigation of materials which are amenable to large commercial use, these plants have received little attention, and their potential for commercial exploitation has not yet been established.

In the last few years, however, the interest in naturally occurring plant products has increased, as it can be judged by the number of international symposia and seminars held and the research papers published on this topic.

Noteworthy news has been published by Chemical Marketing Reporter on a co-operation between Calgewe Inc. and Gustafson Inc. (11). The companies have agreed to collaborate on a project to develop biological products to aid the control of plant diseases.

Judicious selection and use of botanical pest control materials should bring substantial economic and social benefits both in increasing food production and in public health programmes.

The specific agro-climatic natural endowments of many developing countries offer a host of plants growing wild or cutivated, which contain pest control materials, so these countries have a unique potential in the field of botanical pesticide industries.

In this promising area, the lack or scarcity of information available and the diversity of opinions highlight the need for a systematic, co-ordinated and in-depth investigation by scientists in both the developing and developed countries.

Investment for establishing plants to produce botanical pesticides is not excessive and such plants would contribute to saving foreign currency in developing countries by using local labour, occasionally local sources of diluents and surfactants, by the reduction of transportation costs and dependence on foreign suppliers.

Since significant differences exist among countries, it is evident that wide-range agro-ecological, socio-economic and political considerations must precede the decisions to be made.

insect population and plant diseases may widely vary from one region to the other, not only in kind, but also in behaviour and relative importance to the agricultural production. Differences also exist in the relative degree of development of the agricultural techniques and production.

The toxicity of pesticides may have a different meaning and importance in developing countries from that existing in industrially developed countries. Due to deficiency of safety equipment and protective clothing, acute toxicity may rise to an overriding importance in developing countries.

As the use of highly toxic pesticides may not be entirely avoidable, a restrictive trend is needed in the regulations.

The need for adaptive research is basically important for planning a successful programme of agricultural development in all developing countries.

III. b Expectations of plants with some examples selected

For botanical species and their active ingredients which are to be utilized as effective pest control agents, the following characteristics are desirable.

The plant species should:

- -be a perennial (thus not requiring replanting every year
- -be easy to grow (quick groth and good resistance)
- -not need special skill or training for growing
- -not become a weed or host plant pathogen itself
- -be easy to harvest
- -not be expensive to grow (little space, labor. water and fertilizer requirements)
- -offer complementary economic uses (as a source of food

The pest control agent obtained from these plants should:

- -effectively control a broad range of target pests and diseases
- -be safe to wild-life and man
- -pose no environmental hazard
- -be easy to extract, formulate or use with available skills
- -not need expensive equipment
- -allow conversion of the waste products of the production process to fertilizer

Based on literature sources, Table 9 contains some plants for pest control summarized by S. Ahmed et al. (12). The growth habits of the plants and some characteristics of the pest control agents are listed (before studying the table, see the symbols for explanations).

Pest species that can be controlled by the plants listed in Table 9 are shown in Table 10.

The list focused primarily on insects which are the most important in African countries, but the study could also be extended to further investigations on other pests and diseases.

III. c. Some selected plants containing botanical pest control materials

1. Azadirachta indica (Neem tree), Melia azedarach (Chinaberry) /(MELIACEAE)

1.1. History of the natural product azadirachtin

In literature articles and surveys, Azadirachta indica (A. Juss), (Meliaceae) commonly known as neem tree, and Melia azaderach (Meliaceae), known as chinaberry have been in the focus of considerable recent interest owing to their potent physiological effects upon many insect species.

Insect repellent property of neem leaveshas been known in rural India since ages, surprisingly no systematic studies were undertaken till early 60's to determine and confirm the efficacy of neem as an insect repellent or as an insecticide. The earliest recorded indication on neem acting as an insect repellent was made perhaps by Mann and Burns in 1927 (13) who quoted an observation that during the locust cycle of 1926-27 the adult locusts did not feed on neem leaves. The next report in the literature was by Astrakhantzev et al. (14), who reported the efficacy of water and alcohol extracts of Melia azedarach as an aphicide against Brevicoryne brassicae. The alkaline alcohol extracts prepared from 32 g of fruit per 100 ml were the most effective, producing 98.2 % mortality after 48 hours. That was one of the first reports indicating insecticidal activity of the neem extracts, though the concentration used was very high.

Pruthi (15) found that neem leaves mixed with grain, or kept in a 5 to 7 cm layer over the stored grain, protected the commodity from damage or storage pests.

Fry et al. in 1938 (16) reported protection of cacao beans by Melia azedarach against Ephestia cautella wlk. Systematic studies on the repellent and insecticidal properties of different parts of neem and its products started in the early sixties. The very high antifeeding properties of the neem seed kernel against desert locust created great interest, and a number of research workers throughout the world started working on these plants; they isolated and identified the active ingredients from the fruits of the two neem varieties viz. Azadirachta indica and Melia azedarach.

A synthetic way for producing azadirachtin is not yet known.

As a result of its biological activity, international conferences have been held. (First International Neem Conference, Rottach-Egern, Germany, June 1980; Second International Neem Conference, Giessen University, Germany, May 1983 and Third International Neem Conference, Nairobi, Kenya, July 1986).

It can be said without exaggeration that at present there is hardly any other chemical compound with such advantageous properties available for pest control.

1.2 Mechanism of action

The effectiveness of azadirachtin as pesticidal agent, antifeedant, repellent, hormonal and growth regulator can be classified, though the mechanism of action has not been unambiguously identified.

Earlier observations on locust and preliminary work on different insect pests suggest that the biological activity of the neem products is mainly due to the antifeeding action, which some of the researchers have referred to as "gustatory repellent".

In the case of storage pests, practically very little work has been done to determine how grains are protected from damage caused by the different insect species, as the eggs are laid by the insects inside the grains, thus should have no connection with the neem product. There is very little evidence of a contact or stomach poison action of azadirachtin.

The most important development in recent years has been the finding relating to the hormonic activity of some of the neem constituents.

Garcia et al. (17) have found that feeding and ecdysis inhibition of azadirachtin on Rhodnius prolixus (a blood sucking insect) is an indirect effect due to an interference of azadirachtin with the endocrine system rather than through the inhibition of chemoreceptors.

Given through a blood meal, a dose-response relationship of azadirachtin was established using anfeedant effect and ecdysis inhibition as effective parameters. The effective dose (ED_{50}) was 25.0 ug/ml and $4x10^{-4}$ ug/ml of blood, respectively, for antifeedant and ecdysis inhibition effects. These findings, that is a many-fold difference between ED_{50} of the antifeedant and of the ecdysial effects emphasize that the two physiological effects of azadirachtin are distinct from each other and, especially, that inhibition of ecdysis is not the result of a reduced food intake.

Remarkable that Ecdyson given orally 5.0 ug/ml and juvenile hormone analogue 70.0 ug/insect countered the ecdisys inhibition as induced by azadirachtin.

Some other findings (e.g. Rembold et al. (18)) earlier disruption of metamorphosis in Epilachna varivestris. Redfern et al. (19): moult inhibition of milkweed bugs; and Warthen et al. (20): chitin synthesis inhibition) seem to prove the hormonic activity of neem products.

Conseqently, azadirachtin may be widely used in experimental insect endocrinology, which will probably contribute to clarifying the mechanism of action of these promising

botanical pest control materials.
The relative safety of azadirachtin to man can be proved by the fact that its twigs are regularly and commonly used in South Asia for brushing teeth.

1.3 Plant habit

The neem tree and shrub, commonly found in South Asia and in parts of Africa, is quite easy to grow; it requires virtually no care by the farmer and nil or very low quantity of fertilizer (maximum 10 kg/ha) and water. It thrives under humid, semi-arid and arid conditions, thus it can be grown in the tropical, subtropical and mediterranean parts of Africa.
The perennial neem tree begins to bear fruit in about 5 years, becomes fully productive in the 10th year and reportedly lives for over 200 years.

1.4 Parts of the plant containing the active ingredient, its extraction, formulations

In earlier work only the neem leaves were tested, and mostly against the pests of stored grain. In later years, its leaves, seed, oil and cake (the residue after oil has been extracted from seed) have all been found to possess pest control properties.
In most of these reports neem fruit and kernels have been found to be the most effective, however, in the absence of a standard terminology, there appears to be some confusion regarding the actual plant parts and the products tested.
A number of workers have used the terms fruit, seed and kernel, perhaps meaning the same part, i.e. decorticated seed, though in some cases the entire dried fruit may have been used.

The purification of azadirachtin is, unfortunately, difficult, especially on a preparative scale, due to the complexity and similarity in structure of the compounds found in the seeds and foliage of the plants. The best technique of purification is HPLC.

Yamasaki et al. (21) reported a preparative isolation of azadirachtin of single peak purity, utilizing the rapid and inexpensive technique of flash chromatography, combined with HPLC.

The extraction of azadirachtin was more efficient when the ground neem seeds were first defatted with n-hexane and the defatted seeds were extracted six times with methanol at room temperature.

In most cases, the difficult preparative isolation can be avoided. It was provedby Devakumar et al. (22) who tested four fractions of neem oil for their effect on larval emergence and mortality of Meloidogine incognita. Pure oil extracts were inactive in both cases, whereas limonoids were highly active.

Most commonly used plant parts and formulations:

- Leaves can be used after drying without any other preparation, mostly against the pest of stored grain (see Table 11).
  The dried leaves can be milled and/or extracted depending on local possibilities (dusting powder or other sprayable form).
- Seed powder can be obtained by grinding unshelled seeds in an electric mill.
- Neem oil can be obtained from dried, shelled and ground seeds by hand or a hydraulic operated pressing machine.
- The azadirachtin extract is more efficient than the neem oil or powder, but it requires relatively modern

extraction and separation equipment and professional knowledge; therefore extraction can only be suggested for the countries listed in groups 2 and 3 of Table 6.

Based on a literature search and survey, Table 11 shows (13) a summary of neem parts or products and concentrations used against different types of pests.

1.5 Economic value

All parts of the plants can be used for pest control purposes: leaves, flowers, fruit and seeds. The space-need of producing the active ingredient which is able to control 1 ha of crop is generally 5-50 m^2.

One tree produces about 30-50 kg of fruit annually. Thirty kg of the seed yields about 6 kg of neem oil and 24 kg of neem cake (23).

Effective control of a broad range of pests is possible with azadirachtin (see Table 10 and 11) in 10 ppm dosage when used as a contact poison; further insect growth regulator, antifeedant, repellent and also some fungicidal and nematocidal action has been demonstrated. Duration of the pest control lasts from 2-3 days to 2 or more months, depending on the species, dosage and formulation.

1.6 Other economic values of the plant

- The green leaves are used as medicinal fodder for cattle, as it seems to be an anthelmintic.
- The aqueous extract of leaves can be used to relieve muscular pain and also as a cure for skin infection; for this reason neem oil is used in manufacturing soap.
- The decoction of the bark is used as a tonic to relieve muscular pain of influenza.

- The bark is adstringent and bitter.
- The waste obtained after the oil extraction (neem cake) can be utilized as a special insecticidal active fertilizer.
- Neem provides fuel and hard timber for termite resistant building and furniture.
- It can be a source of fuel wood.

2. Derris elliptica and Derris malaccensis/(LEGUMINOSAE)

2.1 History of the natural product rotenone

Rotenone is the trivial name of the insecticidal component of certain Derris and Lonchocarpus species, all closely related botanically and belonging to the family of Leguminosae.
Derris, the most extensively studied plant could be important for certain African countries, especially for East Africa, Kongo, Zanzibar, where there thrive various types of Derris species; among them the tropical shrub and vine D. elliptica and D. malaccensis are the most important.
Insecticidal properties of the derris root had been known for centuries by the natives of China and East Africa, and it was used as a fish poison. Its use as an insecticide in nutmeg cultivation was reported in 1848 (24).
Commercial exploitation started in the second decade of this century when the extract of the root was patented in England as an insecticidal spray.
Among the African countries, Zanzibar has produced significant quantities of derris root; unfortunately, current production is much reduced because of competition by stucturally simplier synthetic analogues.

Although during the last 20 years Robertson and his co-workers (25, 26, 27) extensively attempted to achieve the synthesis of rotenone, the problem has not been completely solved yet.

2.2 Mechanism and spectrum of action

Rotenone is a selective non systemic insecticide with some acaricidal properties, environmentally friend because of low persistence and lack of phytotoxicity.
Effectiveness of the extract was attributed at first to a simple constituent (rotenone) which could be isolated from the roots with a suitable organic solvent in crystalline form.

These extracts also contain a number of related compounds other than rotenone, which are obtained as an uncrystallizable residue after complete evaporation of the solvent. The percentage of total extractives, as well as the ratio, rotenone/total extractives, varies widely, and depends upon several factors, such as the species, the method of cultivation, and the solvent used. After the extraction, the residue, freed from rotenone as completely as possible, is known as "derris resin".
First, the insecticidal effect of derris resin was ascribed to an occluded rotenone content. Various comparative tests of derris and rotenone, however, indicated that some active ingredients other than rotenone must be present in the extracts. Jones et al. (28), for example, found that powdered derris resin that contained only about 25 % of rotenone was as toxic to mosquito larvae as was pure rotenone; or, Campbell et al. (29) observed that a kerosene extract of derris, from which no rotenone could be isolated, was effective against houseflies.

These results, proved on the one hand that rotenone was not solely responsible for the insecticidal effect, on the other hand, they led to further intensive investigations of derris resin samples, originating from a number of different species and varieties of derris root.

The mode of action is not quite clear. According to Lauger et al. (30) the effectiveness of rotenone is due to the presence of a toxophoric group -CO-C=C-O-L, where L represents lipid-

L L

solubilizing groups enabling the compound to reach the site of action. These groups in rotenone are the benzopyran and benzofuran rings and methoxy groups.

According to Tischler (31), rotenone and rotenoids have been shown to act either as a contact or a stomach poison, without specific effects on the motor nerves and attached muscles of insects. Derris extracts could enter the insect body through the alimentary canal, the spiracles and tracheal system, or directly through the integument.

As to the toxicological data of rotenone: the lethal dose was found to be 3 g for rabbits, 0.6 g for rats and 0.06 g for guinea pigs (32, 33).

The pest species controlled by derris extracts are shown in Table 10.

2.3 Plant habit

Derris malaccensis and *Derris elliptica*, commonly found in tropical parts of Africa as perennial shrub or vine, are quite easy to grow, without any need of special skill or training of the farmer; they require no or a very low amount of fertilizer and labour and harvest is simple.

The parts of the plants used for pest control purposes are the roots, but in case of *D. elliptica* the leaves are also employed. Commercial roots contain from about 0.5 % up to as much as 13 % of rotenone and 5 to 31 % total of other rotenoids (34).

2.4 Formulation

There is no need for special equipment for formulation, which includes dusts made from the ground root and applied on a non-alkaline carrier, stabilized with phosphoric acid. Other application forms are spray or emulsion, generally containing 10 % of the active ingredient.

2.5 Economic value

One hectar of cultivar can be protected from the target pests (listed in Table 10) by the help of derris plant harvested and pretreated from 10-25 m^2.
As a result of low persistence in residues, there is no environmental hazard.

2.6 Other economic values

- -Rotenoids are sources of medicines, controlling ectoparasites of live-stock (35).
- -After the extraction, the rotenone-free plant parts are useful for the protection of soil erosion.
- -Wastes from the formulation process can be converted into a fertilizer.

As a result of low persistence in residues, the product is safe to wildlife and man, and there is no other environmental hazard. Thus, based on the above mentioned facts, Derris elliptica and Derris malaccensis, furthermore the related plants such as Tephrosia vogelii of LEGUMINOSAE (Table 9), could be considered potential botanical pesticides in all tropical African countries, which have no special industrial background.

3. Chrysanthemum cinerariaefolium (Pyrethrum cinerariaefolium) /(ASTERACEAE)

3.1 The properties of pyrethrins

Pyrethrum is a naturally occuring insecticide, obtained from the dried flowers of Chrysanthemum cinerariaefolium Vis. of family Asteraceae.

Certain African countries (Kenya, Tanzania, Equador, Uganda, Rwanda, Congo) belong to major producers of the plant.

It has long been used as a natural contact insecticide: at least since the early 1800s in Persia and Yugoslavia. By 1828, pyrethrum was being processed for commercial insect control , and by 1945, imports of pyrethrum into the USA reached a peak of 18 million pounds (36).

The dried flower heads contain the insecticidal principles collectively called "pyrethrins", of which six have been isolated and chemically identified as Pyrethrin I, II; Cinerin I, II and Jasmolin I, II. The effectiveness and degradability of the components are different; the pyrethrins are more effective and degradable than cinerins and jasmolins.

The instability of natural pyrethrins have hitherto limited their use in agriculture and forestry, in spite of the very small effective doses (about 45 g/ha pyrethrin is required for the control of some field pests). To overcome the above problems, a number of researchers have started the modification of natural pyrethrins, which resulted in a remarkable change in their properties, particularly in photostability.

3.2 Plant habit

Though the plant thrives under humid, semi arid or even arid conditions in mediterranean and tropical climatic zones, the production of pyrethrin has been found to depend very largely on weather, on soil types and on the strain of the species. The yield, depending on these three factors may vary in the range from 550 to 1350 kg of dried flowers (10 % w/w moisture)/ha. The plant can be successfully grown in the tropics only at altitudes which provide a cool or cold period.

For optimal production of the active ingredients, investigation of the soil content (N, P_2O_5 and K_2O) is advisable. (The optimal quantities are 70-80 kg/ha of nitrogen, 100-120 kg/ha of phosphorus and 90-100 kg/ha of potassium).

Though the plant is perennial, the yield of dried flowers/ha declines in the course of time, thus necessitating periodic replanting. The plant begins to bear flowers from the first year, becomes fully productive in the second or third year and lives for 8-10 years. The pyrethrin content of the flowers reaches a maximum at the time of full bloom (about 4 months after planting); the flowers are then picked by hand.

The highest concentration of pyrethrins is found in the flowers, particularly in the discs or achenes, but there is a small insecticide content also in the stem and leaves of the plant. In commercial practice only the flowers are harvested.

3.3 Economic importance and cost effectiveness of the different forms

Precise production figures are not available, but the dry flower production of the world has been estimated to vary between 15.000 to 25.000 tons yearly.

More than 90 % of the world production comes from five countries: Kenya, Tanzania, Equador, Rwanda and Japan.

Generally the crude extract ("pyrethrum concentrate") is exported to developed countries, mainly to the USA, England, Italy and Australia. Natural pyrethrins are also widely used in Japan.

The price of the dried flowers with 0.9 % active ingredients is about USD 4.2/kg, and that of the extract containing 20 % active ingredient is USD 82.5/kg; from these, the calculated price of the 100 % pyrethrin extract is USD 412.5/kg or USD 86,207/t (37).

Depending on the species of the plant, the time of the harvest, the soil and climatic conditions, an average of 400-600 kg of dried flowers can be produced on 1 ha; on extraction that yealds 3.6-5.4 kg/ha of active ingredient, in case of 0.9% pyrethrin content of the dried flowers; consequently, the hard currency earning, which can be achived, is USD 1490-2230/ha (calculated with USD 412.5/kg pyrethrin price).

Generally, 45 g/ha pyrethrin extract is required for the protection of 1 ha, which means 45 x 0.4125 = 18.6 USD/ha protection cost.

According to international practice, the cheapest forms are dusts with 0.3% global pyrethrin content, made from dried and milled flowers mixed with auxiliary materials (carriers, fillers, solvents, etc.)

The effective dose of these powders of 0.3% pyrethrin content being, 15 kg/ha, the requirement is 5 kg/ha of dried flower and taking into account the USD 0.6-0.8/kg cost price of the pyrethrum flowers, it gives a very advantageous USD 3-4/ha protection cost.

It is also known that some other natural pesticides have synergetic effect with pyretnrins (rotenone, azadirachtin,

nicotine, quassin, etc.), so using them in combination permits further reduction of the pyrethrins' dosage and consequently the protection cost.
The effective dose and form against tillage pests is spray with 0.01% active ingredient. One kg of dried flower is needed to prepare 1000 litre solution of the above concentration, which can control 1 ha. The protection cost, calculated with USD 0.7/kg average cost price of flowers, is USD 0.7/ha. The above two forms could be produced in many African countries without an advanced stage of industrial background. The active insecticidal ingredients are extracted from the dried, ground flower with a suitable solvent, generally isohexane. After evaporating the solvent, the remaining concentrated, refined extract can be formulated into the final product, usually aerosol sprays.
The dewaxed and decolorized pale extract is usually made by the manufacturing companies that buy the crude pyrethrum extract from the producing countries. However, the producing countries are now moving towards doing their own refining. As a result of this trend, Kenya has already established its own pyrethrum extract refinery, while Rwanda is in the process of installing a refinery unit -to the best of our knowledge- with the assistance of UNIDO.

As a result of the progress made in the manufacture of synthetic analogues, the market share of synthetic pyrethroids accounted for 30% of the world insecticide consumption in 1980 and continue to be widely used (38).
In spite of these facts, the use of natural pyrethrins is expanding, the present demand outstrips the supply, and it is believed to be strong, as that of an environmentally safe insecticide which has several desirable properties such as:

-remarkably wide scope of effectiveness against most common household pests, also such as those of domestic and farm animals, many pest of stored products insects, forest and agricultural pests
-toxicity is an unusually rapid paralytic ("knock-down") effect on flying insects
-powerful insect repellent
-insect resistance to pyrethrins has not been shown to be a practical problem
-remarkable safety to plants, warm-blooded animals and humans
-rapid degradation by sunlight or air, consequently little environmental hazards.

The superior quality of natural pyrethrins combined with improved formulation and application techniques could possibly further reduce the cost, and extend their use for pest control in agriculture and forestry.
Last but not least, production of pyrethrins could make subsistence for tens of thousands of farmer families and as a consequence of growing export possibilities, it is a source of earning hard currency.

4. Schoenocaulon officinale Gray /LILIACEAE

Sabadilla, the extract of the seed of the plant Schoenocaulon officinale Gray, is a selective contact insecticide effective against domestic pests and houseflies.
Its insecticidal properties were known as early as the sixteenth century, but thorough investigation of the plant was started in 1938. It was developed as a commercial insecticide in the 1940s, and by 1946, over 12,000 pounds were imported by the United States, mostly from Venezuela (38). Today, sabadilla is used on a limited basis, mostly on citrus plants.

4.1 Plant habit

S. officinale is a perennial small shrub which thrives in tropical and subtropical climatic zones. Recently, commercial supplies of the seed come almost entirely from Venezuela, Mexico and Guatemala.
A complex group of alkaloids -more than 30- known collectively as veratrine, are the active ingredients; two of these are cevadine and veratridine; these occur in the seeds only, up to a total of 2 to 2.5 % of the dried ripe seeds. Both compounds are more active than pyrethrins. Ikawa et al. (39) found that in tests against houseflies, veratridine was highly toxic (0.20 mg/ml of solvent) and cevadine less toxic (0.42 mg/ml of solvent); these solutions gave practically complete "knock down" in three minutes.
The oil extracted from the seeds effected "knock down", but possessed no killing properties.
Allen et al. (40) demonstrated, however, that cevadine was decidedly more toxic than veratridine to the large milkweed

bug (Oncopeltus fasciatus) and to the red-legged grasshopper (Melanoplus femur-rubrum).

Heating powdered sabadilla seeds to 150^{0}C for one hour, or treating them with alkali was found to increase the toxicity to insects (41). The toxicity also increased on storage. Velbinger (42) reported results of tests with cevadine and veratrine against 49 insect species; both were found to be highly toxic.

The veratrin alkaloids are relatively non-toxic to warm-blooded animals (the toxicity is less than that of rotenone or DDT), but irritant to mucous membranes, and some are terratogenic (43).

4.2 Formulations

For countries listed in Table 6 under point 1 and 2, the following formulations can be advised:

- -dusting powder (dried, milled seed + lime) commonly used against cattle lice and human head lice
- -emulsifiable concentrate (seed extract in kerosene + surfactant can be used as an emulsifiable concentrate)

In countries with well furnished formulation plant (listed in Table 6 under point 3) is advisable to prepare microencapsulated formulations in order to avoid mammalian toxicity and to increase persistence in the field. In such a formulation plant, the kerosene extract can be purified for the utilization in the pharmaceutical industry as a raw material export item.

4.3 Economic value

Today, sabadilla is used on a limited basis, mostly on citrus; nevertheless, certain workers believe these compounds may be worthy of further study (44), e.g. the purified seed extract may be a source of anti-hypertension drugs.

5. Nicotiana tabacum and Nicotiana rustica /(SOLANACEAE)

Tobacco leaves have been used as an insecticide for about 300 years (45). The major biologically active principle, nicotine, was first isolated in 1828 (46). Related pyridine-based alkaloids from tobacco leaves, such as anabasine and nornicotine, were also isolated and shown to be insecticides (47).

Nicotine has been isolated from a number of species in the genera Atropa, Equisetum and Sycopodium (47), but Nicotina rustica and Nicotina tabacum are the most common commercial sources (48).

Nicotine is an alkaloid, acts as an agonist on a specific type of acetylcholine receptor (the nicotinic cholinergic receptor) (49). It is a uniquely effective, non-persistent, non-systemic contact insecticide and effective fumigant with some ovicidal properties.

In spite of its unique effectiveness and an existing demand, the production has been greatly reduced, since organophosphate insecticides have largely replaced nicotine, further, because of toxicity to man by inhalation and on dermal contact.

Current global production is now estimated to be about 200 tons of 95 % nicotine. The suppliers are limited to a few advanced developing countries.

5.1 Plant habit

N. tabacum and *N. rustica* are biennial plants; they thrive under the subtropical and mediterranean parts of Africa (Algeria, Ethiopia, Kenya, Libya, Tanzania, Uganda. Zimbabwe).

For the optimal production of the active ingredient, investigation of the soil content (especially nitrogen) is advisable; before planting it is necessary to prepare the soil thoroughly, and to replant after two years; to protect the plant from certain diseases, e.g. from blue mould (*Peronospora tabacina*).

The cultivation of the plant requires some special skill of the farmer and caution owing to its toxicity.

5.2 Formulation

- Dried, powdered tobacco leaves have long been used against sucking insects. This has been replaced by technical nicotine and nicotine sulphate.
- Usually the 95 % pure alkaloid is marketed; it is relatively volatile and acts both as a contact poison and as a fumigant. It was also used formerly as a greenhouse fumigant. For fumigation, nicotine is applied to a heated metal surface or nicotine shreds are burnt.
- The sulphate is usually marketed in the form of an aqueous solution containing 40 % nicotine equivalent. When added to alkaline water or to a soap solution, the alkaloid is liberated, being then more active than the sulphate alone.

-Another form applied is a dust of 3 to 5 % nicotine content.

5.3 Economic value

The great merit of this natural insecticide is that its production uses an agricultural by-product of the tobacco industry, which has little or no other commercial value.
The pricelevel of nicotine is USD 3-4/kg. The protection of 1 ha requires 0.3-0.6 kg of active ingredient in a solution of 1000 litres solution; consequently the cost of the protection is USD 1.0-1.8/ha.
The treatment with nicotine shred forms (or thermal spreading) is cheaper; 0.159 g nicotine in the air is sufficient in 1 cubic metre, that mean a protection cost of USD 0.03.

5.4 Additional economic value

-The nicotine free tobacco can be applied as fodder or soil fertilizer.
-Tobacco aroma can be used in the cosmetic industry as scent.

The mentioned facts, the very advantageous pricelevel, and the low effective dose of nicotine should give rise to further research to solve the toxicity problems by means of new formulation techniques, which can revive the utilization of this pesticide.

6. Acorus calamus /(ARACEAE)

The roots of Acorus calamus (sweet flag) have long been used in India and Japan as an insect repellent and toxicant (50). The essential oil from the insecticidal roots, available commercially, is reportedly effective against moth, mosquitoes, houseflies, lice, fleas and insects attacking stored products (51) (see also Table 10).

The major active component in sweet flag root oil is -asarone, a chemosterilant for the red cotton stainer bug (Dysdercus koenigii) and other species of insects (51; 52; 53); a repellent for some other species of insects (51) and an attractant for Ceratitis capitata (Mediterranean fruit fly) (50).

The synthesis of -asarone has been accomplished (54) and it may be used as a commercial fumigant for protecting stored grains from insects, e.g. from the rice weevil, Sitophilus granarius (L.) an economically important pest.

6.1 Plant habit

Acorus calamus can be readily grown in tropical, temperate and even in marsh climatic conditions. It is a perennial shrub or herb; it thrives in many parts of Africa. among those Ethiopia is the most important.

Its growing does not require special skill, training and labour of the farmer, or water, fertilizer and place.

Nearly all parts of the plant can be used for different purposes.

6.2 Economic value

The roots are harvested in autumn. Commercial dried roots contain from about 1.5 % up to as much as 3.5 % of -asarone. The powdered roots can be commonly used against the pests of stored grain. The pest control material can be easily extracted, formulated and no expensive equipment is needed. The waste of the formulation process can be converted to a fertilizer.

6.3 Additional economic values

There are complementary economic uses: the plant is a source of medicines for different therapeutic fields; sedative, analgetic and spasmolytic effects have been observed. It is even used for the treatment of status epilepticus (petit-mal).

In combination with other plants (e.g. Rauwolfia serpentina L.), sweet flag is used for the treatment of neurasthenia, and insomnia.

It is also known as a stomachic and carminative.

External use of the ground or powdered form of the roots is useful for relief of rheumatic fever.

Liqueur-, soap-, scent- and tobacco factories are also consumers of Acorus calamus.

IV. Main criteria of establishing a pesticide producing industry based on domestic plants in African countries

Industrialization is one of the chief objectives of every developing country; however, the relative economic positions of agriculture and industry are quite different from land to land.

The industries serving agriculture (producing fertilizers, pesticides and agricultural machinery) substantially contribute to the agricultural and, consequently, to the further industrial development of a country. Therefore, under the conditions of the developing countries which are, in effect, trying to achive agricultural and industrial revolution simultaneously, the building of an "agro-oriented" industry seems to be the first and most important logical step.

In attempting to set up a local pesticide industry, one should ascertain the economical feasibility and viability of the project under consideration, utilize all available techniques, analyse investment - turnover rates, national and international market possibilities, the network of transportation, and survey the human resources, also the raw materials available from domestic production.

These generally applied rules must be completed by special aspects in the pesticide industry.

Many problems of the inhabitants of developing countries could be solved with the help of active agents obtainable from domestic wild or cultivated plants. Such problems are plant protection, crop protection during storage, human and veterinary health protection, nutrition, etc.

By setting up local formulation facilities the above mentioned advantages could be achieved, moreover, an excellent possibility of industrialization of the country would be started. However, handycapped countries with a weak or no industrial background cannot be expected to afford the establishment and running of a modern formulation plant for producing pesticides of natural origin.

The first step is to evaluate the conditions of setting up a pesticide industry.Raw material supply in standard quality has great importance.

The harvesting, collecting, selecting and storage of the raw materials without loss or damage and transportation to the formulation plant can be a serious technical and economical problem.

The cost and the loss of the active ingredients during transportation can be reduced by locally established **pretreatment plants**. In such a plant, possibly near to the growing area, the raw materials could be stored, selected, dried, milled, caked, stabilized, or even extracted to reduce the volume of transportation and to utilise the by-product of the extraction as a nutrient or as a source of biogas, etc.

Although such pretreatment plants require a certain infrastructural level, the rapid return of the capital investment can be expected due to the utilization of the by-products, and reduction of the transport costs.

The end-products of these pretreatment plants, depending on the facilities and requirements, may be as follows:

- -ground or caked raw material from the vegetable source
- -extract of active ingredient in water or in an organic solvent
- -concentrate of the active ingredients
- -simply formulated products (WSC, dusting powder, granules)

These local pre-treatment plants would require:

- -fence: to protect the harvested and collected material
- -buildings: at least some rain protective roof for the stored product and for drying
- -water supply units: well, canal, etc.
- -energy supply unit: biogas, solar, or other, (e.g. diesel-engined generator built in a trailer)
- -equipment: fixed or mobile grinding, milling machinery (crushers, mills, pulverisers, micronisers, etc.); further, vacuum pumps, compressors, stainless steel or plastic containers, extractors, filters.

In the case of an all-year round working plant, the energy supply unit and machinery may be fixed, but in seasonal working plants the use of mobile ones (built in a special container, trailer, ship, etc.) is advisable.
Possible joining to an existing industrial plant (e.g. cotton, tobacco, sugar industry) would be, of course, advantageous. It is highly important to assure well-trained manpower (education, special training courses), with a view to the local possibilities and demands, including:

how to -grow and cultivate the plants
- -select them,
- -harvest the raw product
- -store it without degradation of the active ingredients
- -dry
- -mill, cake
- -extract the active ingredients
- -stabilize the active ingredients,concentrate them, etc.

A seasonal pretreatment plant could be operated with a mobile staff in a fully equipped vehicle.
The vegetable material, in the form of a raw product should

be transported then into a well-furnished formulation plant to make the valuable end-product.
There is a very good UNIDO study on the possibilities of the formulation of chemicals into pesticides in developing countries (55), which describes all the demands and requirements for establishing a local formulation plant.
Since the formulation requirements of botanical pesticides is the same as those of the synthetic ones, only the differences and some other specialities will be emphasized in this study.
The Figure 1 shows the basic functions of a formulation plant (see Appendix).

The given functions depend on the botanical properties of the plant and the chemical and physicochemical properties of the active ingredients.

-In some cases the botanical material contains the sufficient dose for pest control, so it can be used all alone, without the admixing of any other material, (examples are: pyrethrum powder, leaves of neem tree, etc.). In these cases the formulation can be reduced to achieve only stabilization and giving a spreadable form.

-The plants possess suitable texture for formulation, but the active ingredient content is lower than required for pest control;then, there are two ways to make it an effective pest control agent:
addition of the plant's own active ingredient to the ground material in a concentrated form, or to complete it with some other synergetic or additive materials.

-In several cases the active ingredients of the plant are only usable, without the other plant parts; in this case the extracted and concentrated active ingredient is to be formulated in a regular way

It is highly desirable to utilize the total amount of the harvested raw material (manifold applications with or without separation of the components).

In some cases the soluble active ingredient is contained in small isolated pockets in a material which is impermeable to the solvent. If only the soluble content is usable, the plant texture has to be crushed so that all the soluble material be exposed to the solvent; because of the cellular structure of the starting material, the extraction rate will be generally low without a sufficient pretreatment. This pretreatment may be simple crushing (mind the optimal particle size: smaller size will give greater interfacial area between the solid and the liquid, but slower or complicated filtration), or cell wall disruption with the help of physical (e.g. liquid carbon dioxide or liquid ammonia impregnation and expandation), chemical or enzymatic means.

Solvents

The liquid chosen for extraction should be a good selective solvent, and its viscosity should be sufficiently low to allow easy circulation. In many cases pure water or acidic, alkaline water can be applied as solvent; protic or aprotic organic solvents may have greater selectivity, but most of them are flammable and the price is higher.

If the required product has alkaline character, acidic water can be used for selective extraction, and vice versa.

Instead of the usually applied organic solvents, surfactant-containing water or water emulsion can be used for tne extraction of lipoid-type active ingredients. The choice of the most appropriate solvent is very important and often presents a crucial financial problem.

Temperature

In most cases the solubility of the material to be extracted will increase with temperature, resulting in a higher rate of extraction. The upper limit of temperature is determined by secondary considerations (preventing of enzyme action, thermal stability, etc.).

Agitation

In order to increase eddy diffusion, mass transfer of the particles from the surface to the bulk, to prevent sedimentation and to increase the interfacial surface, effective agitation of the fluid is very important, however, it will add to the costs.

Leaching

For the formulation of natural pesticides, the traditional formulation plant (55) must be equipped or completed with special extractors, filters, distillers, etc.

The extraction of certain toxicants from the pretreated natural raw materials is quite similar to the extraction of drugs in the pharmaceutical industry. Thus the well-known equipment and extraction technologies can be applied to complete the pesticide formulation plant.

In the past, leaching was carried out mainly as a batch process, but many continuous plants are now being developed. The type of equipment employed will depend on the nature of the solid (granular, cellular; coarse or fine). Generally, the solvent is allowed to percolate through beds of the coarse material , since fine solids offer too high resistance. The rate of extraction will be a function of the relative velocity between the liquid and the solid. In some plants the solid is stationary and the liquid flows through a bed of the particles; in some continuous plants the solid and liquid move in countercurrent.

Figures 2, 3. 4 and 5 show some types of extraction equipments (56. 57. 58).

The separation of solids from a liquid by a screen, which retains the solids and allows the liquid to pass, is termed filtration and in most cases this operation should follow the extraction. Instead of a detailed explanation of the theory or practice of filtration, some important instruments will be mentioned:

-Cake filtration (gravitation, vacuum, pressure strainer)
-Filter presses (Chamber press, Kelly filter, Sweetland filter)
-Rotary filters (drum filter, centrifuge)

See figures: 6; 7; 8; 9; 10 and 11 (59)

Not only filtration can be performed by the new techniques, such as membrane filtration, ultrafiltration and reversed osmosis, but also the concentration of the active ingredients can be accomplished. These modern procedures require some scientific background and capital investment too, but they open up a new possibility of preparing and concentrating sensitive active ingredients without thermal docomposition. The same result can be obtained by the use of supercritical fluids as solvent for the extraction of sensitive natural products.

Recovery and processing of plant oils

Fats and oils are water insoluble substances which consist predominantly of glyceryl esters of fatty acids, or triglycerides. Common usage considers as "fats" triglycerides that are solid or semisolid at room temperature and as "oils" triglycerides that are liquid under the same conditions.

The commercially important oil-bearing materials include oilseeds (cotton seeds, soybeans, etc.) and oil-bearing fruits (olive, neem, oil palm, copra, etc.).

The recovery of the vegetable oils consists of the following main operations:

Mechanical pretreatment

The cleaning of the raw materials (seeds, fruits) to remove foreign material, decortication (in the case of the larger oilseeds, and reduction of the kernels. Special decortication methods are required for large oilseeds with thick hulls, such as coco-nuts and palm nuts; this is done in the producing regions.

Reductions of oilseeds to relatively small particles or to thin flakes is a necessary preliminary to oil recovery by any means. For the size reduction various equipment, such as crushers, corrugated mixing rolls, attrition mills, or hammmer mills are used.

Cooking (roasting)

Heat treatment invariably precedes the mechanical expression with the aim of coagulating the proteins and make the parent material permeable to oil flow, to decrease the affinity of the oil for the tissue solids, to cause coalescence of small oil droplets and to increase the fluidity of the oil.

Mechanical expression

For the mechanical expression of oilseeds open hydraulic batch presses or continuous expellers or srew presses are used.

In Europe, pressing, either discontinuous or continuous is often conducted in successive steps at increasingly higher pressures. The end-products of this operation are the crude oil and the press-cake which contains 3-6% oil.

Solvent extraction

This is a highly efficient means of oil recovery either from the unpressed seeds or from the oil seed residues (press cakes). By solvent extractions the seed residues' oil content can be reduced to about 0.5% (see also leaching).

Distillation

It is the most widely used method of achieving the separation of liquid mixtures and refining the products.

All pesticide formulation plants should be equipped with some type of distillers, but for the concentration of natural extracts film distillers can be recommended in the first place.

To summarise it in a nutshell, a raw material of natural origin should be generally pretreated before formulation. The most favourable cases are when the active ingredient contained is sufficient for pest control and the other part of the raw material can find use as a suitable auxiliary material. In this case the botanical raw material needs only some admixed stabilizators and the preparation of a sprayable or spreadable form with appropriate particle size. In the other cases the pretreatment (in a local pretreatment plant or in a formulation plant) should consist of:

- size reduction and/or cell wall disruption
- extraction (leaching), filtering
- concentration and/or purification of the active ingredients
- handling of the waste (if there is any) and to utilize them.

The formulation of pretreated natural toxicants follows the usual way of formulating chemical pesticides.

V. Summary

In order to provide long-lasting and really effective help and means to the poverty and hunger-stricken African developing countries, such a relief programme is needed which is based on a complete survey of the agrochemical and nutritional situation and possibilities of the respective countries, keeping to the fore their actual and perspective needs, their technical, research, developmental, organizational, educational potentialities and their problems to be solved.
Realization of a proper project study based on realities could then gradually ensure the self sufficiency in food and fodder for millions of Africans; in addition, the ensuing industrial and trade development could lead to a pesticide export also into developed countries, resulting in the gain of -according to conservative estimation- several million dollars, instead of the present import costs, amounting to the same.

In spite of the fact -as it is shown in this study-, the share of botanical species containing pest control materials remain far behind the possibilities and expectations in the pesticide trade. Even the best known botanical pesticides have hardly moved out of the initial stage of discovery.
These products are the victims of the large-scale production and commercialization of synthetic products.
In this process, beyond the well-known facts, an important part is probably played by the lack of (or limited) research work on the possible subsidiary functions of these valuable plants. Nearly all parts of the harvested botanical raw material can be utilized for different purposes.

As the majority of African countries -owing to their special natural endowments- are the homeland of many plants containing valuable biologically active ingredients, and these plants are partly growing wild and partly cultivable with relatively little work, it is of prominent importance to recognize and widely exploit the possibilities of their utilization in both the developing and developed countries.
In the knowledge of the properties and ways of application of botanical pesticides, the farmer can not only grow these plants, but at the same time protect his crops from the various pests; furthermore, reasonable selection of the plant will result in the possibility of obtaining other valuable materials (medicines, soil ameliorating agents, fodder supplements, sources of energy, etc.). The project can be realized in several stages, depending on the level of development of the country in question:

1. Apart of the cultivated land is used also to grow the plants which can act against the important pests of the given cultivation; or the feral plants are collected, and certain instructions are given how to prepare and use the simplest formulations. This level can be attained by basic education and consultation, and it could result in considerable protection of the crops and in a significant reduction of environmental pollution. This new approach and way of thinking may at the same time form the basis of establishing a local industry.

2. A higher level and advantageous cooperation of the community would be "specialization", when a part of the community will learn the growing and application of botanical pesticides, and will establish or rent a mobile production unit also suitable to produce the basic formulations.

3. In higher-developed countries (see Table 6, groups 2 and 3) the realization of industrial-scale production would be the highest level of utilizing botanical pesticides; it could also provide for the export of these products.

4. Finally, within reasonable limits, also a cooperation of the countries of the continent can be envisaged; the countries without industrial background but with eminently suitable natural endowments for producing the required plant would take up the growing, harvesting and a preliminary treatment of the produce, while further processing would be done in the industrialized countries.

When selecting the botanical species and in the processing of the active principle, in addition to the basic requirements given in chapter III.b, the following aspects are to be considered:

1. The content of the active ingredient in the plants is usually 0.1 and 5 %; therefore a considerable amount of by-products is to be expected, which should advantageously be utilized at the site of production.

2. It follows from those described in point 1, that the establishment of a preliminary processing plant -either local or mobilized- is absolutely necessary, and this fact must be taken into account in cases of countries having no industrial background. Then the selection of the botanical species to be grown or collected must have the aim to allow the simplest and most readily applicable formulations to satify the highly important local need, and to ensure the sale of the excess in a stabilized form.

In higher-developed countries, the preliminary processing unit -also discussed in the present report- should be situated at the same place where the formulation plant is.

3. After stabilization, the active ingredient of vegetable origin can be formulated similar to the synthetic products; therefore the equipment, technologies, and instructions given in chapetr IV of this report and in the UNIDO summary on formulations (55), can be applied.
   It is a great advantage if in the neighbourhood of the cultivation area there is an establishment for the production of drugs, sugar, wool, tobacco or vegetable oil. because the corresponding experience, techniques can be utilized, even if separately from the given industrial establishment.

4. For better economy the parts of the vegetable material which cannot b- utilized as a pesticide should find use for some other purpose, possibly without loss. Depending on the properties of the botanical species, ther are several possibilities to do that, e.g.:
   - production of alimentary substances and fodder by biotechnological process
   - improvement of the properties of the soil: uses as a fertilizer, disinfectant, erosion inhibitor. etc.
   - basic material in drug manufacturing
   - source of energy
   - raw material for building (construction timber, clay-brick additive, etc.)

   In order to achieve the best complex utilization, special attention must be paid to by-products of possible use in medicine, veterinary therapeutics, alimentation and forage.

It must be emphasized that even the simplest formulation may be harmful to both man and environment if applied without the required expertise; for this reason, education of the people concerned, bringing them up to the necessary level in the trade, is absolutely important. The most significant requirements in this respect are listed in the 1990 February issue of GIFAP (86), in agreement with the requirements of FAO, giving directives for producers and manufacturers, as well as for mediators and users.
The rules of approval and application of plant protecting agents, getting increasingly strict year by year, well indicate that professional training -for the producer and up to the user- is of primary importance and it must not be omitted; in this respect, botanical pesticides are no exceptions, either.

In this report an attempt has been made to demonstrate the applicability and the advantages of botanical pesticides over synthetic products; the examples selected are well-known, thoroughly examined, consequently objectively evaluated materials. Owing to the wide scope and complex character of this topic, it would not have been expedient to discuss in detail a higher number of vegetable sources containing pesticides.

The purpose of the report is not to propagate or suggest the exclusive use of botanical pesticides, since each country must find the optimum suited to its economic conditions, and the solution of this problem can be approached in many cases only by a combination of the methods of pest control: mechanical procedures, the use of synthetic products, biotechnological methods and use of botanical pesticides. In this complex agrotechnology, the protection of the crops and environment by the use of botanical pesticides is only a part -yet, a very important part- solving the problems.

The appoach should finally lead, of course, to the application of complex agrotechnics; however, the practical task to be done presently is to find a compromise depending on the given financial possibilities.

The countries of the African continent widely differ in the conditions of environment, economy and particular endowments; therefore, a well founded suggestion decision to support the development can, and should, only be made after a thorough study of the conditions on the spot.

In lack of a profound study adapted to the site and made by a committee of experts, only general principles and possible ways of approach can be suggested, which cannot replace the reliable and thorough exploratory work, still can be of assistance in choosing the proper alternative when the results of the exploration are available; thus, the present study-report has the aim of helping future decisions.

It follows from the above facts that the estabilishment of a botanocal pesticide industry could play a crucial part in improving agricultural productivity, thereby ensuring self-sufficiency in the production of foodstuffs, and solving foreign currency problems of developing countries.

This work should be done on an international level, with close co-operation between African countries and interested international organisations on the following projects:

- study of the main criteria for the establishment of a domestic botanical pesticide industry in the given African country
- appropriate selection of the economically advantageous and promising vegetable sources
- reveal non-published results, survey of the technologies available, estimate potentially existing industrial and manpower sources

-assure proper educational training for the growing and harvesting of the plants selected

-set up local extraction and formulation plants

-secure all requirements for the production of well-defined and stable products of good quality, with minimal by-products and waste, and with maximal industrial safety

-provide instruments for quality control

-introduce appropriate registration rules to secure human and environmental safety

-establish marketing and business management for further potential expansion to acquire foreign markets

-creation of transport possibilities

Such an integrated approach would have an important effect on the industrialization of the agriculture, which would probably contribute to higher living standards in African countries.

The success of this programme basically depends on a well-oriented educational training system in every step of the above process.

Appendix I

Table 1

Estimated world crop losses caused by insects, diseases and weeds, in percentage of potential production (3)

Region	Insects	Diseases	Weeds	Total
Asia	20.7	11.3	11.3	43.3
Africa	13.0	12.9	15.7	41.6
South America	10.0	15.2	7.8	33.0
USSR and China	10.5	9.1	10.1	29.7
Centr. & N. America	9.4	11.3	8.0	28.7
Oceania	7.0	12.6	8.3	27.9
Europe	5.1	13.1	6.8	25.0

Table 2

Yield losses caused by pests in Africa
(percent of the potential yield) (4)

Crop	Pests			
	Weeds	Fungi	Insects	Total
Cereals	15	10	12	37
Sugarbeet	17	17	22	56
Potatoes	12	28	22	62
Vegetables & legumes	13	15	11	39
Fruits	7	12	9	28
Coffee, cocoa	17	22	17	56
Tea	8	4	6	18
Tobacco	11	26	14	51
Oil crops	10	9	15	34
Cotton	8	17	20	45
Rubber	6	17	6	29

Table 3

Consumption and production data of North African (NA) and Tropical African (TA) countries (7,8)

	1975		1980		1985		1990		2000	
	NA	TA	NA	TA	NA	TA	NA	TA	NA	TA
Amount of consumption x	45.1	48.2	44.2	78.4	50.5	21.8				
Value xx	120.4	98.0	138.3	240.9	152.3	79.4				
Production xxx	29.3 xxxx		24.8		20.9					
Projections x										
A							50	30	55	5
B							68	80	101	101
C							63	74	91	87

x Thousands of tons

xx Millions of USD; the value of the statistics is obscured by the changes caused by inflation and by different dollar exchange rates

xxx Thousands of tons

xxxx In 1976

Table 4

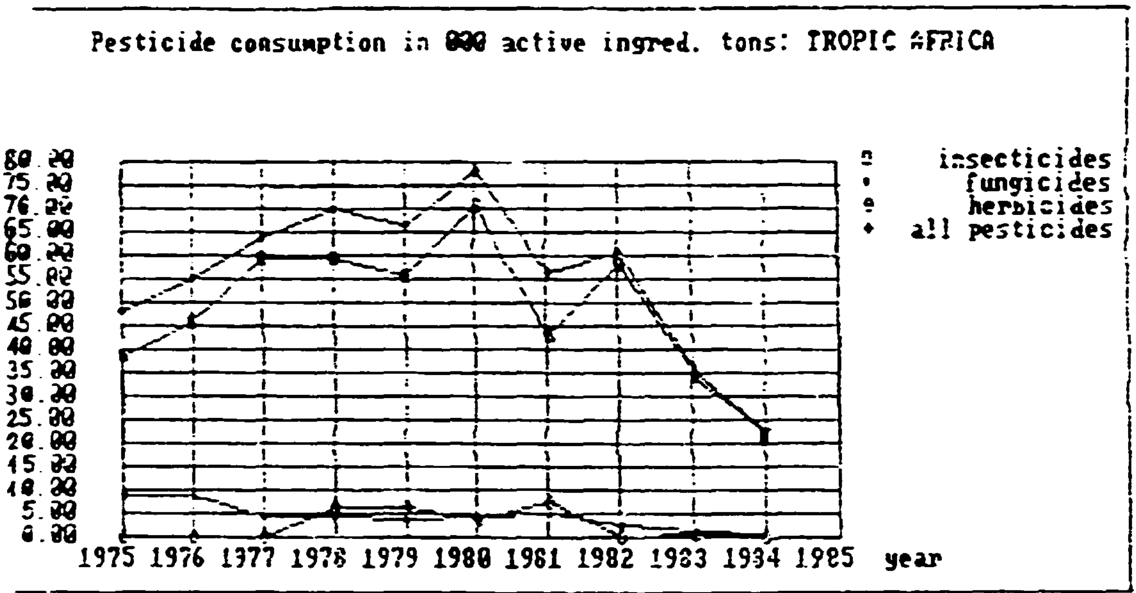


Table 5

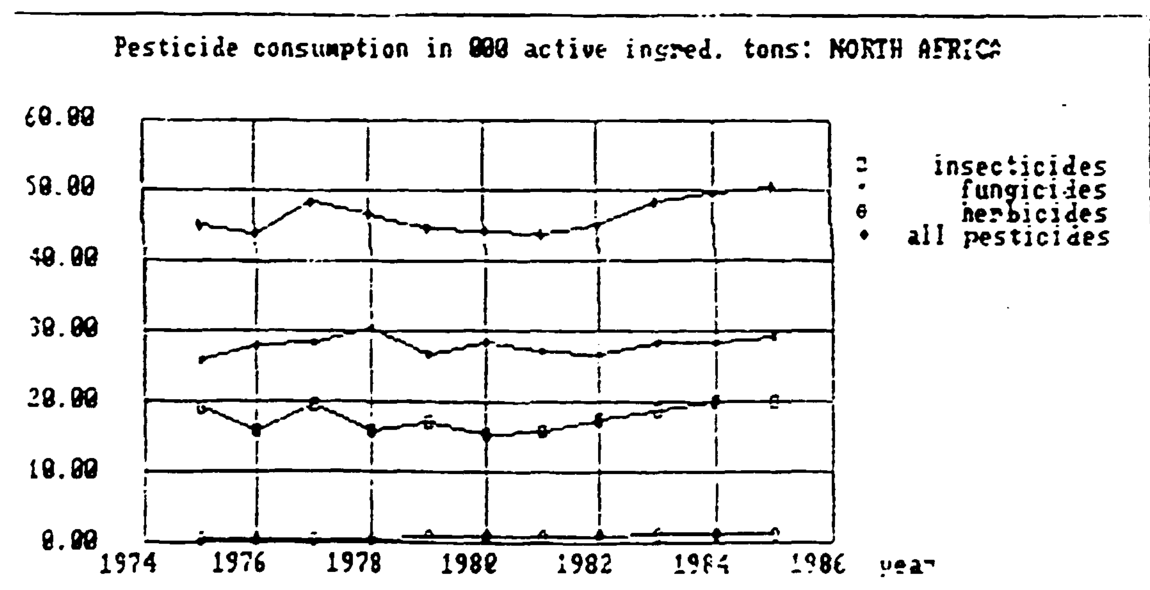


Table 6

Classification of African countries according to their pesticide manufacturing facilities

1. Countries without manufacturing facilities

Angola	Mozambique
Benin	Namibia
Botswana	Niger
Central African Rep.	Senegal
Equatorial Guinea	Somalia
Gabon	Togo
Gambia	Uganda
Guinea	Western Sahara
Malawi	Zambia
Mali	
Mauritania	

2. Countries with formulation plants

Burundi	Libyan Arab Jamahiriya
Cameroon	Madagascar
Ethiopia	Morocco
Egypt	Nigeria
Ghana	Tanzania
Kenya	Tunisia
Liberia	Zaire

3. Countries with pesticide chemical production of their own

Algeria

Zimbabwe

Table 7

Main products/Cash crops	Country
Alfa-grass	L, Mc
Apricot	Tu
Banana	I, Lr, So, U, Ca, Gu, Ga
Barley	A, E, Mc, Se, So, To, Tu, U, Cd
Bean	Eg, K, S, To, U
Citrus	A, E, Eg, L, Mc, Tu
Coco	Mr, Ma, Se
Cocoa	E, G, I, N, Lr, To, Ca
Coffee	E, I, N, K, Lr, Ma, To, U, Ca
Cotton	E, A, I, Eg, N, K, S, Cd, Gu, M, So, To, U, C, Cn, An
Dates	A, Eg, S, L, Mr, Mc, Se, Tu, Cd
Grapes	A, E, L, Mc, Tu
Ground-nuts	N, K, S, L, M, Ni, Se, To, U, C, Ca, Cn, Cd, Gu, Ga, Gm, So
Maize	E, Eg, N, K, Lr, M, Mr, So To, U, C, Ca, Cn, An, Cd, Ga, Gm
Millet	E, L, N, S, So, To, Gm
Oat	Tu
Olives	A, Eg, L, Mc, Tu, An
Oranges	A, I, Mc, Tu, Gu
Pea	Tu
Peach	Tu
Palm oil	I, N, Lr, Ni, Se, To, Ca, Cn, An, Gu, Ga, Gm
Pine-apple	I, K, S

Main products/Cash crops	Country
Potato	A
Pyrethrum	K, Ta, Eq, U, Rw, Cn
Rice	Eg, Lr, M, To, C, Cd, Gu, Gm
Sesame	S, So, U, Gu
Sisal	K, An
Sorghum	Eg, N, K, S, Lr, M, Mr, Mc, C, Cn, Cd
Sugar-cane	A, An, K, Lr, Ma, S, So, U
Tea	K, Ma, U
Tobacco	A, E, K, L, Ma, U, Z
Tomato	A, Eg, Tu
Vegetables	A, Eg, Mc
Wheat	A, E, Eg, K, L, Mc, S, Tu

Abbreviations:

A =Algeria
An=Angola
B =Benin
Ca=Cameroon
C =Central African Republic
Cd=Chad
Cn=Congo
Eg=Egypt
E =Ethiopia
Eq=Equador
Ga=Gabon
Gm=Gambia
G =Ghana
Gu=Guinea
I =Ivory Coast
K =Kenya
Lr=Liberia
L =Libya
M =Mali
Ma=Mauritius
Mr=Mauritania
Mc=Morocco
Ni=Niger
N =Nigeria
Rw=Rwanda
Se=Senegal
So=Somalia
S =Sudan
Ta=Tansania
To=Togo
Tu=Tunesia
U =Uganda
Z =Zimbabve

Table 8

Type of pest control action reported for botanical species (10)

Pest control action	Number of species
Insecticidal	1053
Fungicidal	100
Nematocidal	58
Rodenticidal	29
Herbicidal	14
Molluscicidal	29
Bactericidal	4
Acaricidal	2
Antifeedant	230
Repellent	225
Fish poison	147
Dart/arrow poison	90
"Poisons"	69
Antiseptic	35
Growth inhibitor	32
Attractant	26
Chemosterilant	1
Total	2121

Table 9

Symbols for explanation of Table 9

Plant habit:

(A) Life cycle:1=perennial; 2=biennial; 3=annual

(B) Plant type:1=tree; 2=shrub; 3=woody climber; 4=vine; 5=herb.

(C) Plant habitat:1=tropical; 2=sub-tropical; 3=temperate; 4=semi-arid; 5=arid 6=marsh

Input needs:

(D) Fertilizer (kg/ha):1=nil; 2=upto 10; 3=11-25

(E) Water (above normal rainfall):1=Nil; 2=low amount; 3=medium amount

(F) Labor:1=Nil; 2=low; 3=medium

(G) Space needed to grow the botanical species to protect one ha of crop (square meters):1=5; 2=10; 3=25; 4=50; 5=100; 6=250; 7=500; 8=1000; 9=2500; 10=5000; 11=10,000

Characteristics of the pest control material:

(H) Type of activity:1=contact poison; 2=stomach poison; 3=growth inhibitor; 4=antifeedant; 5=repellent; 6=attractant; 7=fungicidal; 8=nematocidal

(I) Dilution at which pest control material is effective: 0=not applicable; 1=1:2; 2=1:5; 3=1:10; 4=1:100; 5=1:1000; 6=1:10,000; 7=1:100,000

(J) Parts of plant used for pest control purposes: 1=whole plant; 2=root; 3= bulb/corm; 4=bark; 5=wood; 6=stem; 7=leaves; 8=flowers; 9=fruit; 10=seed

(K) Duration for which control action lasts:1=as long as the botanical species living; 2=seasonal; 3=2 month or more; 4=2 to 1 month; 5=2 weeks; 6=1 week; 7=2-3 days; 8=1 day or less

Preparation and use of pest control material:

(L) Method of preparation: 1=Nil (no preparation needed); 2=drying; 3=aqueous extract; 4=grinding; 5= pressed or distilled for oil; 6=chemical extraction

(M) Method of application: 1=planting only; 2=mixed with bait; 3=surface spreading; 4=mulching; 5=dusting; 6=spraying

(N) Equipment needed for formulation: 1=none; 2=can be improvised by farmer; 3=can be fabricated in village; 4=needs expenses beyond the means of the small-holding farmer; 5=needs a laboratory for formulation.

(O) Skills needed for preparation/application:1=farmer can prepare and apply himself; 2=skills can be easily imparted to the farmer ; 3=some complex skills needed; not all farmers can master these; 4=needed skills are beyond the capabilities of the average small-holding farmer in developing countries

Environmental impact:

(P) Toxicity to higher animals and man: 1=not known toxicity; 2=suspected toxicity; 3=known to be toxic

(Q) Cautions needed in use: 1=no known adverse environmental effect; 2=plant is a host to pests; 3=plant is a reservoir of plant pathogens for insect vectors; 4=plant adversely affects soil properties; 5=plant is potential weed; 6=plant has other adverse effects

Economic value:

(R) Other uses of the plant:0=Nil; 1=provides food for man; 2=provides fodder; 3=source of fibre; 4=source of building material; 5=source of medicines/drugs; 6=source of energy; 7=controls erosion; 8=fixes nitrogen; 9=used as an ornamental plant; 10=has other economic uses

Table 9

Range in characteristics of selected plant species and of their pest control materials (11)

Characteristics

Family and Species	Plant growth: Plant species A	B	C	Input needs D	E	F	G	Pest control materials: Characteristics H	I	J	K	Preparation & use L	M	N	O	Environmental and economic impact value P	Q	R
ACANTHACEAE																		
Adhatoda vasica	1,3	2	1,2	2	1	2	?	4,5	2	2,7	1	2,3	1,2	1,3	1	1	1	5
(Malabar nut)										10		4	5,6					
AMARYLLIDACEAE																		
Agave americana	1	2	1,3	2	1	1,2	1,11	1,2	2	1,2	7	3,6	5	1	1	1	1	5
(Century plant)										7								
ANACARDIACEAE																		
Anacardium occidentalae (Cashew tree)	1	1	1	?	2	2	?	5	?	6	?	5	?	1	1	3	1,2	1
Rhus coriaria (Sumac)	1	2	1	?	?	?	?	1	?	7	?	2	4	1,2	1	1	1	10

Family and Species	Plant growth							Pest control materials								Environmental and economic impact value		
	Plant species			Input needs				Characteristics				Preparation & use						
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
ANNONACEAE																		
Annona reticulata (Custard apple)	1	1	1,2	?	?	1,2	1	1,5	?	7,9	?	2,3 4	6	1	1	1,2	2,5	1
Annona squamosa (Sugar apple)	1	1	1,2	?	1	1,2	1	1,2	?	2,7 9	?	3,4	6	1	1	1	2	1
APOCYNACEAE																		
Haplophyton cimicidum (Mexican cockroach plant)	1	2	2	?	1	1	?	2	?	7	?	3	2	1	1	?	?	9
ARACEAE																		
Acorus calamus (Sweetflag)	1	2,5	1,3 6	2,3	1,2 3	1,2 3	4,10	1,4 5,6	3	2,3 7	2,4 5	2,3 4,6	5,6	1,5	1,2 3,4	1,3	1	5 10
Amorphophallus campanulatus (Telingo potato)	1	5	1,3	?	?	?	1	7	?	7	?	3	?	1	1	3	1	1

	Plant growth							Pest control materials								Environmental and economic impact value		
Family and	Plant species			Input needs				Characteristics				Preparation & use						
Species	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
ASCLEPIADACEAE																		
Calotropis gigantea (Crown plant)	1,3	1,2	1	1	1	1	1	2,3	6	1,7	2	3,4 6	3,5	1,5	1,3	1,3	1	1,5
ASTERACEAE																		
Chrysanthemum cinerariae folium (Pyrethrum)	1	2	1,2 4,5	3	3	3	5	1,5	4	8	5,7	2,4 6	5,6	2,5	2,4	1	1	?
ERICACEAE																		
Rhododendron molle (Yellow azalea)	1	2	1,3	?	1,2	1,2	?	1,2	?	1,7 8	?	3,4	6	1	1	?	5	?
FLACOURTIACEAE																		
Ryania speciosa (Ryania)	1	1,2	1	1,2	1,2	1,3	1	' ?	3	2,6	7,8	3,4	5,6	1	1,4	1	1	9

Family and Species	Plant growth							Pest control materials								Environmental and economic impact value		
	Plant species			Input needs				Characteristics				Preparation & use						
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
GUTTIFERAE																		
Mammea americana (Mamey tree)	1	1	1	?	?	?	?	5	?	10	8	3	?	1	1	1	1	1
LEGUMINOSAE																		
Derris elliptica (Derris)	1	2	1	2	2	2,3	2	1,2 5	4	2,7	6	3,4 6	5,6	2	1,2 4	1,3	1	5
Derris malaccensis	1	2,4	1	1	1,2	1,3	3	1,2 5	4	2	6,7	3,4	5,6	2	1,2	3	1	7
Gliricidia sepium (Madre)	1	1	1	1	2	2	11	4	1	1	6	1	4,6	1	1	3	5	8
Piscidia erythrina (Jamaica dogwood)	1	1	1	?	1	1	?	1,2	?	2,4	?	3,4	5	1	2	?	?	8
Pongamia glabra (Puna oil tree)	1	1	1	2	1	1	1	4,5	4	9,10	3,6	4,6	5,6	1,3	1,4	1	1	5,6

	Plant growth							Pest control materials								Environmental and economic impact value		
Family and	Plant species			Input needs				Characteristics				Preparation & use						
Species	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
Tephrosia vogelii	1	2	1	?	1	1	3	?	4	7	6,7	3	6	1,2	1	3	6	10
(Vogel tephrosia)																		8
MELIACEAE																		
Azadirachta	1	1,2	1,2	1,2	1,2	1,2	1,2	1,3	7	1,7	3,5	2,3	3,4	1,2	1,2	1	1,2	2,4
indica			4,5				3,4	4,5		9	6,7	4,5	5,6	3,5	3			5,6
(Neem tree)							10	7,8		10		6						
Melia azedarach	1	1	1,3	1,2	1,2	1,2	2,3	1,4	?	7,9	1,5	2,3	5,6	1,2	1,2	1,2	1,2	2,5
(Chinaberry)								5		10	6			3				6
										12								
PIPERACEAE																		
Piper betle	1	3	1	?	1	1	?	2	?	2,7	?	4	5	1	1,2	?	?	5
(Betel pepper)																		
RUTACEAE																		
Atalantia																		
monophylla	1	1	1,3	3	3	2	9	5	2	6,7	2	2	4	1	2	1	2	1
(Lime)																		

Family and Species	Plant growth							Pest control materials								Environmental and economic impact value		
	Plant species			Input needs				Characteristics				Preparation & use						
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
SAPINDACEAE																		
Sapindus marginatus (Florida soapberry)	1	1	1	2	1	1	?	4,5	?	10	8	4	3,5	1	1	?	1	9
SIMAROUBACEAE																		
Quassia amara (Bitter wood)	1	1,2	1	1	1	2	?	1,2 3,4	?	4,5	?	4,6	3,5 6	3,5	1,4	1	5	5
VERBENACEAE																		
Lantana camara (Yellow sage)	1	2	1,4	2	1	1	5	1	?	7,8	4,7	3,4	5,6	1,2	1	1,2	1	5
Vitex negundo (Indian privet)	1	1,2	1	1,2	1	1,2	?	1,3	6	7,11	2	3,6	3,6	1,5	1,3	1,3	1	0,5

Table 10

Pests reportedly controlled by selected plant species
(Based on literature search and survey, 11)

ACANTHACEAE Adhatoda vasica Nees. (Malabar nut)

Controls: Rhisopertha dominica (Lesser grain borer), Sitotroga cerealella (Angoumois grain moth), Tribolium castaneum (Red flour beetle),

AMARYLLIDACEAE Agave americana L. (Century plant)

Controls: Sitophilus oryzae (Rice weevil)

ANACARDIACEAE Anacardium occidentale L. (Cashew tree)

Controls:Sitophilus granarius (Grain weevil)

Rhus coriaria L. (Sumac)

Controls: Phylloxera viticolae (Wooly aphid)

ANNONACEAE Annona reticulata L. (Custard apple)

Controls: Macrosiphoniella sanborni (Chrysanthemum aphid)

Annona squamosa L. (Sugar apple)

Controls: Brevicoryne brassicae (Cabbage aphid), Bruchus chinensis (Pulse beetle), Coccus viridis (Green scale), Dysdercus koenigii (Cotton stainer), Luproctis fraterna (Hairy caterpillar), Nilaparvata lugens (Brown planthopper), Oryzaephilus surinamensis (Sawtooth grain beetle), Plutella xylostella (Diamondback moth), Sogatella furcifera (White backed planthoppper), Spodoptera litura (Common cutworm, tobacco caterpillar)

APOCYNACEAE Hyplophaton cimicidum ADC. (Mexican cockroach plant)

Controls: Anasa tristis (Squash bug), Epicauta vittata (Striped blister beetle).Laspeyresia pomonella (Codling moth) Leptinotarsa decemlineata (Colorado potato beetle), Ostrinia nubilalis (European corn borer). Pieris rapae (Imported cabbage worm), Spodoptera eridania (Souther armyworm)

ARACEAE Acorus calamus L. (Sweet flag)

Controls: Bruchus chinensis (Pulse beetle), Ceratitis capitata (Mediterranean fruitfly) Dysdercus cingulatus, D. koenigii (Cotton stainers), Lipaphis erysimi (Turnip aphid), Pericallia ricini (Wooly bear), Rhyzopherta dominica (Lesser grain borer), Sitotroga cerealella (Angoumois grain moth)

Amorphophallus campanulatus (Roxb.) Bl.et Dec. (Telingo potato)

Controls: Helminthosporium oryzae (Brown spot of rice fungus), Pyricularia oryzae (Rice blast fungus)

ASCLEPIADACEAE Calotropis gigantea L. R. Br. (Crown plant)

Controls: Sitophilus oryzae (Rice weevil)

ERICACEAE Rhododendron molle G. Don (Yellow azalea)

Controls: Lepidoptera spp.,Scirpophaga incertulas (Yellow stem borer)

FLACOURTIACEAE Ryania speciosa Vahl. (Ryania)

Controls: Argyria strictictraspis (Sugarcane borer), Diaphania hyalinata (Melon worm), Laspeyresia pomonella (Codling moth), Ostrinia nubilalis (European corn borer) Pseudalelia unipunctata (Army-worm)

GUTTIFERRAE Mammea americana L. (Mamey tree)

Controls: Andrector ruficornis (Beetle), Ascia monuste (Great white cabbage worm), Cerotoma ruficornis (Bean beetle), Diabrotica bivittata (Striped cucumber beetle), Diaphania hyalinata (Melonworm), Macrosiphum sonchi (Aphid), Mysus persicae (Peach aphid), Pachyzanela bipunctalis (Southern beet webworm), Peridromia saucia (Variegated cutworm), Pieris rapae (Imported cabbage worm), Prodenia unipuncta (Armyworm), Sitophilus oryzae (Rice weevil), Spodoptera eridania (Southern armyworm)

LEGUMINOSAE Derris elliptica (Wall.) Benth (Derris)

Controls: Aphis rumicis (Black bean aphid), Ceratitis capitata (Meditrranean fruitfly), Daus spp. (Fruitfly) Lepidoptera spp., Melophagus ovinus, Rhodinius prolixus nymphs, Spodoptera litura (Common cutworm, tobacco caterpillar), Thermobia domestica

Derris malaccensis Lour. (Derris)

Controls: Aphis rumicis (Black bean aphid), Ceretitis capitata (Mediterranean fruitfly), Crocidolomia binotalis (cabbage leaf webber), Dacus spp. (Fruitfly), Henosepilachna sparsa (28 spotted ladybird beetle)

Gliricidia sepium(Jacq.)Walp. (Madre)

Controls: Diacrisia virginica (Yellow wooly bear), Heliothis armigera (Corn earworm), Spodoptera eridiana (Southern armyworm), Trichopulsia ni (Cabbage looper)

Piscidia crythrina L. (Jamaica dogwood)

Controls: Diaphania hyalinata (Melonworm), Dysdercus cingulatus (Cotton stainer), Pachyzanela bipunctalis (Southern beet webworm),Hymenia recurvalis (Hawaiian beet webworm)

Pongamia glabra Vent. (Puna oil tree)

Controls: Rhyzopertha dominica (Lesser grain borer), Sitotroga cerealella (Angoumois grain moth), Spodoptera litura (Common cutworm, tobacco caterpillar)

Tephrosia vogelii Hook. (Vogel tephrosia)

Controls: Aphis citri (Citrus aphid), Crocidolomia binotalis (Cabbage leaf webber), Henosepilachna sparsa (28-spotted ladybird beetle), Orgyia antiqua (Vapour moth)

MELIACEAE Azadirachta indica A.Juss (Neem tree)

Controls: Amsacta moorei (Red hairy caterpillar), Aphis gossypii (Cotton aphis), Bruchus chinensis (Pulse beetle) Chirida bipunctata (Tortoise beetle), Cnaphalocrocis medinalis (Rice leaf folder), Crocidolomia binotalis (Cabbage leaf webber), Dysdercus cingulatus (Cotton stainer), Euproctis fraterna (Hairy caterpillar), Ephestia kühniella, Ephestia cautella, Heliothis armigera (Corn earworm), Leucinodes orbonalis (Brinjal fruit borer), Locusta migratoria (Migratory locust), Myllocerus spp. (Citrus leaf weevile), Nephantis scrinopa (Black coconut caterpillar), Nephotettix virescens (Rice green leafhopper), Nilaparvata lugens (Brown planthopper), Phyllocnistis citrella (Citrus leaf miner), Phyllotreta downsei (Radish flea beatle), Pratylenchus delattrei (Root lesion nematode), Rhizopertha dominica (Lesser grain borer), Schistocerea gregaria (Desert locust), Sitophilus oryzae (Rice weevil) Sitotroga cerealella (Angoumois grain moth), Spodoptera frugipedra (Fall armyworm), Spodoptera litura (Common cutworm, tobacco caterpillar), Sogatella furcifera (White-backed planthopper), Scirpophaga (Tryporyza) incertulas (Yellow steam borer), Tribolium castaneum, Tribolium confusum

Melia azedarach L. (Chinaberry)

Controls: Brevicoryne brassicae, Diaphorina citri (Asiatic citrus psyllid), Heliothis zea (Corn earworm), Ephestia cautella, Lipaphis erysimi (Turnip aphid), Locusta migratoria (Migratory locust), Myzus persicae (Peach aphid), Nephotettix viresvens (Rice green leafhopper), Nilaparvata lugens (Brown planthopper), Orseolia oryzae (Rice gall midge), Pieris brassicae (Cabbage white butterfly) Sogatella fructifera (White-backed planthopper), Spodoptera abyssina (Rice noctuid), Spodoptera frugiderda (Fall armyworm), Scirpophaga incertulas (Yellow stem borer)

PIPERACEAE Piper betle L. (Betel pepper)

Controls: Diaphania hyalinata (Melonworm), Dysdercus cingulatus (Cotton stainer)

RUTACEAE Atalantia monophylla DC. (Lime)

Controls: Sithophilus oryzae (Rice weevil), Sitotroga cerealella (Angoumois grain moth)

SAPINDACEAE Sapindus marginatus Wild. (Florida soapberry)

Controls: Rhyzopertha dominica (Lesser grain beetle), Sitotroga cerealella (Angoumois grain moth)

SIMAROUBACEAE Quassia amara L. (Bitter wood)

Controls: Athalia proxima (Mustard saw-fly), Heliothis virescens (Tobacco budworm), Locusta migratoria (Migratory locust), Agrotis ipsilon (Black cutworm)

VERBENACEAE Lantana camara L. (Yellow sage)

Controls: Aphis rumicis (Black bean aphid), Athalia proxima (Mustard saw-fly), Lipaphis erysimi (Turnip aphid), Ostrinia furnicalis (Asian corn borer), Sitophilus oryzae (Rice weevil)

Vitex negundo L. (Indian privet)

Controls: Achaea jana[illegible] (Croton caterpillar), Bruchus chinensis (Pulse beetle), Diacrisia obliqua (Jute hairy caterpillar), Luproctis fraterna (Hairy caterpillar), Patheticus oryzae (Longheaded flour beetle), Pericallia ricini (Woolly bear), Sitotroga cerealella (Angoumois grain moth), Spodoptera litura (Common cutworm, tobacco caterpillar), Scirpophaga incertulas (Yellow stem borer).

Table 11

Summary on works done on use of neem parts or products for protection against stored grain pests (13)

Neem part or product (dose/conc)	Commodity	Insect pest	Reference
		Leaves	
8.0 %	Cacao beans	Ephestia cautella	Fry and Sons, 1938
10.0 %	Sorghum seeds	Sitophilus (Calandra) oryzae Linn	Krismamurthi, Rao, 1950
2.0 %	Wheat	Tribolium castaneum	Atwal, Sandhu,1970
1.0, 4.0, 8.0/100 parts of seeds W/W	Wheat	Sitotroga cerealella	Teotia,Tiwari,1971
	Wheat	Rhizopertha dominica	Zaz,Bharadwaj,1976
1.0 %	Wheat	Trogoderma granarium Everts	Bains, Battu, Attwal,1977

Neem part or product (dose/conc)	Commodity	Insect pest	Reference
Neem seeds or kernel powder			
0.5, 1.0, 2.0/100g seed	Wheat	T. granarium Everts	Jottwani,Sirear,1965
2.0/100g seed	Wheat	R. dominica (Fabr)	
		S. oryzae Linn	"
0.5, 1.0, 1.5, 2.0 2.5g/100g of seeds	Sorghum	S. oryzae Linn	Desphande,1967
2.0 %	Wheat	T. castaneum Herbst	Atwal,Sandhu,1970
2.0 %	Maize	S. oryzae Linn.	Chachoria,Chandrate,
		S. ceralella Oliv.	Ketkar, 1971
0.5, 1.0 and 2.0 %	Wheat	T. granarium Everts	Saramma, Verma,1971
0.5, 1.0 and 2.0 %	Wheat	R. dominica (Fabr.)	Girish, Jain, 1974
4.0/100 g of seed	Wheat	T. granarium Everts	"
0.5, 1.0 and 2.0 %	Paddy	S. scerealella Oliv.	Nair, 1975
0.25, 0.5	Paddy	R. dominica (Fabr.)	Savitri,1975
0.75, 1.0, 2.0	"	S. orizae Linn. and	"
3.0, 5.0 %	"	S. cerealella Oliv.	"
4.5, 9.0, 18.0 27.0 and 36.0 g/sq ft for impregnation of gunny bags			
0.5. 1.0 and 2.0%	Rice grain	S. cerealella Oliv.	Chelleppa and
		R. dominica (Fabr)	Chelliah,1976

Neem part or product (dose/conc)	Commodity	Insect pest	Reference
0.8 and 2.0%	Jowar, wheat Maize, Bajra, Peas, Bengal gram, Mataki	S.oryzae L. T.castaneum (Herbst.) R.dominica (Fabr.) C.maculatus (Fabr.) Laemophlocus minutus (Oliv.) and Latheticus oryzae (Waterh)	Ketkar, Kale and Tapkire, 1976
1.0 and 2.0%	Wheat	S.oryzae L.	Satpathy, 1976
2.0%	Hybrid sorghum and cowpea	S.oryzae L.	Subramaniam, 1976
2%	Mung	Bruchus sp.	Talati, 1976
-	Wheat	R.dominica (Fabr.)	Zaz and Bharadwaj 76
1%	Wheat	T.granarium(Herbst.)	Bains, Battu & Attval 1977.
Extracts of Neem (seeds, leaves, flower and fruits)			
	Wneat flour	R.dominica (Fabr.)	Jilani&Munir 1973
Seed extract	Wheat	S.oryzae L. and T.castaneum (Herbst.)	Syed Quadri, 1973
1.0%	Green gram	C.chinensis L.	Balasubramanian, 1977

Neem part or product (dose/conc)	Commodity	Insect pest	Reference
		Neem oil	
2.0%	Bengal gram	Callosobruchus sp.	Anonymus,1973-74
10, 20, 40, 60 80 and 100 ml/sq.ft.	Paddy	R.dominica (Fabr.)	Savitri, 1975
1.0%	Green gram	Pulse beetle	Jayaraj, 1976
2.0%	Mung	Bruchus sp.	Talati, 1976
8 g oil inside gunny bag of size 20.5 x 15.5 cm	Jowar, Wheat Maize, Bajra Peas, Bengal gram, Mataki,	Rice weevil, red-flour beetle and larvae and long headed flour beetle	Ketkar, Kale and Tapkire, 1976
Aqueous extract of deoiled neem seed as stabilizing effect of pyrethrins		T.castaneum (Herbst.)	Ahmed and Gupta, 1976 Ahmed, Gupta and Bhavanagary, 1976
Neem oil extractive 1.0% emulsion	Maize Green gram	Sitophilus oryzae L. Callosobruchus sp.	Ravi Prasad, 1979

Table 12

Natural pyrethrin products

Firm/Company	Name of product	Active ingredients
Antec AH International Ltd., England	Flydoxn	pyrethrum+ piperonyl butoxide
Chilton Industrial Estate,England	Flydown	pyrethrum+ piperonyl butoxide
Ashe	Vapona Green	pyrethrum
	Arrow Fly Wasp Killet	pyrethrum
Boot's	Boot's Garden Insect Spray	pyrethrum+Lindane
Denka Chemie BV, Holland	Denka Anti Green Fly	pyrethrum+ piperonyl butoxide
	Doggy Insecticides	pyrethrum+ piperonyl butoxide +dezinfectant
	Spritex Super	pyrethrum+ dichlorvos+ piperonyl butoxide

Firm/Company	Name of product	Active ingredients
Fairfield American Corp. An AOSI Company, USA	Aqueous Pyranone	pyrethrum+ piperonyl butoxide
	Food Plant Fogging Insecticide	pyrethrum+ piperonyl butoxide
	Orione	pyrethrum+ piperonyl butoxide silicagel
Frowein GmbH and Co. West Germany	Detmol	pyrethrum+ piperonyl butoxide +bioalletrine+ bioresmetrine+ deltametrine+ permetrine+HCH +methoxichlor
	Detmolin	pyrethrum+ piperonyl butoxide+ chlorpyrophos+HCH+ dichlorvos+ malathion
	Fog	pyrethrum+ piperonyl butoxide+ dichlorvos+ malathion+ methoxichlor+HCH

Firm/Company	Name of product	Active ingredients
W.H. Groves and Family Ltd., England	ULV 400	pyrethrum+ piperonyl butoxide
	Pyrethrum Food Spray	pyrethrum
	Lindane/Pyrethrum	pyrethrum+Lindane
	Filiam Plus	pyrethrum+ piperonyl butoxide +bendiocarb
Killgerm Chemicals Ltd., England	Py-Kill/64	pyrethrum+ synergetic compound
	Py-Kill/13	pyrethrum+ synergetic compound
	Py-Kill/400	pyrethrum synergetic compound
	Pyrethrum Spray	pyrethrum+ synergetic compound
Synchemicals Ltd. England	Py Powder	pyrethrum+ piperonyl butoxide
	House Plant Pest Killer Aerosol	pyrethrum+ resmethrinum

Firm/Company	Name of product	Active ingredients
Turbair Ltd.,	Turbair Flydown	pyrethrum+ piperonyl butoxide
	Turbair Killsect Short Life Grade	pyrethrum+ piperonyl butoxide
	Turbair Super Flydown	pyrethrum+ piperonyl butoxide

Table 13

List of plants having pest control properties (56-85)

Botanical name	Fungi-cide	Insecti-cide	Nemato-cide
Abies balsamea (PINACEAE)		+	
Acorus calamus (ARACEAE)		+	
Actinidia polygoma (ACTINIDIACEAE)		+	
Adhatoda vasica (ACANTHACEAE)		+	
Aerva lunata (AMARANTHACEAE)	+		
Agave americana (AMARYLLIDACEAE)		+	
Ageratumconyzoides (COMPOSITAE)	+	+	
Allium cepa (LILIACEAE)	+		+
Allium sativum (LILIACEAE)	+		+
Amaranthus spinosus (AMARANTHACEAE)	+		
Amorphophallus campanulatus (ARACEAE)	+		
Anabasis aphylla (CHENOPODIACEAE)		+	
Anaearidium occidentale (ANACARDIACEAE)		+	
Anamirta cocculus (MENISPERMACEAE)		+	
Annona cherimola (ANNONACEAE)		+	
Annona reticulata (ANNONACEAE)		+	
Annona squamosa (ANNONACEAE)		+	
Antidesma pentandrum Blanco (STILAGINACEAE)	+		
Anthocephalus chinensis (NAUCLEACEAE/RUIAC.)			+

Botanical name	Fungi-cide	Insecti-cide	Nemato-cide
Arthemisia vulgaris (AOTERACEAE)	+	+	+
Aristolochia elegans (ARISTOLOCHIACEAE)		+	
Aristolochia tagala (ARISTOLOCHIACEAE)		+	
Atalantia monophylla (RUTACAE)			+
Averrhoa bilimbi (AVERHOACEAE)	+		
Azadirachta indica (MELIACEAE)	+	+	
Barleria cristala (ACANTHACEAE)	+	+	+
Basella rubra (BASELLACEAE)	+		
Bidens pilosa (ASTERACEAE)	+		
Bignonia spp (BIGNONIACEAE)	+		
Blumea balsamifera (ASTERACEAE)	+		
Brassica integrifolia (CRUCIFERAE)	+		
Bryophyllum pinnatum (CRASSULACEAE)	+		
Callicarpa candidans (VERBENACEAE)	+		
Callotropis giganteae (ASCLEPIADACEAE)		+	
Capsicum frutescens (SOLANEACEAE)		+	
Carica papaya (CARICACEAE)	+	+	+
Cassia alata (AESALPINIACEAE)	+		
Catharanthus roseus (APOCYNACEAE)	+		
Centella asiaticum (APIACEAE)	+		
Chrysanthemum cinerariae folium (ASTERACEAE)		+	
Chrysanthemum coccineum (ASTERACEAE)		+	

Botanical name	Fungi-cide	Insecti-cide	Nemato-cide
Chrysophyllum oliviforme (SAPOTACEAE)	+		
Clorodendrum siphonantus	+		
Cocos nucifera (ARECACEAE)		+	
Coleus scutellarioides (LAMIACEAE)	+		
Corchorus olitorius (TILIACEAE)	+		
Crassocephalum crepediodes (ASTERACEAE)		+	
Datura metel (SOLANACEAE)	+		
Derris eliptica (LEGUMINOSAE)	+	+	+
Derris heptaphylia (LEGUMINOSAE)		+	
Derris malaccensis (LEGUMINOSAE)		+	
Derris philippinensis (LEGUMINOSAE)		+	
Desmodium zangelicum (FABACEAE)			+
Echinaceae angustifolia (ASTERACEAE)		+	
Echinaceae purpurea (ASTERACEAE)		+	
Eclipta prostata (ASTERACEAE)		+	
Eichorinina crassipes (PONTEPERIACEAE)			+
Eichornia neriifolia (PONTEPERIACEAE)		+	
Eichornia pucherrima (PONTEPERIACEAE)	+		
Elephantopus scaber (ASTERACEAE)		+	
Elephantopus thomentosus (ASTERACEAE)		+	

Botanical name	Fungi-cide	Insecti-cide	Nemato-cide
Enthada phaseoloides (MIMOSACEAE)		+	
Erythroxylon coca (ERYTHROXYLACEAE)	+		
Euphorbia hirta (EUPHORBIACEAE)	+		
Gardenia jasminoides (RUBIACEAE)	+		
Gardenia vulgaris (RUBIACEAE)	+		
Gliricidia sepium (LEGUMINOSAE)	+	+	
Halophyton cimicidium (APOCYNACEAE)		+	
Halophyton crooksii (APOCYNACEAE)		+	
Heliopsis helianthoide (COMPOSITAE)		+	
Heliopsis longipes (COMPOSITAE)		+	
Hibiscus esculentus (MALVACEAE)	+		
Impatiens balsamina (BALSAMINAC.)	+		
Imperata cylindrica (POACEAE)			+
Ipomoea aquatica (CONVOLVULACEAE)	+		
Ipomoea batatas (CONVOLVULACEAE)	+		
Ixora coccinea (RUBIACEAE)	+		
Jatropha gossypifolia (EUPHORBIACEAE)	+		
Jatropha demaltifida (EUPHORBIACEAE)	+		
Lansium domesticum (MELIACEAE)		+	
Lantana camara (VERBENACEAE)		+	
Leucaena leucocephala (MIMOSACEAE)	+		+

Botanical name	Fungi-cide	Insecti-cide	Nemato-cide
Leucosyke capitellota (URTICACEAE)	+		
Lonchocarpus urucu (LEGUMINOSAE)		+	
Lonchocarpus utilis (LEGUMINOSAE)		+	
Mammea americana (GUTTIFERAE)		+	
Melia azaedarach (MELIACEAE)		+	
Mentha arvensis (LAMIACEAE)	+		
Mikania cordata (ASTERACEAE)	+		
Mimosa pudica (MIMOSACEAE)	+		
Mirabilis jalapa (NYCTAGINACEAE)	+		
Moringa oleifera (RUBIACEAE)	+		+
Mussaenda anisophylla (RUBIACEAE)	+		
Nerium indicum (APOCYNACEAE)	+	+	
Nicotiana glauca (SOLANACEAE)		+	
Nicotiana rustica (SOLANACEAE)		+	
Nicotiana tabacum (SOLANACEAE)		+	
Ocimum basamicum (LABIATEAE)		+	+
Pachyrhizus erosus (LEGUMINOSAE)		+	
Phaeanthus ebracteoplatus (ANNONACEAE)		+	
Phyllanthus neruri (EUPHORBIACEAE)	+		
Physostigma venerosus (LEGUMINOSAE)		+	
Piper betle (PIPERACEAE)		+	
Piper nigrum (PIPERACEAE)		+	
Piscidia erythrina (LEGUMINOSAE)		+	
Plumbago auriculata (PLUMBAGINAC.)	+		
Plumbago indica (PLUMBAGINACEAE)	+		
Plumiera acerminata (APOCYNACEAE)	+		
Pogostemon cablin (LAMIACEAE)		+	

Botanical name	Fungi-cide	Insecti-cide	Nemato-cide
Pongamia glabra (LEGUMINOSAE)		+	
Portulaca oleracea (PORTULACEAE)	+		+
Pseudocalymna alliaceum (BIGNONIACEAE)	+		
Pseudoelephantopus apicatus (ASTERACEAE)		+	
Psidium guajava (MYRTACEAE)	+		
Quassia amara (SIMARUBACEAE)		+	
Rhododendron molle (ERICACEAE)		+	
Rhus coriana (ANACARDIACEAE)		+	
Ricinus communis (EUPHORBIACEAE)		+	+
Ryania speciosa (FLACOURTIACEAE)		+	
Samanea saman (FABACEAE)	+		
Sapindus marginatus (SAPINDACEAE)		+	
Schonecaulon officnale (LILIACEAE)		+	
Spilanthes acmella (COMPOSITAE)		+	
Spilanthes oleraceae (COMPOSITAE)		+	
Stachytarpheta jamaiensis (VERBENACEAE)	+	+	
Sterculia foetida (STERCULIACEAE)	+		
Tabernaemontana pandacaqui (APOCYNACEAE)	+		
Tagetes minuta (ASTERACEAE)	+	+	
Tagetes erecta (ASTERACEAE)	+	+	+
Tagetes patula (ASTERACEAE)		+	
Teclea trichopocarpa (RUTACEAE)		+	
Tephrosia virginiana (LEGUMINOSAE)		+	
Tephrosia vogeli (LEGUMINOSAE)		+	

Botanical name	Fungi-cide	Insecti-cide	Nemato-cide
Thevetia peruviana (APOCYNACEAE)		+	
Tinospora rumphii (MENISPERMACEAE)		+	
Tithonia diversifolia (ASTERACEAE)		+	
Tridax procumbens (ASTERACEAE)		+	
Tripterygium forestii (CELASTRACEAE)		+	
Tripterygium vilfordii (CELASTRACEAE)		+	
Xanthoxylum piperitum (RUTACEAE)		+	
Xanthoxylum clava-herculis (RUTACEAE)		+	
Veratrum album (LILIACEAE)		+	
Veratrum nigrum (LILIACEAE)		+	
Vitex negundo (VERBENACEAE)	+	+	
Zebrina pendula	+		
Zingiber officinalae	+		

Appendix II

Figure 1

Basic function of a formulation plant

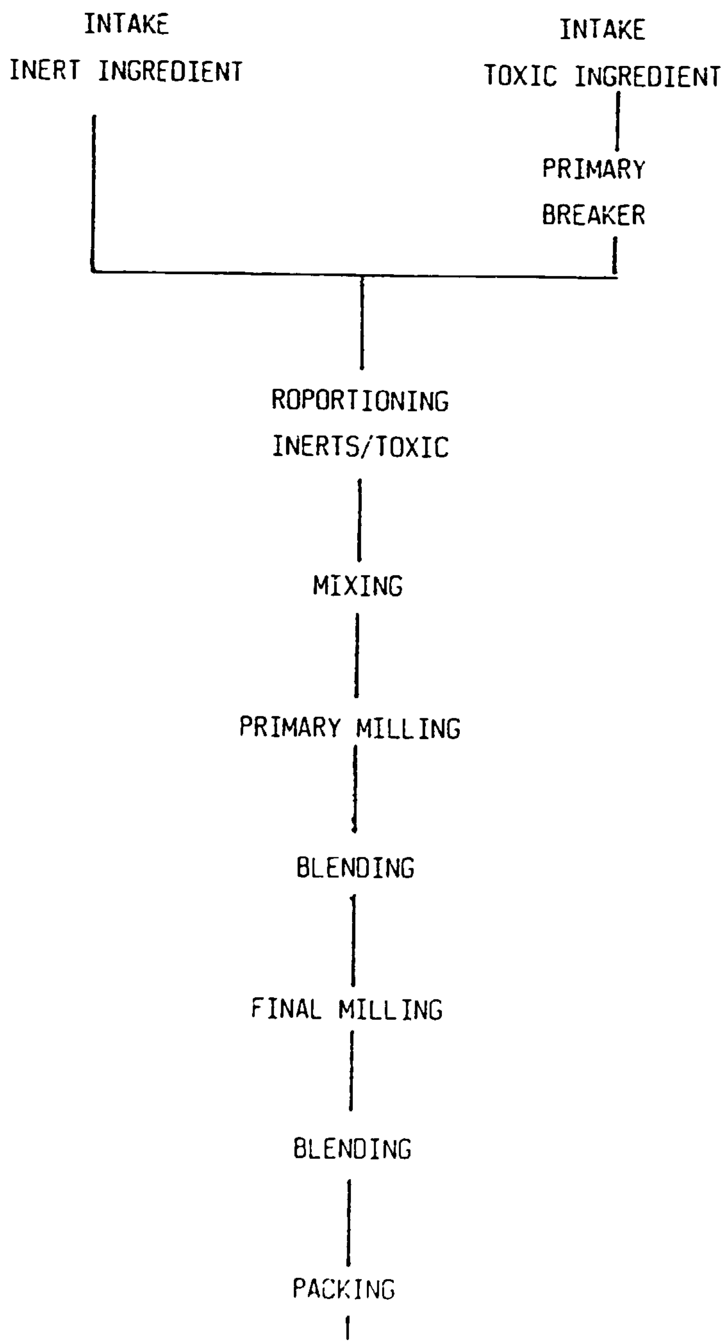


Figure 2

Batch plant for extraction of oil from seeds

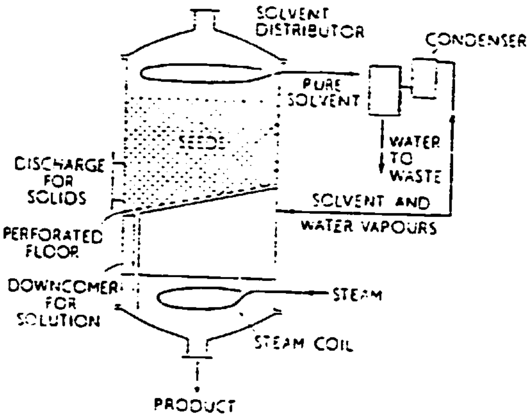


Figure 3

Bollman extractor

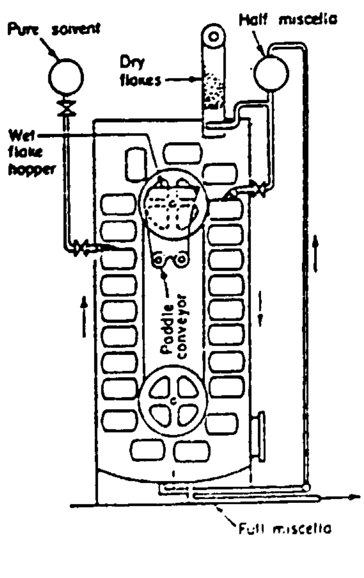


Figure 4

Rotocell extractor

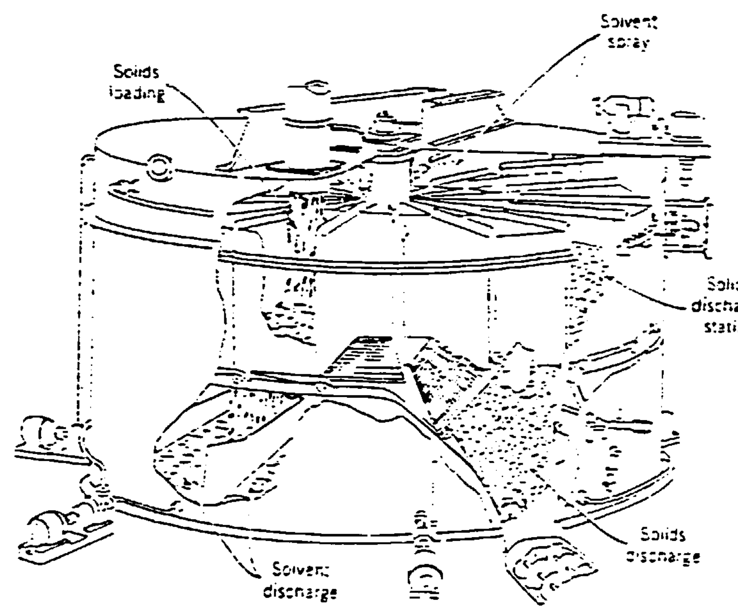


Figure 5

Continuous leaching tank

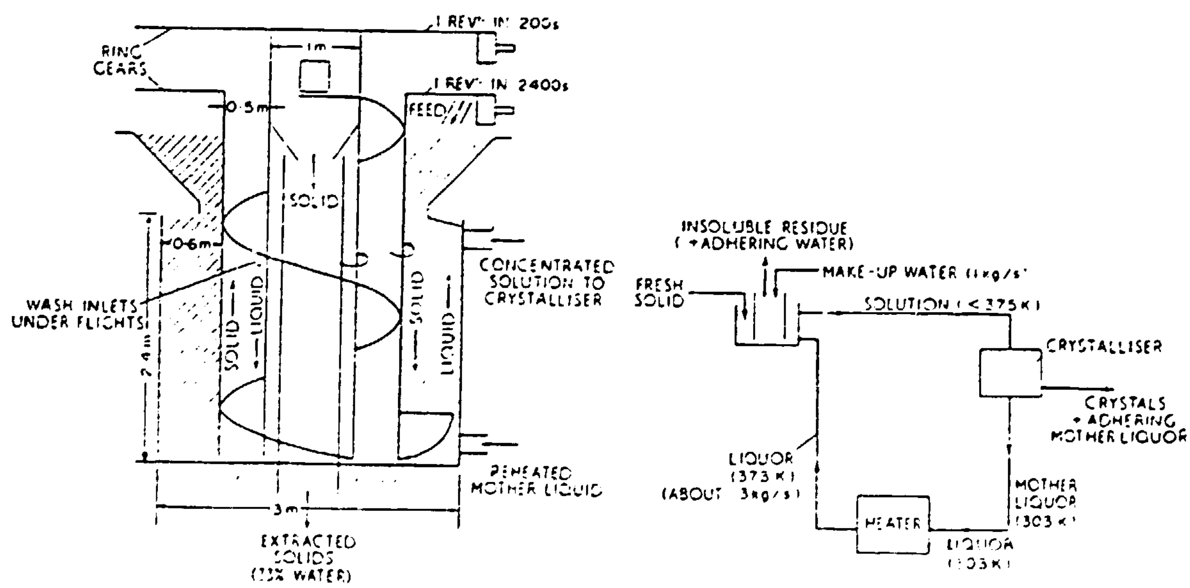


Figure 6
Chamber press

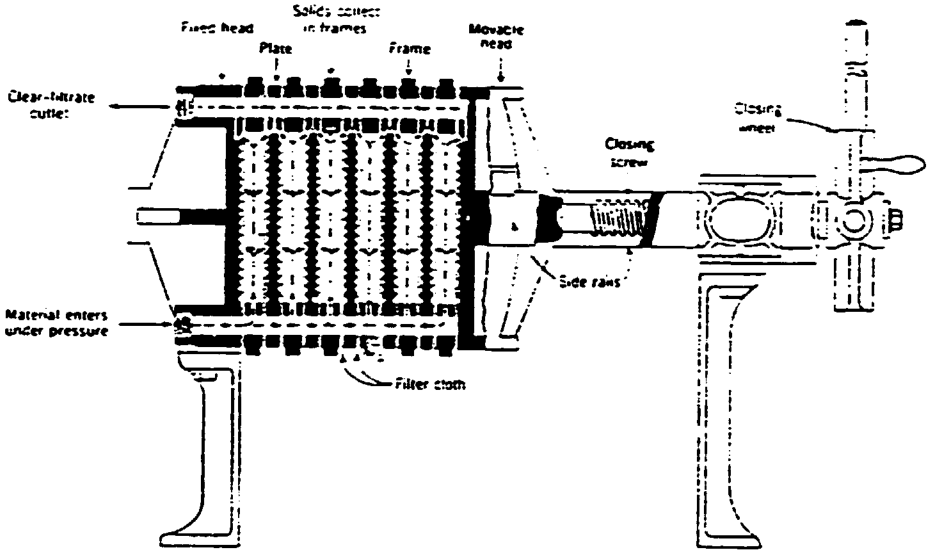


Figure 7

Filter leaf from a Kelly filter

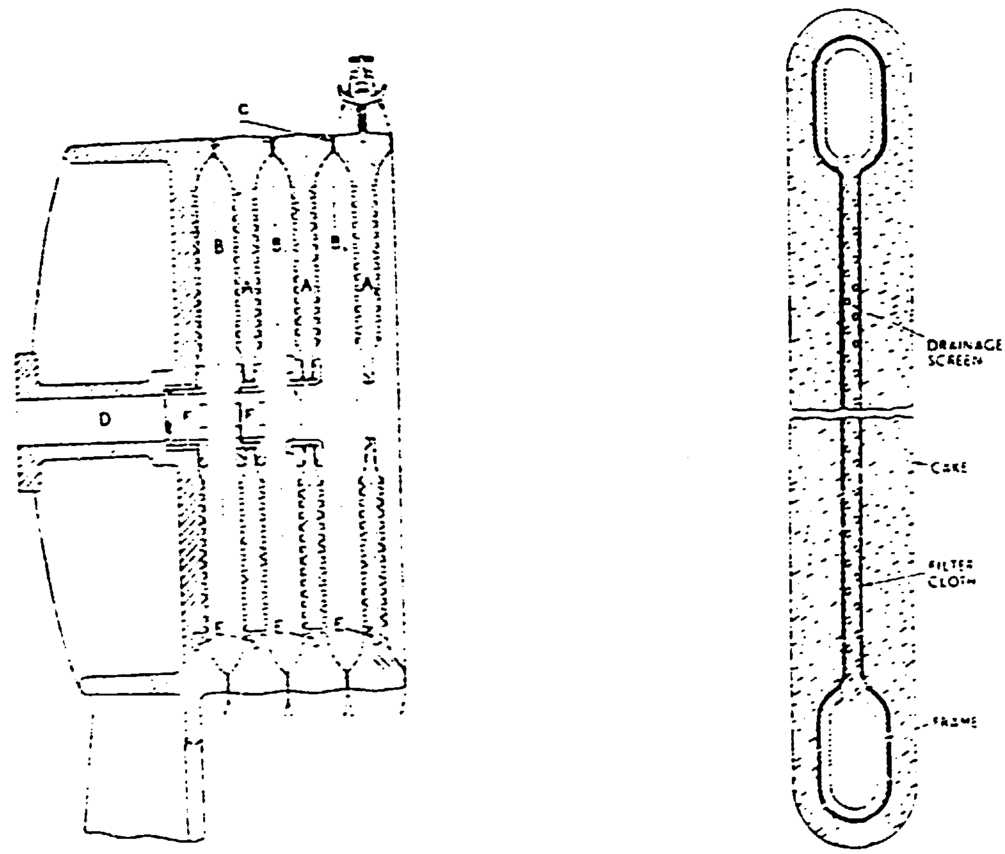


Figure 8
Sweetland filter

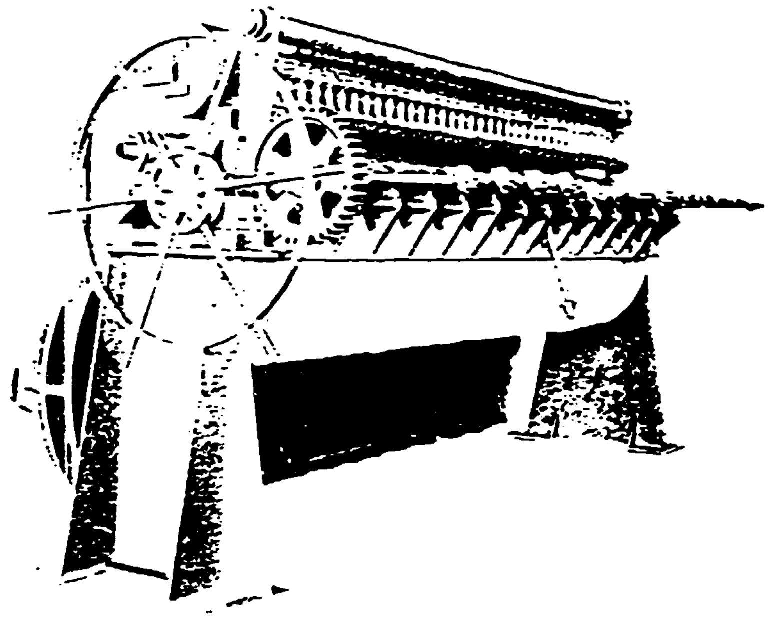


Figure 9
Typical layout of rotary drum filter installation

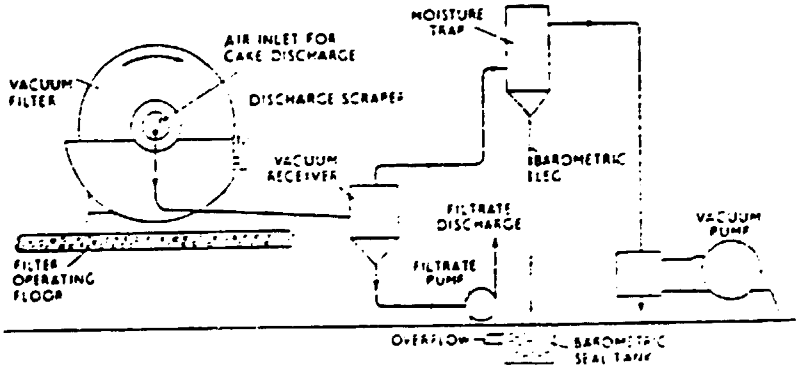


Figure 10

Underdriven centrifuge

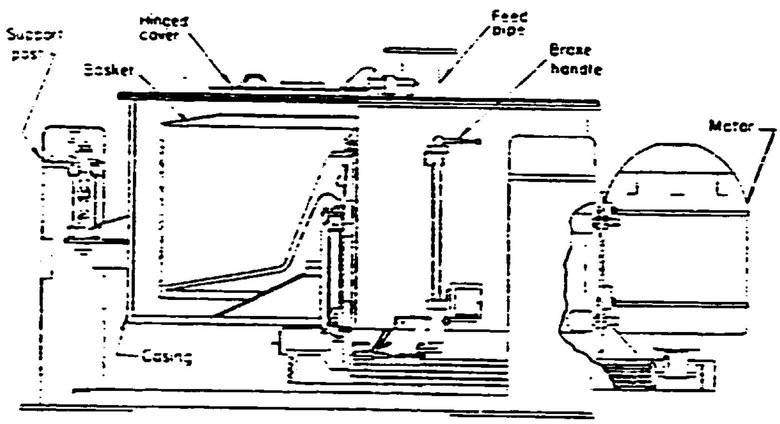
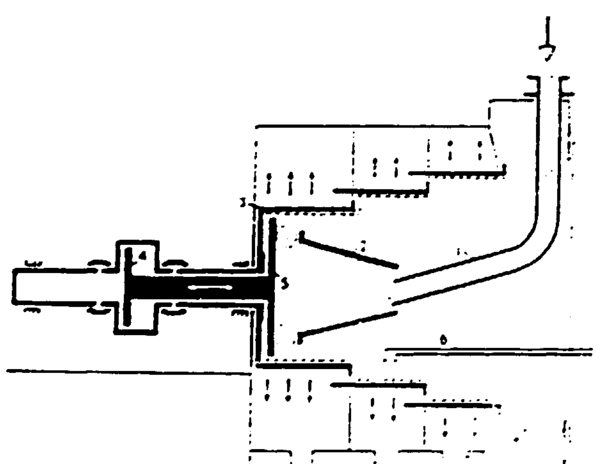


Figure 11

Pusher centrifuge for low concentration slurries



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