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TECHNICAL AND MARKETING ASSISTANCE TO PYRETHRUM PRODUCING COUNTRIES

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RWANDA

Technical report: Survey of the world pyrethrum market and its
med-term tendency, taking account of new competitors*

Prepared for the Government of the Republic of Rwanda
by the United Nations Industrial Development Organization

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* This document has not been edited.

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SUMMARY

Western world pyrethrum supply was as a matter of fact a Japanese monopoly at the beginning of the 20th Century :
Japan blockade, during the Second World War, stopped all exports and induced start-up of replacing crops in Kenya, Tanganyka and Belgium Congo : at present these crops still ensure the almost total world production.

The crops, in Africa, are done by hand, by several ten thousands of small producers, for whom pyrethrum crop represent an important contribution to their annual earnings :
the recent development, quite unknown presently, of large cultivations totally mechanized till the harvesting step, in Australia and South Africa, presume that these 2 countries will appear soon as important and aggressively competing producers, more especially dangerous for traditional African producers as high yield varieties selection work seems to be already actively undertaken.

Improvement of varieties developed in Africa appear as the most urgent priority : it is a must to recover and vulgarize to the farmers clones, which - in 1990 small experimental parcels - had provided exceptionally high yields (reaching to 7.000 kg of fresh flowers per hectare, that is to say equivalent to the best known Australian varieties.

It is an evidence that such yields (based on the harvested weight 5 times more important than the today's harvests) would help pyrethrum cultivations to be competitive face to potatoes cultivations ; they would also grant the factory to obtain more regular and more important supplies, without any need for increasing the per-kilo flowers purchasing price.

World pyrethrum consumption - including all qualities, but more especially in "pale refined extract" quality usable in aerosol formulations - is superior to the figures stated in the S.R.J. Robbins study :
assessed in 1984 as 100 tons/per year of natural pure pyrethrins, this world consumption reach in reality 200 tons/per year (of which 100 tons are for U.S. and 50 tons for Europe needs)

Pyrethrum remain a valued insecticide due to its natural origin and to its rapid effect rarely equalized in terms of "knock-down" and "flushing effect" ; it also is appreciated for its very low toxicity, for the tiny residues remaining after use and for its photolability (which guarantee a safe use) : in spite of a price more expensive than synthetic pyrethrinoid ones, pyrethrum will retain for the coming years the quite special favour of the Anglo-Saxon customers (these people moreover, have agreed for simplified registration files, pyrethrum being considered as "cleared as safe" - as in opposition to the synthetic pyrethrinoids to be submitted to long and costly toxicological tests).

This contribute to protect the actual pyrethrum market in USA, UK and in Germany. But it is advisable to pay attention to the quite recent development of new photolabile synthetic pyrethrinoids - as Tetramethrin and above all the Japan Sumitomo Fralethrin (ETOC), all of them developed by big industrial companies able to invest large sums (at least 2 millions US\$) for the experimental works requested for obtention of the authorization for use in the sectors previously exclusively reserved to natural pyrethrins.

Due to these facts - it is wise - contrarily to some previous reports - not to count on a regular 5% per year increase of the future consumption, but on forecasting that pyrethrum consumption will be maintained at the very most on its present level - which means 200 tons/per year expressed in 100% natural pyrethrins.

For all the African producers, pyrethrum exports are the origin of an important currencies earning and an essential contribution to the socio-economic balance for many thousands of small growers families, in each of these countries. Consequently to remain competitive it is a must for them to adopt the following measures very rapidly (or at least, as soon as the present insecurity conditions, prevailing in some countries as Rwanda, will have disappeared and normal revival of the works will be possible)

- . select clones of new high-yield strains, multiply them and vulgarize them to the growers ;
- . maintain, nearby the growers, a reinforced team of agricultural advisers - with view to keep the interest of the growers for pyrethrum cultivation and to advise them for improving flowers yield harvested by hectare (objective will be to recover high figures realized formerly, i.e. 2.300 fresh flowers per hectare) ;
- . initiate, jointly with the growers, an "observatory point" able to compare the actual agricultural revenues obtained from crops competitive to pyrethrum and this will help for fixing purchase prices at the growers level ;
- . reduce the pyrethrins losses, at every production step
 - controlling permanently the driers temperature and avoiding any super heating point over 60°C,
 - checking that the crushing machines run without notable over-heating,
 - responsabilizing the staff in charge of the extraction work in order to obtain a true respect of the operating rules and especially those concerning the crude extract final concentration.
- . all African producers plants will have as objective to reach, as a minimum, industrial extraction yield in the range of 4,5% crude extract (with a minimum 31% pyrethrin content) with regard to the dried flowers weight put into process :
This is more specially feasible that this yield was reached and sometimes exceeded by many African producers even some of them (as Rwanda) have seen their extraction yields declining during the last years (when it was very difficult, due to local conditions, to handle the process and organize the work at the best) ;
- . obtain financing of a pyrethrum extract security stock, enabling to maintain supplying continuity to the faithful customers, even in case of a bad crop on one year : supplying regularity is a key factor for maintaining natural pyrethrum market stability, as any shortage or price speculation turn definitively a part of the users toward synthetic pyrethrinoids.

For a complete efficiency of pyrethrum processing companies - especially in the case of the Rwandese company - it is recommended to :

- restructure, if necessary, its balance-sheet presentation and transform the public organism into a State company with its own industrial and commercial nature, benefit from more flexibility in the administrative rules and with a financial policy aiming at ensuring maximum independancy with regard to its unique real share-holder, the country State Government,
- focus its interest on pyrethrum activity and possibly to other vegetal products extraction utilizing the same equipments - without approaching, as example, the essential oils plants distillation, which is a completely different technology, :
- . concede to external independent operators all the diversifications - as packaging and distribution of insecticides formulations - this to be done in the frame of contractual agreements for providing the basic insecticide or for establishing links as share-holders in their assets.

I. INTRODUCTION

Cultivation and utilization of *Chrysanthemum Cinerariaefolium* for insecticide purpose go back to the beginning of Christian era in China : then, it has been grown, for the same purpose, in Dalmatia and in Iran, later on in Japan and finally in East Africa.

As a result of the blockade against Japan during World War II, USA need to have alternative sources for pyrethrum flowers sustained the development of new cultivations in Kenya, Tanzania, Zaire, Rwanda.

Since 1960, setting-up of extraction facilities nearby the cultivation areas, in Kenya and Zaire, has allowed to avoid bulky and costly transportation of the flowers to USA and UK - and to avoid losses in the pyrethrin content.

At the same time, Rwanda exported its dried flowers, especially for supplying extraction needs of the neighbouring plants in Kenya (Pyrethrum Board of Kenya at Nakuru) and in Zaire (Société pour le Traitement des Produits Agricoles au Kivu - TRAPAK at Goma).

In 1963 - as Kenya and Zaire refused to buy the Rwandese harvested flowers - an American lady-farmer living in Rwanda succeeded in interesting Rwandese government and UNIDO in order to build an extraction plant at Ruhengeri/Rwanda.

Since 1963, Kenya and Tanzania grew into the 2 most important regular world suppliers for pyrethrum extract. Other countries - as Ecuador and Papouasia-New Guinea - took also an interest in this exploitation, but at a smaller scale.

In 1980 Australia decided to invest in an important research program for improving varieties, and also to introduce mechanized industrial cultivations - whose results appear to be remarkable - more especially as the Australian moderate climate ensure to pyrethrum a short flowering season, which is extremely different from the African countries where flowering is spaced out quite all along the entire year.

In other respects, experimental cultivations have been recorded in different countries - as South Africa, Morocco, but also France, Italy, Spain - as with the moderate climate of the last ones it can be expected, as in Australia, to obtain a short flowering season (which enable mechanized cultivation and harvesting).

At last pyrethrum appears as one of the rare industrial plants whose extraction is carried out by hundreds or thousands tons per year : pyrethrum allows to provide full use in economic conditions for big extracting equipments built formerly for other purposes and frequently partly unused.

When pyrethrum extract international market take a risk to be the purpose of new perturbances

- first, due to the production fluctuations in Africa (Rwanda, as an example, is practically out of any production presently, due to local insecurity) ;
- secondly, due to the imminent arrival of the Australian competition - which seems to have optimized the quality of the cultivated strains and also mastered the parameters of an industrial mechanized cultivation ;
- at last, due to recent homologation of new synthetic pyrethrinoids - which will be very soon accepted for food industries use (notably in USA that were till now, the privileged market field for natural pyrethrum extracts)

UNIDO considered as useful to evaluate the real level of the pyrethrum world consumption and its market mid-term tendency.

Carrying out of this document has given, at the same, an opportunity to make a bibliographic review of most of the scientific documents published on pyrethrum.

All these informations enable producing countries and UNIDO to have at their disposal a unique up-to-date document, gathering all essential informations about pyrethrum, from production till international market survey, including mid-term tendency (this document is indeed a summary of the scientific reports published since 1960 about pyrethrum subject).

This document ought to contribute to decision making about pyrethrum production policies for the coming years : in the hope that it will be a useful tool at the time to decide the objectives to be fixed

- in terms of improvements to bring at the different steps to ensure rentability and competitiveness in pyrethrum exploitations ;
- in terms of staff training programs (with view to improve cultivations methods and to better master the industrial parameters - from the flowers drying till obtention of the final extract) ;
- in terms of marketing policy for the crude or refined extracts produced.

N.B. - It has not been always possible to obtain from some countries their specific statistical datas actualized

- . either for commercial secrecy reasons, in order to protect themselves against other producers competition,
- . or, more frequently, because the imported quantities are too small in terms of tonnage to justify a specific custom statistic number - and this has conducted some countries to include recently pyrethrum in larger statistical groups including other products (and evidently, in this case, figures are not usable for the particular pyrethrum purpose).

This explain why specific figures reported in this document seem sometimes aged by some years - but in this particular case, contacts established with the pyrethrum market international specialists have allowed to collect competent opinions and to include in this report their guidances which can be considered as usable and reliable (on the contrary, it is advisable to consider with prudence the customs statistical datas collected, as these can include notable errors as a following to wrong seizure of the information : it explains why, as far as possible, it is recommended to compare and cross the figures between export producers statistics and import buyers statistics - but it is rare to obtain complete access to them.

2. THE PYRETHRUM PLANT

2.1. History

Pyrethrum is very probably one of the oldest plants to be known with an insecticide effect : it is already mentioned, during the first century of the Christian era, in a famous Chinese book named CHOU-LI (collection of the rites and handy informations for the use of CHOU dynasty government members).

Since 1500, its use began to be widespread under different brand-names frequently related

- either to the country of origin : as "Persian powder", "Caucasian powder", "Kraille powder", "Mismake powder",
- or to its claimed effects : as "Powder against bugs", "Ferrand or Ferry or Vicat insecticide powder", "Julien morto-insecto".

At the beginning of the 19th Century, everyone still knew the traditional use of an insecticide powder, named "Persian powder", which was simply a mix of crushed flowers from *Chrysanthemum roseum* and *carneum*.

Around 1920 - 1925, thanks to Fryer, Tattersfield and Vayssière pushes, different scientists devoted interest to this insecticide plant - but it was only in 1925, with Staudinger and Ruzicka scientific works, that the chemical structure of pyrethrins was discovered and their insecticide effect explained.

Originally the plant was discovered and possibly cultivated in Persia. Later on, cultivation was extended in Dalmatia and particularly, since 1881, in Japan at such a scale that Japan had acquired a dominant position on the world market on the brink of 1914 war.

After 1928, following British impulse, pyrethrum cultivation was successfully introduced in Kenya and Tanganyka - and Belgians followed samely a little after in Belgian Congo.

At the beginning of World War II, due to the blockade, Japan exports having become impossible, cultivation was intensively developed in Kenya - and Japan practically disappeared as producer.

Other cultivations were also launched (Ecuador and India), or experimented in various countries (URSS, Réunion, Malaysia, Madagascar and, more recently, Australia and South Africa).

2.2. Cultivation

Pyrethrum is a plant from moderate climate countries. Determining factors for a good crop and a good pyrethrin yield are essentially

- a 1.000 to 1.200 mm annual rainfall,
- a field location sheltered from drying winds.

In Africa - where are located most of the current cultivations - these climatic conditions have conduced to implant culture between 1.500 and 3.000 m, in order to enjoy a relatively mild temperate climate (so pyrethrum is grown in the same area than cereals, potatoes and strawberries - which will oblige to a similar economic return).

In Kenya, for example, interest for cultivations done at 1.800 m altitude has been proved : as a matter of fact the bud start-off after a fall of the surrounding temperature below 18°C during 6 consecutive weeks.
On the contrary, if temperature exceed 27°C, it inhibits the growing of floral buds (cf. KAMAN - Pyrethrum Post 1990 - 18.1.7).

In Europe or in Australia, mainly in Tasmania, where climates are much more moderate there is no need to establish pyrethrum cultivation in altitude.

2.2.1. Methods of cultivation : small holdings, plantation crops

Pyrethrum seeds are sown in nurseries, and later on transferred to the fields : in Africa pricking out of the small plants is done by hand in small plantation crops ; it is expected to get mechanized planting in every country where pyrethrum is (or will be) cultivated in large cultures, as in Australia. One of the best cultivation arrangements (cf. LHOSTE - Phytoma 161) consist in planting 2 ranks with 30 cm distance between them, these two ranks being themselves one meter distant from the next double ranks - that will greatly help for further cleaning or harvesting works.

Optimum density appears around 50 - 55.000 plants per hectare.

2.2.2. Up-keeping of land under cultivation

Agricultural labour include usually repeated hoeing.

However, particularly in large and mechanized cultivations, herbicides use has provided promising results :

initially, Heptame was used, but better results were obtained with more adequate herbicides.

According to a scientific study published in Pyrethrum Post 1989

- with VENZAR, it has been possible to obtain a result equivalent to hand-work with hoe, by applying 2 sprays corresponding each to 1,15 kg/per hectare ;

- with METRIBUZIN, good results when applied after sprouting against broad-leaf and grass weeds, by applying 0,6 kg/per hectare ;

- with BUTAZON + ATRAZIN, applying 1,4 kg/per hectare, after sprouting : this combination is cheaper than metribuzin treatment and frequently easier to be obtained in shops.

2.2.3. Pyrethrum pests

According to the countries, pests of pyrethrum crops differ largely. First of all, it is surprising to note that pyrethrum, a plant with insecticides properties in itself, is nevertheless attacked by insects and dust mites which must be eliminated (organophosphorus compounds appear to be effective against these dust mites).

Pyrethrum is attacked as well by a fungal disease, named Ramularia bellunensis.

At last, nematodes attacks can be dread, but it has been possible to obtain, through selection work, resistant varieties.

2.2.4. Effect of fertilizers

Impact of fertilizers - on flowers harvested weight or on pyrethrin content - was frequently contested, due to lack of scientifically done experiments : it is true to say that in Africa the small individual growers are often too poor for looking at fertilizers purchase or for understanding the interest of their use.

Dressing of fertilizers is still a must for obtaining a good crop. It has been evaluated (cf. LHOSTE - Phytoma n° 161) that a field producing 450 kg dried flowers lost its fertility by Nitrogen 9 kg, potassium 4,5 kg and phosphoric acid 2,5 kg.

In other respects, an agronomic experiment - related in Pyrethrum Post 1990 - has pointed out that a sufficient fertilizer input increase the flowers yield by 296 K during the first year, by 400 to 506 K during the second year and by 556 K during the third year.

Even now it is quite sure that the high yields obtained in large mechanized cultivations are due for a part to the impact of fertilizers inputs comparable to those applied for other industrial crops : African producing countries have to look at fertilizer supplies and at popularization of their use, if they want to reach comparable and competitive yields.

2.2.5. Pyrethrum crops yields

Expected yields - expressed in dried flowers weight per hectare - fluctuate from 350 K to 500 K the most frequently (that is to say about 1.750 to 2.000 kg/per hectare of freshly harvested flowers).

However, in experimental spots, with fertilizer input, Kenya has demonstrated that dried flowers yields can reach 850 to 1.750 K/per hectare, with most of the results in 1.000 to 1.200 K/per hectare (cf. WANJALA - Pyrethrum Post - June 1991).

Popularization effect and constant attendance in the fields close to the small growers are crucial for obtaining high yields in Africa - as it is important to collect all the flowers through repeated collections.

It will be far easier to obtain high yields in large sized mechanized cultivations, because - being located in mild temperate countries - where seasons differ clearly in terms of temperature and days length, they will benefit with a simultaneous start-off of the floral buds at winter end : it will result in a flowering at the same time, enabling a unique harvest.

Here there is a complete difference in vegetation face to the African countries - where seasons are not clearly contrasted with and due to this they will not have a short period flowering time : this explains that - in Africa - flowering time will be spread quite all along the year, with the need of repeated harvests - with risk of a partial non-harvest when the growers are required at the same time for other works more urgent or more profitable for them.

2.2.6. Pyrethrum flowers harvesting

The active insecticides matters (pyrethrins) are located in the flowers : maximum content does not last long - in the seeds, at the early beginning of the deflowering stage, that is to say when petals begin to incline (cf. LHOSTE - Phytoma n° 161).

In Africa, flowering being spaced out on many months, all the flowers are not ripening at the same time - which obliges to pick them one by one at the favourable time - requiring qualified and frequently available hand-workers (a well-trained picking-woman may gather in 20 to 25 kilos of flowers a day).

In Kenya, everyone uses to visit the fields for a crop harvesting every 2 or 3 weeks and this, all along the flowering season enlarged upon 9 months.

In the mild temperate countries, mechanized crop will be done in a single operation the difficulty will be to collect the flowers with the minimum length of remaining stems.

2.3. Development of new high-yield strains

In such competitive markets as the insecticides ones, pyrethrum keeps with difficulty its market share face to synthetic pyrethrinoids, in terms of treatment cost - the pyrethrum treatment cost being 4 to 5 times more expensive:

it is therefore essential for pyrethrum producing countries to reduce their production costs at every step starting by selection and cultivation of new high-yield strains providing maximized pyrethrin recovery yield per hectare.

This yield will be optimized if all terms of the following formulas are fulfilled individually :

"Pyrethrin content of the flowers x weight of dried flowers collected per hectare"

or more precisely

"Pyrethrin content of flowers x number of flowers per hectare x average weight per dried flower"

2.3.1. Genotypic and phenotypic correlations in pyrethrum and their implication in selection

PARLEVLIEET works in Kenya - and more recently those of BATH and MENARY in Australia provided the necessary knowledge for all who are determined to improve, from now on, pyrethrum strains.

The key conclusions of BHAT and MENARY report (cf. BHAT and MENARY - Pyrethrum Post 1986 - 16.2.61) are

- . the pyrethrin content and the number of flowers per plant have, for a large part, genotypic characters :
as starting elements for selection work, there will be searched for isolated individuals (or clones) containing already initially high pyrethrin contents and/or a large number of flowers per plant ;
- . the other studied characters - as height of the stems, average weight of the flowers or number of stems developed on the same plant - seem to be less important for the selection work.

In other respect, it will be highly recommended to follow the advices provided by PARLEVLIEET in his work devoted to pyrethrum selection work (cf. PARLEVLIEET - Pyrethrum Post 1974 b - 13.2.47-54) namely that

- . when doing mass selection work, it is possible to anticipate a 10 per cent improvement per agricultural year, simply by selecting and multiplying each year the clones isolated as the best 10 per cent of the plants grown for the yearly selection work.

2.3.2. Objectives for a selection work and measures to foresee

It is recommended for each producing country to improve through selection work, the indigenous strains, with in-out of high-performance seeds (obtained from selection specialists or from foreign botanical gardens collections).

Objective will be to attain - after some years work

- pyrethrin yields of over 1,5%, in the range of 2% and possibly even 3 - 3,5% (as these yields have been obtained on some selected clones in Rwanda in 1982);

- dried flowers crops largely over the usual 500 kilos per hectar, with an objective to obtain 1.000 to 1.200 kilos (while knowing that in selection parcels it has been sometimes possible to attain 2.400 kilos per hectar).

Applying the above-mentioned principles (chapter 2.3.1.) BHAT and MENARY have obtained a remarkable clone, named H 80014, whose pyrethrin yield reported to the hectar reached 48 kilos (= 2.416 K dried flowers collected per hectar, with pyrethrin content of 2,02%) : this strain officially registered in 1986 (cf. Hypopyrethrum Crop - SCI - 19E4.24.619-620) is likely now developed in large cultivations in Australia and indeed has been possibly improved since 1986.

2.4. Drying and crushing of pyrethrum flowers

Pyrethrins are sensitive to light but also to warmth : due to this, drying is one of the critical steps of production operations - as risks for recovering losses are important if temperature is not carefully checked all along the drying procedure, in order to avoid overheating at every step.

2.4.1. Temperature control for avoiding pyrethrins deterioration

Optimal conditions for a good drying of the pyrethrum flowers have been seriously studied and, as they are published in Pyrethrum Post, their conclusions deserve to be considered and applied by every professional producer (cf. Pyrethrum Post 12.2.77 - 82 and 6.2.25 - 29).

In brief, the following points can be essentially retained :

- drying at 40°C would be ideal for a safe protection of the pyrethrin content - but appears to be too long for being applied practically in industrial conditions ;
- drying at 100°C destroy the pyrethrins ;
- a good compromise is to dry at 50°C, if drying is conducted in closed ovens, or at 60°C - 80°C if drying in ventilated driers.

Kenya scientists moreover recommend to their growers not to exceed 60°C drying temperature.

These operating conditions meet the conclusions of a scientific study done by GODIN (cf. GODIN - Journ. Sci. of Food and Agriculture - 1965-16-186, mentioned "Chemistry of Pyrethrins", a report written by J.B. MOORE of MGK, published 1974 as UN Document ID/75.Vol. II) namely that

- . extracts done with flowers dried at 80°C are as active as the extracts done with fresh flowers,
- . it is a must not to reach 120°C during drying, as this overheating would totally destroy pyrethrins, more specially the pyrethrin I.

In Rwanda, drying is performed by direct drying in horizontal driers with warm air, fired-up with wood or peat fire - sometimes, as a preliminary step, with a preceding drying in open air on wooden wattles (use of locally produced peat has allowed to ensure a regular supply, avoiding purchases paid in currencies and long truck transportation, through entire Africa, of the fuel previously used for the driers).

It is warmly recommended - everywhere it is not yet realized - to fit out staff in charge of drying with easy-to-handle temperature measuring equipments with sounding rod, in order to perfectly follow and control drying operation.

If same equipments are able to record datas, it would provide a possibility for a subsequent control of the attention paid by the staff in charge of drying and eventually to have at management disposal precise elements for justifying a reward for quality work.

Finally, the objective being to obtain dried flowers with a final 10% moisture

- firstly, it is not desirable to estimate the final moisture "by hand touching" (as it is done in Rwanda by the staff in charge of drying), this evaluation being far too approximate ;
- secondly, it is recommended to provide the staff in charge of drying, with small electronic moisture measuring equipments equipped with sounding rod, selecting the same simple and cheap material as the one classically in use for moisture control of grain at the arrival at agricultural cooperative stores.

2.4.2. Dried flowers crushing operation

Crushing, next step after drying, will deserve a special attention in order to avoid temperature rise and to obtain a coarse powder - named "grist" - free of fine particles, thus enabling a good solvent percolation during the extraction.

As following recommendations done by A.T. DALGETY (in his special report A.T. DALGETY - DP/PNG/74/035 - UNIDO/TCD 461 published 11/8/75),

- a crushing machine with knife-blades will be used for, with a sieve of 3 mm holes.
However, if flowers moisture is a little over the standard specifications, it would be wise to use a sieve with smaller holes, in the range of 2 mm holes.
If flowers moisture is exceeding 12% at the end of the drying operation, crushing operation must not be implemented and flowers will be dried again.

- Standard specifications to be obtained at the end of crushing are

Sieve sizes	% retained
18 mesh (= 1 mm)	< 5%
25 mesh (707 microns)	} > maximum possible has to be retained on sieves 35 and 45 mesh
35 mesh (500 microns)	
45 mesh (354 microns)	
60 mesh (250 microns)	

and the quantity passing through the sieve 60 mesh has to be lower than 5%.

- Before to undertake crushing, will be added to the flowers half of the antioxydant (BHT) quantity admitted in final extract.
- After crushing, the coarse powder (= grist) will be let to rest during 24 hours, before processing for extraction : it appears that this rest period allows the powder to well cool-down and to loose static electricity possibly stored during crushing.
- Equally note that a coarse powder ("coarse grist") will be better for obtaining an easy solvent recovery at the end of the extraction.

2.5. World pyrethrum production and its geographic distribution

2.5.1. Worldwide pyrethrum production

Since 1950, pyrethrum production expanded largely in Africa - passing from 3.500 tons dried flowers in 1950 to 6.500 T in 1958, for the total production of the 3 African producers (Kenya, Belgian Congo, Rwanda/Urundi) to which it would have been right to add the Japanese production (2.000 T in 1955-56).

From 1959 to 1967, production statistical figures for Africa have not been recovered, but Ecuador appear on the world scene (culminating in 1965 at 2.000 T/year) and also Papouasia-New Guinea (reaching 450 T/year); at the same time, Japan is declining to 1.000 T/year.

From 1967 to 1974 average world production is in the range of 15 to 16.000 tons per year.

From 1974 to 1976, sharp increase (+ 20%) to 18 - 20.000 tons with a maximum in 1976 at 20.400 tons (at that time Ecuador only represents 800 tons/year and Japan 300 tons/year ; world production is thus essentially African).

From 1977 to 1980, important production fall (- 26%)

From 1981 to 1986, stabilization at 14 - 15.000 tons level.

From 1986 to 1990, tendency to a clear revival of the market and average production reach or pass-over 16.000 tons.

It is also the time chosen by Australia for undertaking an in-depth study in view to realize mechanized cultivation of selected strains.

To the opinion of several professionals specialized in pyrethrum problems market, current average world production reach now 20.000 tons per year (expressed in dried flowers).

This production is equivalent to the world consumption needs : due to the cyclic nature of the pyrethrum agricultural productions, it would be advisable to build a security stock with view to ensure continuity of the deliveries in the event of a bad crop - which is always a possible risk on 1 year.

Besides, it would also be recommended to the African producers to reach an agreement in order to avoid the spasmodic movements of the world pyrethrum production, with the objective to ensure a 15 - 16.000 tons minimum production and a production of 20 - 22.000 tons maximum - such a deal require to act truly in concert which is not really existing in present days.

2.5.2. Geographic distribution of the production

1993 estimation

Kenya	15.000 tons	(# about 75% of the total production)
Tanzania	1.500 tons	(# about 8% of the total)
Rwanda	500 to 1.000 tons	(# about 3 to 5% of the total)
Ecuador	150 tons	(# about 1% of the total)
New Caledonia	250 tons	(# about 1% of the total)
Australia	2.200 tons	(# about 11% of the total)
South Africa	?	
China	?	

which means, in all, about 20.000 tons dried flowers tons per year.

Main things to be memorized are :

- . Rwanda will have to look at a complete resumption of cultivations, as they were more or less non-existent or at least done with difficulty due to insecurity conditions all along last years ;
- . Australia appear to approach industrial production and to master it ;
- . South Africa and China took an interest on pyrethrum production, but no statistical datas are available about them ;
- . Cyclic fluctuations of cultivations and crops - frequently under influence of collective infatuation (when prices move up) as under influence of a brutal disaffection (when flowers over-produced are not bought or when they are paid late) - make industrial users worry rightly : it is recommended to producer countries to seat and consider together the whole of the measures suitable for a better pyrethrum credibility as an active insecticide product available at any time ;
- . Industrial users have not to suffer from unexpected agricultural events : During 1981-82, following an exceptional crop evaluated at 22.824 tons - which would not have been totally paid to the growers or which have been paid late - pyrethrum crop fail in interest and sometimes was abandoned, so that 1986 crop dropped to 5.712 tons.
(Result was a sharp shortage in deliveries, a speculative jump in prices, a severe market unbalance and sometimes a turn of the users from pyrethrum to alternative insecticides).
It is the personal responsibility of the producing countries to avoid destabilization of their agricultural producers, as their fidelity is the guarantee of future regular supplies.

3. THE PYRETHRUM EXTRACT

The use of flowers powder as insecticide is disappearing and turning into pyrethrum extracts utilization : thus it is possible to avoid bulky and costly transportation, as to prevent pyrethrins deterioration, those being weak and frequently spoiled according to bad storage conditions of the flowers powder.

3.1. The different qualities

As said, pyrethrum extracts are easier to be transported (as they are more concentrated in active constituents) and easier to be handled as much as for industrial formulators as for the final users.

Two groups can be distinguished : the crude extract
and the refined extracts

Crude extract has been classically utilized for a long time, but its waxes high content and its dark-brown colour make its use frequently hard to please (defective functioning of aerosol nozzles due to waxes plugging) or unpleasant (risks of stains due to the natural dark colour of the crude extract).

Refined extracts - known as "pale extracts" - have a lower content of waxes and a pale yellow colour : they are better adapted for the use in aerosol sprays, which are now most in use.

3.2. The crude extract

3.2.1. Customary production technologies

As far as crude extract production is concerned, production processes are nearly the same, as it seems, from one producer to the other.

In Kenya, the extraction unit refurbished in 1974 is carrying out the solid-liquid extraction of the flowers - coarsely ground - by means of a countercurrent process using Hexane as solvent :

Flowers would be pneumatically transported, inside the factory from the storage place to the extraction unit.

Extraction liquid is next vacuum-concentrated and extraction residues are vapour-treated in order to recover hexane solvent (cf. Pyrethrum Post 1974-75).

N.B. It has to be noted that Kenyan factory has at its disposal an inert gas generator unit (probably CO - CO²) which is used during handling (in order to avoid fires induced by static electricity) and all along the solvent extraction or recovery (in order to avoid explosion risks).

In Rwanda, extraction is, as well, done with N-Hexane (as solvent) and with the use of BHT anti-oxydant of an amount of 0,25 kg per ton - the process in use is said "semi-batch percolation system" and the plant equipments are similar to those used in Ecuador, New Guinea and Tanzania (cf. UNIDO Report DP/RWA/66/503 - 1977) : this can be easily understandable as Rwandese factory was built by English contractor Mitchell Cotts who owned in the past the Tanzanian plant.

In Papouasia/New Guinea, the extraction plant, initially built by an English Company, needed a complete refurbishing in 1984 :

rather than to maintain or to renovate an oversized factory, Papouasia/New Guinea would have decided to turn now into mobile units utilizing for flowers extraction a modern technology (which has not been disclosed), enabling to use each unit at its full capacity.

This information will deserve to be corroborated, as - generally speaking - mobile units are frequently badly adapted for an efficient extraction work, particularly if solvents are to be used :

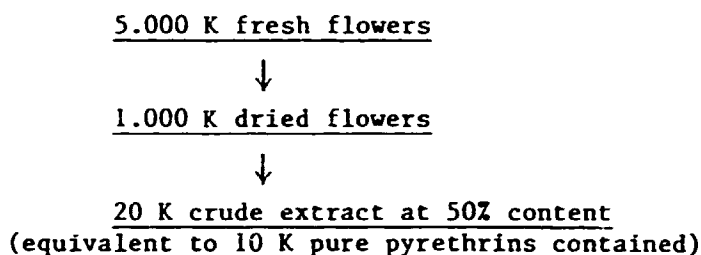
mobile units were most often set aside except for extractions using water as solvent and in the particular case of raw material to be extracted is plenty available at a low cost (as in this case it is possible to admit to extract incompletely with the mobile units and to compensate by treating larger quantities).

3.2.2. Recovery percentage yields

Extraction recovery yields are not disclosed by each producer for obvious competition reasons :

the objective - which is probably reached solely by Kenyan plant - is to process dried flowers (with a 1,5% pyrethrin content and a 10% moisture) with a final 5% recovery yield in the form of a crude extract (containing 30 - 32% pyrethrins), this 5% yield being expressed with regard to the in-put weight of dried flowers.

Expressed in a simplified way, one can say that often



That is to say a 1% average yield compared with the dried flowers put in processing (Kenya would obtain regularly a 1,25% yield).

Real recovery yields let appear important pyrethrin losses all along, from the fresh flowers collection till the crude extract obtention :

it is recommended to appoint a junior engineer with unique duty to detect origin of losses and to sensitize staff operators to the various measures able to avoid them (in a so competitive market, producers who would continue to recover only 4% yield would be condemned to disappear in a quite near future).

As a consequence of the losses cumulated one step after the other, it can be considered that most frequently 60 to 70% solely of the fresh flowers pyrethrins content are recovered in the final crude extract - and this is a promising view to see that improved working conditions would be able to bring an essential economic advantage in this ever so severe competition.

3.2.3. Yield losses : origin of, measures for avoiding them

Losses occur all along the production line.

- Losses on the fields due to incomplete harvesting

This type of loss does not implicate the extraction recovery yield, but affects directly the income of the grower and the total quantities delivered to the factory. More frequently, partial harvesting originate from a lack of interest of the grower for pyrethrum, when at the same time a more profitable cultivation asks for his work.

It is recommended, according to the local mentalities, either to reward the good yields by giving them a bonus, or to impose a minimum yield.

- Deliveries of abnormally humid flowers

There where the flowers are paid to the growers according to the fresh flowers weight, it is important to avoid overweight resulting from watering down of the flowers just before their delivery :

It is recommended to control with a simple electronic moisture-tester if the flowers humidity content is within standard results bracket - and to refuse (or to accept with a rebate on purchasing price) the abnormally humid deliveries.

- Pyrethrins losses due to drying operations

It is likely that 10% of the pyrethrins content are destroyed during drying process, if this one is not carried out with a good control.

At this stage, the use of simple electronic moisture-testers with sounding rod, is not only a recommendation but is imperative.

- Pyrethrins losses at crushing step

Pyrethrins losses due to crushing can arise

- . either from overheating of the material mass consequently to a too strong crushing or to a lack of maintenance on the knife-blades (these ones have to be replaced periodically, knowing that it is better to replace some of them frequently rather than changing all of them rarely),
- . or from a too big proportion of fine dusts, which will harm the efficiency of the solvent percolation through the mass during the extraction to be done later on : a control on the spot with a "superposed sieves box" will provide to the staff the way how to act upon for the best during crushing process.

- Pyrethrins losses during the extraction operation

Pyrethrins losses during extraction can mainly originate

- . either from a permanent control done with insufficient care during the extraction process,
- . or from a degrading oxidation of the pyrethrins, when anti-oxidizing agent use has been forgotten or insufficiently dosed, or rendered impossible due to supplies shortage,
- . or from a too high processing temperature or an insufficient vacuum during the final concentration step,
- . or from an oxidation caused by surrounding air contact, when extraction operations are done without inert gas.

- Pyrethrins losses during storage

These can originate

- . either from the use of unsuitable containers made out of a material that spoils the pyrethrins (i.e. iron drums without epikote resin coating inside),
- . or just from thefts, because high extract value gives to the product an attractive market value under a low volume.

The different ways to reduce losses have been partly identified hereabove ; the following measures will be added :

- Appointment of a person - with an engineer level knowledge - as a "Quality man" in charge to identify where process can be improved, to motivate those who can bring directly improvements and to obtain gratifications awarded in direct relation with the final results. Same person will have, as a duty, to meet the direct operators and to detect with them the origin of each break or each fall in the yields - in order to determine an objective for future and enable a continuous improvement survey program - in the frame of "Quality Circles";
- a daily record of the produced quantities and an immediate search of the origin (if a fall in production appears) - this will help especially to prevent extract thefts at the end of extraction process ;
- a strict selection of the production staff according to their aptitude to have attentive regard to the written procedures - and not at all according to recruitment criterions mainly based on political friendship. The quality of the staff being essential for the survivorship of the enterprise, every production staff people insufficiently rigorous in his job, must be replaced at one and transferred to another job.

It can be a good solution to select production staff members - and also the guards - among former soldiers or policemen, who have acquired a good mentality for following imposed rules.

3.2.4. World crude extract production and its geographic distribution

Total quantities produced in the world are corresponding roughly to the world market needs (200 tons of pure pyrethrins per year)

- with a pending risk of non-recoverable fall in case of failing supplies,
- with too erratic cyclic changes - in prices and quantities offered - for this production which is depending of small growers at the limit of economical self-survival :
indeed, these people - in the hope of improving their earnings - are always prepared to turn to any new culture with a possible better profit - and later on renouncing to it as soon as they will face a difficulty for selling their crop or turning to another hopeful income source.

Due to the above reasons, it is recommended to the producing factories to consider as very important to establish faithful links with their growers

- by assuring them a cash-payment for the delivered flowers, as small growers are always in need for cash money and are therefore interested in such crops quickly paid to them ;
- by buying the whole of their crops, even in the years when crops are exceptionally galore ;
- by establishing a concerting council including representatives of the growers, in order to have a permanent control on pyrethrum profitability which has to be similar to the other local crop ones.

Geographic distribution of the production has much changed and will certainly evolve again soon :

- . In 1930 Japan was covering 90% of the world market, with 6 - 7.000 tons of flowers equivalence
- . In 1955 African productions grouped to 70% and Japan was only 30% of a world production evaluated at 7 - 8.000 tons of flowers equivalence
- . In 1966 African productions reached 80%, Japan 6%, New Guinea 2% and Ecuador 12% of the world production increased in all to 15 - 16.000 tons of flowers equivalence.
- . In 1990 African producers hold 80 - 90% of the production, Japan having disappeared, Ecuador and New Guinea having decreased strongly.
- . In 1993 The significant arrival of the Australian productions announce a new trend for a partial transfer of the production towards mechanized cultivations, more especially as South Africa and some European countries seem to take an interest in it, pyrethrum being one of the rare plants which extraction is performed at an industrial level representing a processing by hundreds of tons, and indeed several thousands tons per year. This interest expressed by industrialized countries leave to think that culture and production in Africa have now reached a level-stretch or their maximum.

3.2.5. Crude extract world producers

Each country producing pyrethrum flowers carry out their transformation at least to the crude extract stage :

- in Kenya - PBK, the Pyrethrum Board of Kenya
- in Tanzania - Tanzania Pyrethrum Board
- in Rwanda - OPYRWA, the Rwandese Pyrethrum Office
- in Ecuador - INEXA, Industria Extractora CA
- in Papouasia/New Guinea - Kagamuga Natural Products Pty Ltd
- in India
- in China
- in South Africa
- in Australia - CIG, Commonwealth Industrial Gases Ltd

3.2.6. Pyrethrum crude extract composition

It is essential to have a thorough knowledge of the crude extract composition for everyone who intend afterwards to choose the solvents or the polar blends best appropriated for optimizing purification of this colored crude extract and to tend to a pale color refined extract (with a maximum content of solubilized pyrethrins and a minimum of dissolved waxes and resins).

Summarizing the various reprints with regard to the extract composition (cf. HEAD Pyrethrum Post - 8(4), 3, 7, 1966 and 10(12) 17-21, 1969 and 10(3) 27-31, 1970 as also GRIFFIN - Pyrethrum Post 10(3) 1975), it can be considered that crude extract average composition is

Total pyrethrins	#	30 to 35Z	} which means a total of waxes and resins amounting # 65 to 70Z
Fatty acids	#	20Z	
Hydroxylated fatty acids	#	20Z	
Alcanes	#	4Z	
Carotenoids	#	1Z	
Sterols	#	5Z	
Chlorophyllums	#	0,1Z	
Indefinite	#	15 to 20Z	

3.3. The refined extract, said "refined pale extract"

Its use tend to supplant totally the crude extract and the powder uses - as it can be used in pulverisations and aerosols, avoiding the risk of nozzles stopped up by waxes.

3.3.1. Customary and new technologies of pyrethrum refining

The purpose of crude extract refining is to remove a large part of the natural waxes existing as dissolved in the crude extract - and to take color out of with view to obtain a pale yellow golden color.

Three processes are known for it :

- distillation - which has been extensively studied by GOLDBERG (cf. Goldberg - Journal of the Science of Food and Agriculture - Vol. 16 (1965) p. 104). According to this author, distillation - inside the working conditions proposed by him - would not induce isopyrethrins forming nor any loss in biological efficiency (this point was frequently reported, by other scientists, as a risk appearing in case of pyrethrins heating). It seems that presently discoloration through distillation is a method unfrequently applied at industrial level ;
- the classical technology in 4 steps
 - . elimination of the maximum waxes content, as it is possible, using selective extraction of the pyrethrins through methanol plus water and cooling of the methanolic solution at + 10°C maximum, if possible best cooling temperature is well below 0°C (PRASAD was even recommending to cool to - 20°C; cf. PRASAD - Chem. and Ind. 1969, 23, 756-757);
 - . discoloration of the methanolic solution, with use of adapted charcoal ;
 - . elimination of resins using cooling at - 10°C, after methanol distillation and transfer of pyrethrins in hexane ;
 - . stabilization of the extract by kerosene dissolution, after hexane removal by distillation.

This process, apparently classic, require a great experience, a lot of know-how and a strict respect of the operating conditions recognized by experience as optimal for a final good yield.

This process require a powerful and efficient refrigeration unit - which is not easy to obtain under hot African climatival conditions ;

- the modern extraction technologies using super-critic gases (as CO², butane or propane in liquefied forms) :

These technologies need costly investments - as it is necessary to work under high pressures.

Formerly applied for extracting high value fragrances (as jasmine), these technologies are now applied at industrial scale (since removing procedure of cafein from coffee beans, which has been the way to obtain cafein-free coffee without odorous solvent residual content).

This new process is now applied in Australia, by C.I.G., a company highly specialized in technologies using liquefied gases.

3.3.2. Economic constraints of refining operation

The use of the classical refining process impose a complicated succession of operations, each of them requiring a lot of ability - which necessitate an attentive and skilled staff.

Besides, this process use flammable solvents and require an important availability of frigories (which are expensive to obtain, more specially in a hot Equatorial climate).

Discrepancy in prices between crude extracts and refined extract is limited - only around 15 to 20 \$ per kilo.

Taking into account that refining cost will have to include small pyrethrins loss (unavoidable during the refining operation, probably 1 to 5%), a refining technology can be economical only if it is simple in application and if the operating cost (without including pyrethrin loss) can be mastered at a level inferior or equal to 10 \$ per kilo.

Nevertheless a producing country can have interest to fit out its own refining capacity, even without any supplementary expected profit - as the world market for pale extract is much more diversified (on the contrary a crude extract producer is inevitably submitted to the good will of the refining club members).

3.3.3. World refined pale extract production and its geographic distribution

- . Exact quantities produced are not known with accuracy as there does not exist any official recorded statistics - and also as the production is frequently expressed in terms of gross weight, which include as crude extracts with 31% content and refined extracts adjusted to 20% for USA, at 25% for most of the non-American users and sometimes at 50% for some large users wanting to minimize their transportation costs.
- . Installed production capacities are
 - far over the needs of the market for the liquid-liquid extraction step, it is to say for producing crude extract from dried flowers : as a matter of fact, each country trended to establish 2 - 3.000 tons flowers capacity treatment units, without having in advance made sure that it would be for them a realistic outlet level for future.

Following extraction capacities can be considered as likely to be true

Kenya	12 to 16.000 T, possibly 18.000 T
Tanzania	3.000 T
Rwanda	3.000 T
Ecuador	2.000 T
Papouasia/New Guinea	500 to 700 T
Australia	Capacity is unknown, but exist big extractors (with 2 - 3.000 T capacity, partially utilized for treating other crops) which can be adapted easily for pyrethrum extraction

All these existing capacities, being more than sufficient for the production, will be even more in excess in proportion, as pyrethrin high content in flowers will be obtained in a near future as the result of strains selection.

N.B. - For Kenya, the 12.000 T capacity is the figure expressed by PBK in Pyrethrum Post 1979, when they have announced their project for doubling the former old existing factory : it seems that a new extension capacity has been now installed, as Kenya appear to be able to treat, without difficulty, all the quantities they are producing, estimated at 16.000 T per year of dried flowers.

. Refined extract produced quantities are shared out as follows

	Dried flowers quantities treated	Refined extract quantities produced (expressed in pure pyrethrins 100%)
. Kenya, dominant producer	16.000 T/year	160 - 180 T
. Tanzania, which ensured 20% of the market needs and seems to have been decreased to 8 - 10%	1.500 T/year	15 T
. Rwanda, which fell strongly from 1975 and has been handicapped in 1992-1994 due to the local insecurity	800 - 1.100 T/year	8 - 11 T
. Australia, which develop rapidly and already reach 2.000 T processed per year	2.000 T/year	20 - 25 T

which means a present estimated production of : 203 to 230 T.

N.B. - An overproduction is to fear for the 1995 - 2000 period, as

- . production is not concerted between the different involved parties,
- . Rwanda should recover, during the next years, a quietened economy, favorable to the revival of new cultivations,
- . Australia - and possibly South Africa - are in full expansion phase for their cultivations, all of them established with high productivity strains.

3.3.4. Refined pale extract world producers

The list of the refining-transformers has been reduced significantly from 1977 : the result of is a power pressure from the industrialists acting together facing the producers whose interests are contradictory, even some of them are members of a specialized syndicate (as the African producers who have initiated RWATAKE, but who have not been able together to fix till now a common policy for future).

In 1977, a UNIDO document (cf. DP/RWA/66/503 p. 43) was listing the existing refining-transformers and their out-put capacities :

	<u>Production capacity expressed in refined extract at 25% pyrethrins</u>
Cooper - U.K.	25 T
Mitchell Cotts - U.K.	90 T
Prentis - U.S.A.	15 T
MGK (McLaughlin Gormkey King) - U.S.A.	360 T
PBK (Pyrethrum Board of Kenya) - Kenya	<u>500 T</u>
World refining capacities 1977 :	990 T

(At that moment, in 1977, world capacity for refining was corresponding to 20 - 25.000 tons dried flowers equivalent : it would have been insufficient for treating and refining all flowers crops, but finally was sufficient face to the needs - as Kenya was, at that time, selling its overproduction (3 to 4.000 T dried flowers per year) directly in the form of flowers powder).

In 1991, according to Mr. Le Mouel (cf. Le Mouel report 1991) the number of world most important refiners is now limited to 3 :

	<u>Production capacity expressed in refined extract at 25% pyrethrins</u>
PBK (Pyrethrum Board of Kenya) - Kenya	500 T
MGK (McLaughlin Gormley King) - USA	> 160 T
BEI (Botanical Extract Inter at Penn) - UK	30 T

- N.B. ◦ The 2 other English refiners have stopped their activity, especially Mitchell Cotts, due to severe supplies shortages.
- Refining capacity of MGK, at present, is not disclosed : it can be said that it has been increased, when the old plant has been renovated (this initial plant, built in 1950, was considered as obsolete and requesting its replacement by new equipments - according to Le Mouel, in his 1991 report).
 - BEI (UK) company - equally noted in Le Mouel report 1991 - does not appear to commercialize its production directly, because its name remains unknown for most of pyrethrum market operators : this company is said to be under financial control of Agrofarm UK (which is a market operator known in the pyrethrum extract business) and Indura-Italia (which is a manufacturer known by the producers of synthetic pyrethrinoids cypermethrin and tetramethrin).

It will be also pointed out that some other refining capacities, sometimes rarely used (due to flowers supplies shortage or as a consequence of insufficient mastering of refining technologies), are existing in the following countries :

Malaysia

Rwanda

Ecuador (latter would have a theoretical capacity of 80 T expressed in 25% refined extract).

4. THE PYRETHRUM FLOWERS POWDER

4.1. Specifications

Apart from some countries (UK, Belgium, India) which would buy occasionally pyrethrum flowers dried but non crushed - probably for some particular uses - most of sales are done under crushed flowers powder form - which reduce considerably volume to be transported and consequently freightage.

Pyrethrum powder is standardized at 1,3% pyrethrins content, but Kenya continue - on special request - to provide a quality with a lower content, 0,6% (which would be prepared by mixing equal quantities of flowers powder and of residual extraction marcs).

4.2. Applications

Pyrethrum powder is used as an insecticide since ancient times : between 1930 and 1950, it was commonly sold in Europe "against bugs", but on the contrary very large quantities were used in Far East Asia as of the components of coils used against flies and mosquitos.

Today pyrethrum powder use declined very much in Far East Asia, as a consequence of the replacement of pyrethrum by synthetic pyrethrinoids done by some important producers of mosquito coils.

It can be nevertheless considered that present consumption level will be maintained in future - as there still exists a very large potential market for mosquito coils in all Asian countries, Latin America and particularly where people live outside (for example, the African way of life in open huts) with a too limited revenue for buying modern aerosol sprays.

Applying insecticide pyrethrum powders remains of great interest in these countries due to their "flushing effect" : peculiar quality of pyrethrum makes come out insects hidden in corners or hard accessible crevices, very frequent in all countries with a hot and humid climate.

4.3. World flowers powder market

The detailed statistics of quantities exported by producing countries and of quantities imported by final users countries will be given in detail later on in the present report (cf. chapter 10.2).

Generally speaking, it is of great interest to have an idea of consumption evolution, ever so important for this product : although consumption in 1976 was over 2.000 T, it was only recorded at 500 T level in the customs export-import statistics for 1980-1981, while admitting that some of the transfers have possibly been omitted or recorded (it seems indeed that some countries which are not producing pyrethrum extract are growing pyrethrum solely for selling some tons of flowers powder - probably as under contract cultivations which are reported from time to time in Morocco, Italy, Spain, Central Europe and even in Madagascar).

It is reasonable to estimate 1994 sold quantity of pyrethrum powder in the world represent about 500 T per year - a figure much lower than before but now having reached its stability level.

5. THE PYRETHRUM MARC (i.e. PYRETHRUM EXTRACTION RESIDUE)

5.1. Specifications

Pyrethrum flowers extraction residue, named "marcs", does not contain any more pyrethrins and therefore devoided of insecticide properties. But, as a tradition, it is still used as one of the classical components of the mosquito coils : this regular use is possibly due to the fact that pyrethrum producers are delivering the marcs with a constant particle size (= granulometry) and well adapted to enable afterwards a controlled and extended diffusion of the insecticide activity (cf. Pyrethrum Post 1979). It can be indeed expected that size of particles is ever the more important as proportion of marcs used in the insecticide mixture applied on the coil is high (about 30 to 38% of the total weight).

5.2. Applications

As explained above at chapter 5.1 main use of the marcs is not only to serve as a filler (i.e. excipient) but also as a help for absorbing and fixing the pyrethrum extract used in the mixture applied on the mosquito coils. (regularity of quality explain why industrial users accept to pay a freightage cost equal to price of marc itself - due to the good expected results - even when other vegetal scraps are available in the vicinity of the industrial factories).

Marcs as well have been used for cattle feeding but without particular interest : till now, it is only as it is a cheap vegetal material available in the vicinity of the pyrethrum factory at a low cost. It would be of no sense to transport marc far away, as its nutritive value would not justify high transportation costs.

As marcs produced quantities are very important (marcs represent about 90 to 95% of the dried flowers weight put into processing), production factories can have a problem for evacuating and eliminating them : an in-depth study deserve to be done

- either for providing marcs to the growers with view to spread them on their fields, which will bring to the soil organic plant humus,
- or to burn them in special boilers with heating recovery, enabling important savings on fuel purchases.

Last solution is especially to be considered for Rwanda, a country obliged to pay its fuel needs in hard currencies and because of high truck transportation costs as suppliers are distant : using the marcs would bring the important advantage to eliminate the risks for a factory-break due to delayed arrival of tank trucks.

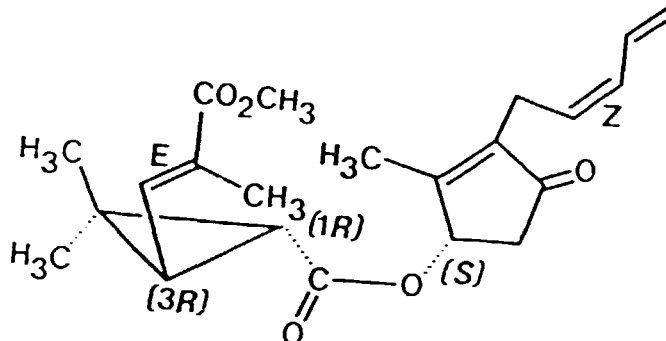
5.3. World marc market

Consumption (which reached 5.000 T for Japan only in 1970-1975) amount now 2.000 tons maximum : it is still used as an excipient in the insecticide mixture for mosquito coils, but other fillers are now frequently used for the same purpose by the industrial users, for cost reasons or for easier local availability.

6. PYRETHRINS - PYRETHRUM ACTIVE ELEMENT

6.1. Pyrethrins formulas

Chemical analysis of pyrethrum extracts was initiated by STAUDINGER and RUZICKA (1924), LA FORGE and BARTHEL (1945), MUNZO and HARPER. These scientists put to the fore that pyrethrum contained 4 insecticide compounds, each of them with a very complicated structure but quite similar one to another and showing isomer possibilities : the most complex one is the structure of pyrethrin II, which present 5 isomer possibilities

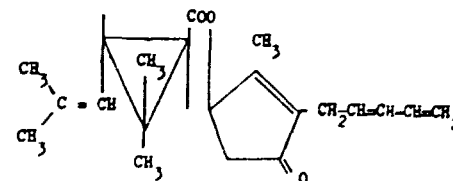


Pyrethrin II (cf. TESSIER - Actualité chimique - December 1986)

Existence of cyclopropane ring was at this time something absolutely unusual and existence of several asymmetrical centers drew especially the attention of the scientists community (as, at the same time, most of them were searching for realizing synthetic pyrethrinoids with a more simplified structure than natural pyrethrins one - and this has been the origin of allethrin discovery in 1949 by SCHECHTER).

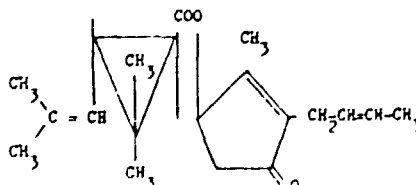
The 4 pyrethrins, the active components of pyrethrum, are

— *la Pyréthrine I*, formée d'une combinaison entre l'acide chrysanthémique et le céto-alkyl pyréthrolone;



— *la Pyréthrine II*, formée d'une combinaison entre l'acide pyréthrique et le céto-alkyl pyréthrolone;

— *la Cinerine I*, formée d'une combinaison de l'acide chrysanthémique et du céto-alkyl cinérolone.



— *la Cinerine II*, formée d'une combinaison d'acide pyréthrique et du céto-alkyl cinérolone.

(cf. LHOSTE - Journées Françaises d'études et d'informations consacrées aux insecticides agricoles - Paris, August 1960 - Tome 1 - p. 69 - 79)

6.2. Pyrethrins analysis and the different methods

Due to the diversity of the producing countries, pyrethrum extract was rapidly submitted to comply with international specifications - as for the assay methods to be used for international commercial transactions as for the specifications of the different standardized qualities offered to the market.

6.2.1. Methods in use for trade operations and for commercial transactions between producing countries and buyers

2 assay methods are in use :

- . the method named PBK - applied to every international transaction, except for USA :
it is a reproducible and credible method, but time-consuming (it requires one entire day for one technician for realizing one single assay carried out in duplicate);
- . the method named AOAC, applied for transactions with USA :
it uses the Deniges reagent and is also called "mercury reduction method".

N.B. - It is to be pointed out that a standard 25% European quality extract (with assay done by PBK method) is an extract with a usual content of 15% in pyrethrins I and 10% in pyrethrins II.

AOAC method is known for undervaluating the pyrethrins I content, with regard to PBK method : thus, a standard 25% extract (according to PBK method) will provide following assay results

- by PBK method	pyrethrins I	15%
	pyrethrins II	10%
- by AOAC method	pyrethrins I	12,5%
	pyrethrins II	10%

the result is that - approximatively - it is possible to approach the AOAC result lowering by 2,5 units the content of pyrethrins I assayed by PBK method.

N.B. - Usually, sellers and buyers are agreeing together by direct understanding : exceptionally, they ask for arbitration to an independent laboratory referee, as STILWEIL and GLADDING - New-York.

6.2.2. Methods applied for selection work of new strains - and for the industrial day-to-day control

- by the traditional assay method, using colorimetric determination evaluated by spectrophotometer unit - but these colorimetric methods fail frequently in terms of specificity - and, due to this, can induce important errors ;
- by HPLC (High Pressure Liquid Chromatography)
This quite new method is promising for future, the unique one able to presently perform rapidly multiple analysis, with a good specificity - as it is a need for strains selection works. With HPLC - after pyrethrins extraction done with a set of small size laboratory Soxhlet extraction units - the assay is finalized in 1 hour time instead of a full-day work.
(HPLC method applied for pyrethrum determination has been explained and detailed by Kaman - cf. Pyrethrum Post 1990 - 18.1-7).

- N.B. (1) The only objection to the use of HPLC method (and it is necessary to keep it always in mind) is that there does not exist - as a referring product - any pyrethrin highly purified standard : therefore analysts are obliged to use a pyrethrum extract recognized as a reference standard. This pyrethrum extract (to be used as a standard by HPLC, in parallel with the sample to be assayed) will have been itself assayed by PBK method, or preferably obtained directly from the Pyrethrum Board of Kenya : PBK indeed provide the world over samples of "World Standard Pyrethrum Extract", which will allow to users to carry out safely sub-standard samples for their daily analytical needs.
- N.B. (2) Samples of this world standard can be obtained on request sent by fax (Kenya fax n° 45274) addressed to the PBK Chief Chemist (cf. Pyrethrum Post 18.4.92).
- N.B. (3) For detection of residual pyrethrins, among others, in drinkable waters, an especially adapted method - derived from the classic HPLC - has been agreed by EEC (cf. EEC Guide Lines EEC 80/778): this method - named Debon, Segalen, Cooper method - is fully detailed in a special reprint (cf. Pyrethrum Post 1989).

6.3. Pyrethrins lack of stability

Pyrethrum extracts (or at least pyrethrins, which are the active part of them) are

- . degraded by light,
- . degraded by oxidation, which is even possible during storage or extraction course,
- . degraded by increased temperature,
- . probably degraded equally under effect of some metallic ions - which are acting as oxidative catalysts in particular.

6.3.1. Advantages of this unstability

Pyrethrins fragility - even if it restricts its use - bring a real advantage in terms of public health and environment : pyrethrin effect is fast but fleeting, with the interest to be destroyed practically without remaining harmful residue.

Due to this absence of residual toxicity and to its good tolerance - particularly in the case of the refined extract which is considered as hypo-allergenic (cf. Zucker - Pyrethrum Post 1966.8(3) 7) - pyrethrum extract is chosen preferably in USA for the food industries use - and this, in despite of the real pressure done by synthetic pyrethrinoids producers : US rules of EPA (Environment Protection Agency) consider since a long time pyrethrum "cleared as safe", due to its innocuousness which has been confirmed by years of regular use without any incident.

It is also important to point out that pyrethrins disappearing rapidly, they avoid the risk of transmission in the mammals through the food chain : on the contrary with using other long-acting insecticides accumulation of significant and sometimes harmful concentrations can be obtained, particularly in the fatty cells of superior mammals.

6.3.2. Disadvantages of this unstability

The obvious disadvantage of the pyrethrins weakness is their short action duration when product is applied in locations submitted to intense solar ultraviolet rays : for this reason, pyrethrins are no more used as agricultural insecticide, with some rare exceptions as market gardeners (for applying insecticide late treatments on vegetables just before gathering) or by "biological" cultivations adepts (those persons refusing the use of synthetic insecticides).

6.3.3. Storage and utilization cares in order to preserve the activity - Types of formulations

Pyrethrins shading off causes being clarified, many scientists tried to improve pyrethrins stability (with relatively satisfactory results) and to precise the best conditions for storage :

- protection from direct light : opaque containers,
- protection against oxidation, even along the production process : use of inert gas, use of anti-oxidizer in sufficient quantity (the most commonly used being BHT, to be added at 4% dose - cf. Moire - J. Sc. Fed. Agr. 1954 - 5.500),
- protection against warmth : storage has to be done, if possible, in rooms with an inside temperature inferior or no more than 20°C,
- protection against some metallic ions (iron, copper, zinc, lead) : it is known that metallic traces often have an oxidative catalysts effect on many products.
In matter of pyrethrins, this effect has not been clearly proven (cf. Taiwan work - Pyrethrum Post 1974) but prudence require to avoid plain iron containers and to prefer iron drums with an epikote resin varnish inside or to use aluminium cans, if possible with same varnish inside.

6.3.4. Pyrethrins stabilization through micro-encapsulation

This method proved to be of real interest and would certainly deserve to be used more frequently by industrial formulators :

the only objection is cost price increase of this insecticide which is already considered as more expensive than its competitors.

But obtained results are so good that they ought to be better vulgarized near formulators :

- . an experiment done on 27 different formulas resulted in a protection maintained during 10 days against tsetse fly bites and 7 days against tick attacks (these two insects being vectors of severe cattle diseases and sometimes of human diseases too) - Cf. Galun and Coll. Jerusalem University - Pyrethrum Post 1983 - 15(3)90 ;
- . a micro-encapsulated pyrethrin speciality - named SPECTROL - prove to be active during 1 month for invasion control of cockroaches and cats fleas (cf. Bennet - Pyrethrum Post 1978 - 14(3)68) ;
- . a formula with a 14 days long-time action against ticks and pets (dogs and cats) fleas has been reported in Pyrethrum Post : it would be an aerosol spray with isopropanol and an inert polymer inducing a film coating able to extend the duration of pyrethrin activity ;

- . 3M Company has particularly invested in this technology survey, through its affiliated branch WHITMIRE : their micro-encapsulated extracts are marketed in USA and South Africa ; some special grades are produced as very thin particles able to pass through the spray nozzles without any plugging risk.

6.3.5. Pyrethrins applications and efficacious doses

For every use, pyrethrins will be associated to synergists compounds - which will reinforce their activity and consequently contribute to reduce the cost of the effective insecticide dose (cf. chapter 7).

Main uses for pyrethrins are

- against flies : Pyrethrin 0,1% (or 0,015 to 0,15% if used with PBO 1/10 as synergist).
It is to know that, in order to obtain a knock-down and destroying effect comparable with allethrin, it would be necessary to use this last one at a concentration of 1% (or 0,3 to 1% if synergized with PBO 1/10) : this is noted to let remark that, for some particular uses, natural pyrethrins are more costly per kilo, but the minimum effective dose is considerably lower (cf. Goodwin - Pyrethrum Post 1956).
Nevertheless, it is fair to admit that, generally speaking, natural pyrethrins cost of treatment is 2 to 4 times higher than with synthetic pyrethroids, especially the most recent ones :
so, instead of natural pyrethrins used at 0,15% concentration, it will be possible to use tetramethrin at 0,25% concentration (this last one being purchased at 85 - 100 \$/kilo, calculation demonstrate that tetramethrin treatment will be 3 times cheaper than with natural pyrethrins);
- against German cockroaches ("blatella germanica") :
Natural pyrethrins, in this very special case, are unequalled, more especially as their flushing effect is involved :
this flushing effect make put out the cockroaches from the crevices and other fissures where they like to hide in warm and humid atmosphere.
Effective dose against cockroaches is a solution with 0,01 to 0,05% concentration (cf. Pyrethrum Post - December 1988);
- against mosquitos :
Frequently in form of mosquito coils, widely used in Africa, Latin America and Far East, all countries where it is open housing and where users have a too insufficient revenue for buying more expensive formulas, as sprays : Japan has become a specialist of the building for the special machines devoted to coils production ;
- against ticks and pets fleas :
Here, it can be recommended to utilize, as far as possible, formulations with extended action duration - as the formula reported above at paragraph 6.3.4. and recorded in Pyrethrum Post 1986 :
 - . action duration is extended by addition to the aerosol solution of a neutral polymer which will induce a film coating deposit after evaporation of the ISO-propanol solvent,
 - . efficacy is reinforced by 2 synergist compounds (PBO and 4 octyl-bicycloheptanedicarboximide),
 - . a repulsive effect for the insects, obtained by using of 2 appropriate repellents ;
- against ectoparasites ("varroa jacobsoni") living at bees expense :
Bee-keeping cares, natural pyrethrins appear to be very interesting as much more effective than VOLBEX, with the advantage to do not leave noticeable residus (instead of Volbex which, after treatment, is remaining in bee-wax at a significant concentration) - (cf. Pyrethrum Post 1987);

- against house bugs :
This has been a long time the greater traditional use for pyrethrum powders ;
- for safekeeping of corn grains storage,
In Kenya it is used 50 gr of pyrethrum powder in each 90 K corn grains bag ;
- for desinsectization in food industries and for every domestic spray uses :
For these uses which are now certainly the most important quantitatively, it will be interesting to look forward at 2 reprints :
 - . one of them concern up-to-date sprays formulations (cf. Lee - Pyrethrum Post 1967 - 9 (2) - 18 and 1969 - 10 (2) 9),
 - . the other one detail the directions where pyrethrum is interesting for sprays use (cf. Skarp - Pyrethrum Post 1957 - 4 (2) 34);
- for destroying varied dipter insects and dust mites (related to Tyroglyphus genus) which sometimes are invading mushroom plantings :
Those being frequently located in old dark quarries, pyrethrins are not taking the risk to be too quickly destroyed by light and they have the advantage to do not let awkward residues on the mushrooms (cf. Lhoste - Phytoma n° 161);
- for fighting fleas and dust mites, through use of shampoos and hair lotions containing 0,35 to 1,8% pyrethrins concentration, sometimes with addition of 1 to 4% acetic acid ;
- for decontamination of planes, on their arrival from malaria risks areas :
Spray aerosols are used on the arrival of the planes and before disembarking of passengers : "knock down" and "kill" effects of natural pyrethrins argue most often in favour of their choice (cf. Busvine - Pyrethrum Post - 1952 - 2 (4) 23 and Pal - Pyrethrum Post - 1953 - 3 (2) 6) ;
- for horticultural uses against plant louses :
In this case, natural pyrethrin solutions are for more active if their pH acidity is adjusted between 6 and 9 ;
- for creams and lotions used as a protection or as a repellent against mosquitos :
Here natural pyrethrum ensure 4 hours of complete protection, with 80% protection still kept after 8 hours - and sometimes during 1 month if formulation is a photo stable emulsion (cf. Pyrethrum Post 1988).

7. SYNERGY AND PYRETHRINS SYNERGISTS

7.1. What does Synergy mean ?

This word, derived from old Greek language, has been recovered as a medical expression, in 1876, to characterize the association of 2 medicines - when, becoming stronger jointly, they result in a final effect superior than the simple addition of the two individual results obtained from each medicine.

In the particular case of pyrethrins and pyrethrinoids, synergist name is applied to cheap products which are able, when added to the insecticide, to increase considerably their effect.

7.2. Interest of synergist use

Synergists products, which are added to the formulations, are therefore enhancing the insecticide power of pyrethrins and pyrethroids - enabling to reduce the concentration of the most expensive component :
the way the synergists are acting is totally different from pyrethrins ways, most of them do not contain any proper insecticide activity.

Insecticide effect of pyrethrins is in relation with their impact as neurotoxic poison for insects and more generally speaking for arthropods :
this effect is due to their combination with the lipidic stratum of the nervous cells membrane ; the cationic exchanges through membranes, which are the origin of nervous transmission, are for this reason severely disturbed (inducing a choc effect and uncoordinated movements of the insect).

Synergists are acting through inhibition of the enzymes in charge of eliminating neurotoxic poisons :
the result of their effect is that duration and intensity of pyrethrins action are lengthened and even increased, when added to the insecticides formulations.

7.3. The various synergists

The first synergist to have been used is sesame oil (cf. Eagleson 1940-1942, Haller 1942), in which the genuine active part as pyrethrins synergist has been identified under the name of "sesamine", a chemical structure characterized by presence of a toxophor "methyl-dioxy-phenyl" group.

As a following to this discovery, other synergists have been discovered, showing also the same toxophor group in their formulas :

piperonyl-butoxyde
piperonyl-cyclonene
N-propylisome
Sulfoxyde (a mix of isosafrol-n-octyl sulfoxyd and isosafrol-n-octyl sulfone)
Sesoxane (= acetaldehyd - 2 (2 ethoxy ethoxy) ethyl 3.4.methylen dioxyphehyl-acetal)
S 421 (= octochlorodipropyl ether)
Bucarbolate (= mono-n-butylether of piperonylic acid diethylen glycol or butylcarbitol-6-propylpiperonyl ether).

More recently, new synergists - no longer including the toxophor group "methyl - dioxy - pnyl" - have been developed and especially MGK 264 (= N-octylbicyclo 2.2.1.5. hepten 2.3. dicarboximid).

- N.B. : It is interesting to note that, exceptionally, MGK 264 is a synergist showing equally insecticide properties by itself - on the contrary of all other synergists which are practically devoided of any knock down or toxic effect on insects.
- N.B. : It is the use to add synergists concentrations 5 to 10 times higher than the pyrethrins or pyrethroids ones, in view to obtain optimum synergism effect :
cost of goods for synergists being low, formulators have interest to obtain high synergism and accordingly to reduce at its minimum, compatible with maintained efficacy, the concentration of natural pyrethrins (which is the expensive component of the formulation).

Synergists have interested many scientists and a lot of scientific datas about them have been recorded :

this subject has been studied with many details by LHOSTE (cf. Lhoste :

- (1) Synergism to be applied to anti-parasites products -
Produits pharmaceutiques - 1955 - 11 (6) 395 - 404
and 1955 - 11 (7) 484 - 488
- (2) Vegetal origin insecticides
C.R. des Journées Françaises d'études et d'information consacrées
aux insecticides agricoles
August 1960 - Tome 1 - p. 69 - 79
- (3) Pyrethrins - Phytoma n° 161).

8. NATURAL PYRETHRINS AND NEW SYNTHETIC PYRETHRINOIDS COMPETITION

Natural pyrethrins are essentially distinguished by

- . a "knock-down effect", sometimes named "shock effect" - indicating that flies fall down immediately, agitated and buzzing,
- . a "killing effect" on insects,
- . a "flushing effect" on crawling insects, obliging them to come out from crevices and wall clefts,
- . a "repellent effect" against insects attacks,
- . an important photolability,
- . the advantage to let actually practically no residues,
- . a very low toxicity and especially a very good skin tolerance,
- . a cost price unhappily often higher than the competitive synthetic pyrethrinoids ones.

Synthetic insecticides, then potential pyrethrum competitors, are compared to pyrethrum mainly in terms of "knock-down" and "killing-effects", but more recently for ecological reasons, people are also taking into account the level of residues remaining after use.

Synthetic insecticides can be classified in 4 large main groups :
organo-chlorides, organo-phosphorides, carbamates and synthetic pyrethrinoids.

- . the organo-chlorides compounds - including DDT, dieldrin, toxaphen and lindan - widely used as soon as in the years 1940 - 1950, are now very cheap but toxic and long persistent.
(It is to remember that these persisting effects are so durable that they are transmitted all along the alimentary chain, with possible consequences bad for the environment - as indirect destruction of non-harmful insects and possible risks for humans).
For these reasons, organo-chloride compounds use is now submitted to severe rules, even often prohibited in many countries ;

- . the organo-phosphorides compounds - most of them acting as contact insecticides - have an immediate toxicity greater for humans, but they are less persisting and they are inducing less dangerous residues than organo-chloride compounds :
for these reasons, they are widely used in agriculture, in barns and all food industries products warehouses.

In this group are found malathion, methyl-parathion, diazinon and DDVP (dichlorvos) :

organo-phosphides are till now by the most frequently used, especially in USA, as insecticides utilized by gardeners and also as the active compound in formulations for pets (even it is known that insects tend to get to be insecticides resistant in the long run) ;

- . the carbamates - one of the most well-known being Propoxur from Bayer developed mainly against mosquitos and sucking insects - are valued in many applications related to public Health, particularly against crawling insects, including fight against cockroaches in rubbish chutes.

Carbamates would have the advantage to selfdestroy rapidly after use and do not accumulate in the animals bodies - but they are considered as fairly expensive.

- Synthetic pyrethrinoids are the results of many research works contracted for obtaining new insecticides with the pyrethrum properties but with a more simplified chemical structure than the natural pyrethrins ones (it is known that natural pyrethrins having a very complicated chemical structure are very difficult to synthesize).

Allethrin has been discovered in 1949 by Schechter : it has been the first of a long family of pyrethrinoids, which represent now more than 30% of the world insecticides market.

Synthetic pyrethrinoids can be classified in 3 categories :

- First of all, those with good knock down performance, but with low residual activity, as

- . Allethrin Pynamin, the first synthetic pyrethrinoid, introduced on the market in 1949
- . Bio-allethrin Pynamin forte, superior to allethrin against mosquitos, developed in the 1970
- . S-Bio allethrin Esbiol - Knock down effect superior to allethrin bio-allethrin and even to natural pyrethrins. Its use remain important : For France solely production would represent dozens of tons
- . S-Biothrin EBT - It is a mix formulation containing 60% Bio-allethrin + 40% S-Bioallethrin endowed with a high knock-down power
- . Kadethrin Equally endowed with an exceptional high knock-down power
- . Tetramethrin Neo-pynamin, a product developed by Sumitomo - Japan from 1960, and later on by Endura - Italy when patents exhausted.
Active and photosensitive, it is a severe competitor for natural pyrethrins
- . Pralethrin ETOC, Neo-pynamin forte - a patented quite new derivative from Tetramethrin.
It is potentially the most dangerous competitor for natural pyrethrins, including on USA territory, as it is already agreed for food industries use in USA

Though it will be noted that most of these synthetic derivatives present an activity spectrum narrower than those of natural pyrethrins :

- . Allethrin derivatives (as Bio-allethrin, S-Biothrin and S-Bioallethrin) are now widely used for anti-mosquitos diffusing tablets, but they are not so efficacious against cockroaches.
 - . Tetramethrin and Pralethrin are frequently highly estimated except for fighting mosquitos. These two products would also be less effective than natural pyrethrins in term of "flushing effect", with view to push the insects, as cockroaches, out of the wall crevices where they took refuge.
- Secondly, those with good performances for killing effect, but with solely moderate performances as far as shock effect is concerned, all of them having the advantage of low residual activity, as
- . Resmethrin NRDC 104, developed around 1965 under various brand names (Cryson, SBP 1382, Pynasect)
 - . Bio-resmethrin NRDC 107, also developed around 1965

- . d-Phenothrin Sumithrin, developed in Japan, leave significant residual activity.

All these derivatives have been initially developed with view to associate them with those of the first category -- and to bring a complementary action by their killing effect on the insects which have been crashed under the knock down effect of the first.

- o Thirdly, the latest pyrethrinoids generation involve the halogen photo-stable derivatives : those are not again direct competitors for natural pyrethrins but they are promised - due to their photostability which ensure a long action duration - to a large market in agriculture (a market which is practically unimaginable for natural pyrethrins as they are too transient in their action and too breakable by light).

This third group contains as

- . Permethrin NRDC 143 (Pounce, Ambush, Permasect, ...)
- . Cypermethrin NRDC 149 (Ripcord, Barricade, Arrivo, Ammo, Cyperkill, Cymbush)
Twice more efficient than Permethrin ; would be produced especially in UK by Mitchell Cotts
- . Deltamethrin NRDC 161 (Decamethrin, Decis, Butox, K-othrin, all of them marketed by Roussel-Uclaf-Hoechst with a large success in agricultural treatments).
Would be 10 times more effective than Permethrin.
- . Fenvalerate S.5602 (Pydrin), mainly produced in Japan.

It is good to draw the attention on the very big research funds invested by big international companies to research and development of new performant insecticides, so important are the potential markets notably in the agricultural sector.

For these reasons, it has been published that

- . in 1985, areas receiving insecticides treatments were up to 80 million hectares representing a turnover - at the final user level - of 6 milliard francs (# 1,1 milliard US\$),
- . for 1990, the expectations for areas to be treated have reached 130 to 150 million hectares,
- . this explain why Roussel-Uclaf-Hoechst Group, as a following to the success of the Deltamethrin world sales, has recently announced that
 - a Decis producing factory will be built in a near future in China (Tianjin Roussel-Uclaf Pesticide Company), with a design adapted for producing also S.Biothrin,
 - Roussel research work is presently focused on a soil insecticide of the pyrethrinoids family (developed from 1993) and for obtention of an improved photostabilisation applied to a different insecticides family, the methoxy-acrylates,
 - development started about a new chemical molecule with a strong shock effect against flying and crawling insects with the view to complete directly with natural pyrethrins,
 - a definite policy for accelerating development works in this sector, with joining together under the unique name RUHE (Roussel Uclaf Hygien Environment) all the specialized companies recently bought - as Welcome Foundation/Cooper - UK, Penick - USA, FAC - USA - with the ambitious objective to reach a turnover amounting to 2.200 million francs (400 million US\$) by 1995.

In the field of photolabile insecticides, with a good knock-down effect - a field which was till now quite reserved to natural pyrethrins - it is advisable to pay attention to the recent development of 2 Japanese pyrethrinoids (Tetramethrin and Pralethrin - ETOC) the huge investment done by their inventor, the very powerful group Sumitomo, has been successfully granted by Pralethrin homologation in USA, for use in the premises of food industries.

It is sure that this type of competitor will intensify the struggle for the American market - and this explain our forecasts for a natural pyrethrins market possibly being maintained, but very probably having reached its maximum consumption level.

In other respects, due to the very important research work devoted to photostable pyrethrinoids usable in agricultural field - through very big companies, as Roussel Hoechst - it is likely that some of these new compounds will appear to be less photostable than expected and will be diverted in their development work in order to be marketed as natural pyrethrins competitors :
If natural pyrethrins are determined to keep their market-share, pyrethrum producers must satisfy the market supplies without falling off, but also they will have to optimize their yields and to reach so more competitive prices - and this will incline certainly the users to maintain their present formulations to which they have a real fondness (for a part, every change in the formulas require high expense in homologation fees, but also pyrethrum keep always the superiority in terms of "flushing effect")
Also pyrethrum is politically supported by ecologists due to its natural origin, its very low toxicity and its practical absence of dangerous residues.

9. LEGISLATION AND REGISTRATION APPLIED TO NATURAL PYRETHRINS AS TO SYNTHETIC PYRETHRINOIDS

As a consequence to the risks of residual toxicity and transmission all along the alimentation range in superior mammals, the legislation to be applied to insecticides become more rigorous :

the result is that, in many countries (and more especially in USA and Europe), launching of a new insecticide necessitate a previous homologation based on more and more costly toxicological tests.

In USA, pyrethrum enjoy a great favour for fighting insects in food factories - as its residual toxicity is very small, but particularly because it has been used from long without any damage reported :

For these reasons, EPA (Environment Protection Agency) authorities, considering pyrethrum as "cleared as safe", ask formulators for simplified file (with regard to the file and the experiments which would be required for introducing a new insecticide) this significative advantage granted to pyrethrum explain the very large use of pyrethrum and the relatively low success of synthetic pyrethroids in the USA market of food industries and health sector.

Meanwhile it is prudent to consider that pyrethrum will not be authorized in future without some constraints :

indeed upper-limits of insecticides allowed in food products for human use are stated by law and known as "tolerances" or MLRs (Maximum Residue Limits). These MLRs differ depending the type of food concerned and depending the different States of USA :

As an example, for pyrethrum, EPA (Environment Protection Agency) has fixed "tolerances" levels varying from 0,5 mg/kilo for potatoes to 3 mg/kilo for cereals (and for the synergist PBO tolerances limits vary from 0,25 mg/kilo for potatoes to 20 mg/kilo for cereals).

The result is that even pyrethrum has not to be applied ad libitum even its renown consider it as safe.

Meanwhile, by means of very restrictive tolerances for residual products, the final result is that introducing in USA new synthetic pyrethroids for human food application has been limited till now in a significant way.

From now, if a new insecticide (for example a pyrethrinoid) ask for homologation in USA for human food industry use, the EPA homologation file has to be completed by a FDA (Food and Drug Administration) approval which is granted only after submitting a toxicological file practically as important as if it is for a new human medicinal drug (NDA, New Drug Application). This procedure FDA, being very complicated and costly (2 million US\$), can only be anticipated by very strong companies (as SUMITOMO - Japan which has been successful, obtaining recently homologation for its Pralethrin - ETOC - for human food industry use).

As a consequence to the huge cost of new homologations - which is far over the financial possibilities of middle-size formulators willing to introduce new formulations or new ways of insecticide applications - a trend for reuniting producers - formulators is outlined in USA.

Very soon, it may be resulting in a very limited number of producing factories, frequently related to petrol companies (which are interested to consolidate a captive market for the solvents used as propelling agents for the sprays).

In future, very probably, small formulators will disappear or will limit their activity to market, under their own brand-names, standard formulations issued from big job-processor (who will have paid the homologation file for the formula he intends to produce and package at the names of its various distributors).

As a late information, it is to be known that, following to recent interventions probably initiated by pyrethrinoids producers lobby - the FDA (Food and Drug Administration) have just asked a complementary file to natural pyrethrins producers and users :

This has given rise in USA to a "task-force" joining producers and big users, with view to establish commonly the trials and the file aimed to confirm pyrethrum innocuousness (although assumed from long).

In Europe it is also required to submit a toxicological file for the new synthetic insecticides.

This file is usually financed by the producer of the bulk active product : a copy will be transmitted under closed envelope to the homologation Commission members, as an annex to the general file to be established by every formulator willing to develop a new formula based on this new synthetic insecticide.

Pyrethrum will keep its adepts in Europe, and more especially in Germany where synthetic chemicals are aggressively discussed since July 1993, under the political pressure of the green ecologist party.

It is also important to note that WHO (World Health Organization) has frankly encouraged the use of natural insecticides preferably to synthetic insecticides, due to the frequent resistance freaks and due also to their residual toxicity which is frequently very long-acting (cf. Pyrethrum Post 1990).

10. WORLD PYRETHRUM MARKET

10.1 Pyrethrum extracts : crude extract ("oleoresin") and refined extract ("pale extract")

10.1.1. Worldwide traded quantities

- Statistics can fluctuate from one year to the other : pyrethrum market indeed is affected by repetitive shortages arising regularly every 5 or 6 years (especially in 1978 - 1979 and more recently in 1987 - 1988).

These shortages arise usually as a following to an exceptional crop year : in this case, pyrethrum factories being unable to process and sell rapidly all the crop, they have tendency to refuse to buy the crop exceeding normal yields or to pay them very late to the growers.

These ones, disappointed, abandon their pyrethrum cultivations (usually established for 5 years) and return to food crops - with view to re-establish pyrethrum cultivations again when market will be normalized, but full yield of these new cultivations will require some years to be reached.

- Extracts are usually traded on a base price corresponding to an extract titrating 25% but qualities delivered are usually titrating 30-32%, sometimes 50% when refined extracts are concerned : Customs statistics are sometimes difficult to interpret as frequently they are recording the total of weights delivered, without any account of the contained pyrethrin activity.
- According to the opinion of the main professional users, pyrethrum worldwide quantities traded in 1993 amount to 200 tons pure pyrethrins equivalent :
 - The crude extract is produced and refined locally in Kenya and Australia - unlike the other producer countries as Tanzania and Rwanda, which have not at their disposal refining units, and for this reason are selling their crude extracts to specialized refining companies (MGK in USA and BEI in UK). Use of the crude extract as itself as insecticide is now insignificant, as this extract is so dark coloured that it is staining and, more, its waxes high content make it unsuitable for use in insecticides spray formulations (which represent now a significant part of the total consumption).
 - The refined extract, said "pale extract" is now the quality the most generally used.

10.1.2. Distribution of the usage level according to the countries

Statistical datas available at the time of the report writing are sometimes rather old - they have been up-dated as far as possible - but with difficulties from some countries reserved to communicate their statistical datas, probably for protecting themselves in terms of competition.

These datas have been crossed with the opinion of big world-users - who have at their disposal private market surveys, always considered as confidential matter.

In 1956, distribution of the consumptions was estimated as follows, based on a worldwide total market evaluated at that time at 100 tons per year (expressed in pure pyrethrins) and taking into account the percentages of consumption per country as mentioned by the Pyrethrum Board of Kenya.

USA	58 T PYRETHRIN 100% PURE, i.e. 58% of WORLD CONSUMPTION					
Far East	14.5 T	"	"	14.5 %	"	"
UK	9 T	"	"	9 %	"	"
France-Germany	2 T	"	"	2 %	"	"
Rest of Europe	3 T	"	"	3 %	"	"
Argentina	8.5 T	"	"	8.5 %	"	"
Middle East	2 T	"	"	2 %	"	"
Africa	3 T	"	"	3 %	"	"

From 1976 to 1980 the different international Customs statistics, which have been consulted for imports and exports, appear to point out a trend for the consumptions which was different for one country to the other - taking as a reference the average fluctuations on these 5 years and also on a forecast for world trade in the range of 150-170 tons per year (expressed in pure pyrethrins).

It is advisable nevertheless to use these figures as approximate, because Customs statistics are adding the imported (or exported) quantities, without taking care of their pyrethrin content (frequently it is 30%, often 25% and sometimes 50%).

USA	70 T PYRETHRIN 100% PURE, i.e. 40% of WORLD CONSUMPTION					
Far East	10 T	"	"	6 %	"	"
UK	25 T	"	"	14 %	"	"
France-Germany	10 T	"	"	6 %	"	"
Rest Europe of which Italy 10 T	25 T	"	"	14 %	"	"
Latin America	5 T	"	"	3 %	"	"
Middle East	0	"	"	0 %	"	"
Africa	5 T	"	"	3 %	"	"
Canada	10 T	"	"	6 %	"	"
Australia	10 T	"	"	6 %	"	"
Sweden - Finland	3 T	"	"	? %	"	"

In 1993, with reference to a world market now estimated up to 200 tons per year (expressed in pure pyrethrins) and following opinion of professional specialists consulted for the present distribution of the world consumption has now become

USA	100 T PYRETHRIN 100% PURE, i.e. 50% of WORLD CONSUMPTION				
Europe	50 T	"	"	25%	" "
Rest of World	50 T	"	"	25%	" "

with a large maintained potential in Far-East and Africa for the formulations widely utilized against mosquitos, in every place where populations are living in open houses (as example for mosquitos coils).

The real market, as the potential market, for China remain unknown today : China can easily become an important producer, for its domestic uses - but it is also a possibility to see China turn resolutely to synthetic pyrethroids (as a following to the late agreements with Roussel-Hoechst with view to initiate an important production plant for S.Biothrin and Deltamethrin - Tiansin Roussel Uclaf Pesticide Company).

10.1.3. Current prices

History : Selling prices of pyrethrum extracts fluctuated, from 1968 to 1993, not only under the pressure of world price inflation (1970-1977 essentially) but also as a consequence of the shortages period recorded in a quite cyclic manner (the most severe shortages having been felt in 1978-1979 and particularly in 1987-1988).

These large variations are very damaging for the maintaining of natural pyrethrins use, as every sudden price increase urge the user to turn to synthetic pyrethrinoids (as they are always available and at a much cheaper cost).

In other respects, every high prices period act also as enticing away the growers, on an irrational trend for increasing their pyrethrum cultivations acreage :

it will result in an over-production, which will induce a fall in market price at a level which become insufficiently profitable for covering cultivation costs and for competing with other traditional local cultivations - this is explaining the cyclic and periodic fluctuations affecting pyrethrum market from years.

Crude extract

Prices as listed hereafter correspond to FOB (Franco of Board) prices as practised for pyrethrum crude extract 25% from African source (all prices quoted by the various African producers are very similar and always high in scarcity times, but lower prices, by 5 or 10%, are sometimes practised by less organized producers when there is over-production or when they want to reduce their stocks level).

FOB PRICE PYRETHRUM EXTRACT CRUDE 25% - AFRICAN ORIGIN				
1968... 20 \$	1973... 19 \$	1978... 26 \$	1983... 38 \$	1988... 55 \$
1969... 18 \$	1974... 21 \$	1979... 35 \$	1984... 24 \$	1989... 58 \$
1970... 17 \$	1975... 22 \$	1980... 63 \$	1985... 24 \$	1990... 62 \$
1971... 17 \$	1976... 23 \$	1981... 45 \$	1986... 25 \$	1991... 64 \$
1972... 18 \$	1977... 24 \$	1982... 40 \$	1987... 47 \$	1992-93 66 \$

Refined pale extract

Prices applied for the refined extract, said "pale extract" are usually 17 to 25% higher than crude extract prices and this is confirmed on many years.

As example, in January 1990, Kenyan pale extract 25% AOAC was quoted 70 \$/kilo FOB - and at the same time crude extract 25% was sold at 60 \$/kilo FOB - it is to say a difference of 10 \$/kilo (= 17%).

In 1993, pale extract 25% was frequently sold at 80 \$ and crude extract 25% at 66 US\$/kilo FOB - it is to say a difference of 14 \$/kilo (= 21%).

As an evidence, price quoted for pale extract is fluctuating according to the quantities purchased and to the position of the buyer in the pyrethrum business :

for these reasons, it will be possible to see big quantities sold from Kenya at 75-80 \$ for pale refined extract 25% - but prices will be in the range of 80 to 90 \$ for small orders lower than 1 ton issued from European small final users (these customers are not buying directly to the refining companies, but through large international merchants who buy important lots and take the risk to build in Europe-big stocks immediately available).

It is good to know also that refined extract price inside USA is traditionally higher than in Europe : in 1993, face to 80 \$/kilo prices noted in Europe, domestic prices in USA were reaching 90 \$ and more they concern a pale extract quality standardized only at 20% (instead of 25% when European quality is concerned).

It seems that this high prices policy go back historically to the epoch when the main pyrethrin competitor was Dow Chemicals Company, selling at high prices its synthetic organophosphide insecticides.

10.1.4. Mid-term market trend

For crude extract, the sales for use "as it is" will tend to disappear as the dark colour of this extract occasion sometimes disagreements (as surface staining where the insecticide has been applied or as sprays nozzle clogging due to the high wax content of the crude extracts).

Crude extract sales will be maintained by the producing countries which are not equipped with refining possibilities - but these producing countries may be submitted to pressures of refining companies - as these are now only 4 of significant size in all the world (MKG in USA, BEI in UK, PBK in Kenya - this one being at the same a big producer and seller of crude extract - and Ecuador, treating its own production).

The future of crude extract trade will depend for a large part of the decisions to be taken soon by MGK - USA : M. Le Mouel indeed, in his 1991 report, was stating that the MGK Minneapolis - St. Paul factory was built in the years 1950 and arrived to the end of its economic existence ; he was reporting equally that - due to internal reasons, MGK Board had postponed the decision to build a new plant.

If this new plant is created, MGK will continue to be an important buyer of crude extract. On the contrary, if MGK would decide to save and not to build a new refining plant in USA, possibly preferring to deal with Australia or South Africa, it will result that the crude extract market of the traditional African producers would considerably decrease :

It is wise to recommend to the crude extract producers to establish links or long-term contracts with refining companies, or alternatively to equip themselves with refining possibilities as a safeguard for their cultivations keeping.

For refined extract, said pale extract, sales will be more and more focused on this quality which is a need for spray formulas.

With the arrival of new refining technologies, new qualities sometimes far more concentrated in pyrethrins will be available to the users - but till now there is no major interest established for these qualities, as everyone can fear an increased weakness of the highly purified pyrethrins.

To be noted that, if pyrethrin stability may be extended through various methods as micro-encapsulation, in a significant way (as some recent experimentations seem to have succeeded for) - it would be a great interest for one of the producers to realize himself this micro-encapsulation and to offer to the formulators a well controlled micro-encapsulated pyrethrins grade able to be used in every formulation, including insecticides sprays.

Natural pyrethrins utilizations (mainly under the form of refined extract quality) differ from country to country :

• In USA

75% of the consumption (i.e. 75% of the 100 T consumed, as expressed in pure pyrethrins) are utilized for insecticide treatments in food industries plants.

25% of the consumption are utilized for household insecticide sprays, particularly for all the public health sectors (including disinfection of hospitals and public buildings) and also for disinfecting the rubbish chutes (pyrethrum being a very effective repellent agent against cockroaches

This favourable opinion for pyrethrins is an attitude typical to Anglo-Saxon mindful to use insecticides which will not let damageous residues and recognized as inoffensive through a long experience of its use.

• In Europe

Pyrethrins sales in food industries are - at the opposite of USA - small in France and Germany.

Also pyrethrins use in the public health sector is quite less in Europe than in USA.

Consumption of natural pyrethrum in Europe is essentially directed for household insecticide sprays : an extension of the consumption should be possible, mainly for disinsectization of the rubbish chutes, as pyrethrum effect on cockroaches is spectacular and far superior than most of the competitive products.

However, European countries with Anglo-Saxon culture or under influence of ecologists (as the "Green" political party in Germany) support more and more the WHO recommendation adopted in 1990 in favour of natural insecticides use, rather than synthetic insecticides use, due to the induced resistance risks assumed by synthetics and due to the residual toxicity risks as a following to their use.

If pyrethrins based insecticides formulators argue on these elements, keeping and possibly increasing significantly the European consumption may be hoped for in the coming years.

On the contrary, there is no real hope for an extension of natural pyrethrins use, at a large scale, for agricultural treatments due to their photolability, all the more as long acting synthetic pyrethrinoids (as deltamethrin) have acquired a solid position in this important market share.

However, for specialized cultivations, natural pyrethrins can be the right answer for precise needs :
for example, in mushroom beds where photolability is no more a risk and where pyrethrins are the good choice for destroying various dipters and some dust mites of Tyroglyphus family (cf. LHOSTE - Phytoma 61); some people have also recommended them for biological cultivations, but it is not at all sure that it would represent a significative consumption.

10.2 Dried flowers powder

Flowers powder is the usually sold grade - as it is less bulky than not ground entire dried flowers : this allow a good saving on the shipping costs (in 1984, shipping cost was 130 \$/ton for Japan, 220 \$/ton for USA and 115 \$/ton for Europe, i.e. about 5 to 10% of the FOB price).

Standard grade for flowers powder contains 1,3% pyrethrins in average, but Kenya is also offering a grade titrating 0,6% only (prepared as a mix of flowers powder and pyrethrum marcs, in equal parts, this quality would be always appreciated in some countries - according to PBK information).

Prices in use for flowers powder grade (with a 1,3% pyrethrins content) increased from 1977 to 1981, about in the same proportion than extract prices, passing from 0,80 \$/kg in 1970-1977 to 2,50 \$/kg in 1981. This last quotation tend to fall for a part now, as a consequence of large quantities offered in a market where the demands are lower than before.

FOB PRICE PYRETHRUM FLOWERS - AFRICAN ORIGIN						
Years	1976	1977	1978	1979	1980	1981
Price in £/T	419-434	450-480	520-545	488	822	1282
Price in \$/kg	0,80	0,80				2,50

Flowers powder exports are handled essentially by Kenya. Tanzania is exporting much less quantities, mainly to Japan and China. Ecuador exports, not regularly, to USA and Latin America markets. South Africa appears for the first time on this market in 1981.

PYRETHRUM FLOWERS POWDER - QUANTITIES EXPORTED						
Exporters	1976	1977	1978	1979	1980	1981
Kenya	3665 T	3276 T	1395 T	564 T	554 T	422 T
Tanzania	389 T	456 T	289 T			
Ecuador	165 T	150 T	5 T	12 T		

Flowers powder imports - which are more or less the reflect of the consumption - were large till 1977, mainly for East Asian countries and also Italy.

A sudden consumption fall has been recorded after 1976 in Malaysia (which was the most important East Asian consumer) as a following to shortage and resulting price increase :
Malaysia decided at that time to abandon definitively pyrethrum and to turn itself to synthetic pyrethrinoids for their mosquitos coils productions.

Also Italy, biggest European consumer at that time, reduced considerably its consumption from 1975 and especially 1978.

Only the Caribbean decided, in 1984, to return to pyrethrum powder as active insecticide matter for their mosquitos coils production, but impact on world trade will be insignificant : it is likely that a large part of the pyrethrum powder imported by USA is re-exported for Caribbeans and Latin America needs, as direct imports from producing countries are rarely reported in the consulted customs statistics.

PYRETHRUM FLOWERS POWDER - IMPORTED QUANTITIES ***						
IMPORTERS	1976	1977	1978	1979	1980	1981
Japan	700	716	375	130	250	-
Hong-Kong	528	219	152	60	15	-
Malaysia	520	486	120	55	50	70
Singapore	-	-	100	-	-	-
China	163	-	62	?	?	?
Thailand	25	-	158	-	-	-
USA*	81	130	130	130	130	130
Argentina	47	30	-	12	?	?
Colombia	15	-	-	5	?	?
Brazil	-	-	50	15	-	-
Spain	100	31	38	40	90	71
France	-	-	-	15	-	-
Greece	-	143	70	60	70	60
Italy	155/254	146/319	32/119	-	10/39	5
U.K.	-	-	-	-	65	15
Belgium	-	-	-	29	-	-
Netherlands	101	-	-	-	?	?
India	75	119	70	49	45	190

(*) USA figures correspond to the total "flowers powder + marcs", the last ones being not distinguished in the consulted statistics.

(**) Italian figures vary according to their origin : nevertheless they corroborate the sudden fall in consumption after 1978

(***) Due to the limited quantities worldwide traded specific statistics for pyrethrum flower are not frequently recorded from 1981, and pyrethrum flowers imported quantities are included in more general headings.

10.3 Marcs (i.e. Extraction Residues)

The pyrethrum flowers extraction residue, named "marcs", was used traditionally as one of the components for mosquitos coils preparation mixture, especially in South East Asia :

It seems however that marcs were only a support or an inert excipient, without any residual insecticide activity (as pyrethrins have been totally extracted).

Marcs exportation declined strongly, because it is a small value item, costly to transport and able to be replaced by other vegetal scraps in powder form, available at low cost in the vicinity of the user factory.

Traded prices for extracted pyrethrum flowers marcs

FOB PRICES FOR PYRETHRUM MARCS						
Year	1976	1977	1978	1980	1981	1982
Kenya	49 £/T	57 £/T	79 £/T	108 £/T	119 £/T	75 £/T
Tanzania	49 £/T	60 £/T	59 £/T			

These prices are equivalent to about 1/10 of the flowers powder price - i.e. about 100 \$/ton in 1975 and 150 \$/ton FOB in 1984 : on a so small value material, incidence of shipping cost (130 \$/ton for Japan in 1984) resulted in the doubling of the marc price and in rendering its cost prohibitive.

Marcs exports were done mainly by Kenya and at a smaller scale by Tanzania. Of course, Rwanda was not a participant to these exports, as - and it was the same for pyrethrum flowers - its geographical situation in the heart of Africa refrained to be competitive due to the transportation costs to African harbours which were adding to the shipping costs.

PYRETHRUM MARCS - EXPORTED QUANTITIES						
Exporter	1976	1977	1978	1979	1980	1981
Kenya	1626 T	3407 T	5270 T	2646 T	3695 T	2680 T
Tanzania	1810 T	1637 T	1805 T	?	?	?

Till 1978, Tanzania was exporting its entire marcs production to Japan.

Marcs imports were handled for the larger part by South East Asian countries, especially Japan, but market stopped suddenly in 1979 when appeared a great shortage and a blazing-up of the prices : the result of this has been the withdrawal of pyrethrum and its replacement by other components for mosquitos coils - as these products are sold to people with a low income.

PYRETHRUM MARCS - IMPORTED QUANTITIES							
Importer	1970-75	1976	1977	1978	1979	1980	1981
Japan	5000 T	1000 T	2976 T	6189 T	2450 T	3486 T	2225 T
Malaysia	?	-	5 T	380 T	130 T	100 T	200 T
Hong-Kong	?	100 t	-	300 T	-	45 T	40 T
USA	?	-	-	50 T	50 T	50 T	50 T

11. SALES AND MARKETING PRACTICE FOR PYRETHRUM EXTRACTS

11.1 Present state

The pyrethrum (and pyrethrum extracts) world trade structures is the direct consequence of the particular aspects existing for this market, i.e. :

- a very limited number of producers (for the pyrethrum plant as for the crude extract), most frequently located in the heart of Africa (Kenya, Tanzania, Rwanda) with some other less important productions elsewhere (Ecuador, Papuaasia-New Guinea, Australia, South Africa, India) - Kenya being the world's dominant producer, accounting for an average of half of world production, but often rather 70 to 75%,
- an even more limited number of processors of pyrethrum extract into a high grade refined product - which provide them evidently a dominant position as buyers.

Today there would only remain 3 as large refining companies

PBK (Pyrethrum Board of Kenya)

MGK (McLaughlin Gormley King Cy)USA

BEI (Botanical Extract International) UK

and 3 less important ones in Ecuador, Malaysia and Australia (CIG - Commonwealth Industrial Gases Ltd).

An English company Mitchell Cotts Chemicals Ltd, that built and owned the crude extract Tanzanian plant, was acting as a refining processor in UK till 1960 : they totally stopped their natural pyrethrins activity at this time, in the years 1960, and turned their production toward synthetic pyrethroids (permethrin, cypermethrin),

- a very large panel of formulators and end-users, of very unequal size
 - . 2 are very important : SC Johnson - USA and RUHE (Roussel Uclaf Hygiene Environment, which group the former activities of Wellcome and Cooper),
 - . possibly 500 small formulators spread in all countries.

This explain why pyrethrum (and its derivatives) trade - from the producing country to the final industrial end-user - is organized along a trading chain with many intervening people (from the exporter to the end-user, with assistance of importer/agent, processor in refining and wholesaler or retailer).

The interest for wholesaler-retailer is justified in this pyrethrum market for 2 reasons :

- . first of all, the final market being very diversified, orders are small sized and commercial approach of the customer is not valuable except in the frame of a large list of products offered simultaneously, as a wholesaler is able to do,
- secondly, the wholesaler store a stock ready for sale - which will play as a buffer-stock in case of bad crop or of sudden price increase.

According to the fact that the 2 large users (SC Johnson and RUHE) are, for each of them, consuming bigger quantities of pyrethrum extract than each of the whole-salers, it is not abnormal to see them contracting directly their purchases with the producing countries or with the refining processors companies.

It is to be pointed out, that each time prices vary, new traders appear in this market with view to conclude exceptional speculative financial gains, which in fact contribute to increase the momentary unbalance.

Invoicing and payment of pyrethrum extracts deliveries is done according to the standard content announced by the producer (30 - 31% for crude extract, 20 or 25% for standard refined extract, sometimes 50% on special request).

The content will be checked on arrival by the purchaser and final settlement will induce a complementary invoice (or a credit note), depending the final content agreed by both parties.

In USA and Danemark, the deliveries are analysed according to AOAC method, when for the other markets deliveries are invoiced according PBK method (which provide slightly higher results, about by 10%, than by AOAC method).

Specialists of this international trade are used to juggle with these discrepancies and have them evidently in mind for fixing their quotations : on the contrary, it is wise for non-specialists to pay special attention comparing statistics and prices arriving from various countries.

11.2 Predictable evolution

Stable prices policy is a constant demand from the industrial users : this would need establishment of important buffer-stocks in order to face up with cyclic shortages - but as regards to their financial cost, the wholesalers-retailers fail now to assume this responsibility.

It is an evidence that the best would be to see the producing countries building themselves the security stocks, either independently or jointly for the 3 African producers in the frame of RWATAKE : but their interests are too frequently divergent and the economy of these countries is often too weak for supporting such financial burden.

No one has discovered till now the right solution and it is not easy to imagine and to bring to reality, particularly with the mid-term risk of the Australian coming competition.

Increasing cost of homologation files (for new formulations, for complying old formulations files with the new standards or for reapproval of obsolete plants after modernization) will make small producers disappear or rejoin for financing the studies in common.

Tendency, very shortly, will be to establish aerosols packaging plants able to centralize the production for a large part of a country, acting as job-processors or sub-contractors on behalf of all the existing formulators (which, consequently, will turn into selling or distributing companies and will stop to be producers themselves) :

these large sub-contractors will assume the homologation cost for the formulas they offer, these formulas being frequently identical for many of the customers (the final product will be only differentiated through its packaging, its brand-name or the choice of promotion).

Large petroleum companies have already taken an interest in this developing industry, for the important captive markets represented by the gas or the solvents used as aerosol spray propellers.

In addition to, mosquito coils will continue for a long time to be produced and sold in Africa and South East Asian countries - as they are and will be widely used in every country where wages are not sufficient for buying aerosol sprays, but also in all countries where open-housing is usual - as it is traditional in Africa.

As far as this particular market is concerned, all future will depend on an efficient marketing approach and also on the success of the new pyrethrinoids (which are evidently willing to enter in this specialized market share, where Japan was long in a dominant position - as Japan was in fact the unique country to manufacture and offer for sale the equipments used for coils production).

At last, it will be a necessity for each producing country to do very soon a choice which will commit the future of pyrethrum for their country :

- on the one hand, African producers anxious to ensure many small growers this minimum life income (and to their country a significant return of currencies) will try to maintain this activity under direct governmental control - as any decision in pyrethrum price policy have an important socio-economic influence.
Nevertheless it appears that cooperation between African producers (RWATAKE) has not been able till now to reach a true concerted policy, so the interests are often divergent,
- on the other hand, the imminent arrival of Australian (and possibly South African) productions will upset many of the traditional links formerly existing between producing countries and large users.

Australia chiefly will provide a supplying security to their customers (based on their large, mechanized and well organized cultures) - at the opposite of African countries (where small growers are frequently reacting on an unpredictable and emotional way, at any important price fluctuation).

But Australian activity will be certainly submitted to imperious profitability ratios (as any private Anglo-Saxon industry), it is possible that export quotations offered for Australian extract will be superior to the African ones, as long as improvement of strains will not have provided sufficiently high yields to be able to pay for the investment loans and to grant a satisfactory capital return - a situation which differs totally from Africa where price fixing policy is more submitted to political than economical interests.

It is an evidence that in a very near future, the various important organizations involved in pyrethrum business will have to fix for themselves their supplies strategies, making their choice between the following options and inventing a new relations scheme, their essential objective being to be granted with a good supply security and favorable long term pricing :

- . maintain strong links with Kenya - important, reliable and traditional producer,
- . keep a part of purchases from Tanzania and Rwanda, as a possible counter-balance to Kenyan pressure and also to dispose of an alternative supply security in case of emergency as social disturbances or factory break-down in Kenya,
- . act with the idea of a new relationship, to be established with Australia whose methods for work are nearer to the American mentality.

For all these reasons, small producers, if they have not at present any refining possibilities, will have a direct interest to establish solid contractual links or pluri-annual contracts for supplies : this can be done either in a frame structure as RWATAKE, or with some of the larger industrial users.
It is extremely important for them to pay attention to this recommendation - as it is an existing big risk, if nothing is decided, to see them rapidly rejected out of the world pyrethrum market trade, which will be soon reorganized on absolutely different basis - as a direct effect of the new people intervening in this business.

12. SURVEY OF THE DIFFERENT PRODUCING COUNTRIES

12.1 KENYA

Kenya is, since 1956, the world most important pyrethrum producer : depending the years, it represents 50 to 80% of the total world production.

In the frame of a planned economy the total production chain from the plant growing till the extract production is mastered from the beginning to the end, with the control of a unique organism, P.B.K. (Pyrethrum Board of Kenya).

The history of pyrethrum production in Kenya has been related and published by TURKONG (cf. Pyrethrum Post 15(4):113 - 117).

Agricultural production

PBK - which dispose of its own extraction and refining facilities at Nakuru - keep under its direct control the agricultural cooperative stores which gather many small growers.

Quantities collected have always fluctuated considerably from one year to the other, as a consequence of climatic variations and also of the economic appeal of other more profitable cultivations.

KENYA PYRETHRUM FLOWERS PRODUCTION (dried flowers)																
1973	1974	1975	1976	1977	1978	1979	1980	1981	1982		1985		1991	1992	1993	1994
T 11000	T 14000	T 15000	T 14000	T 13000	8500	7670	T 10000	T 15000	T 19000		T 3000		T 9000	T 9000	T 15000 (*)	T 15000

(*) estimated

N.B. - The 1982 crop has been larger than the extraction possibilities of the factory and than the world market demand for pyrethrum extract : the resulting effect was an important un-sold stock and a refusal from PBK to buy to the growers a part of their crop. The downhearted growers decided consequently to reduce the acreage of their pyrethrum cultivations and the production fell sharply, dropping to 3.000 T in 1984-1985.

Development of new high yield strains

WANGELA - on small experimental plots cultivated in 1989-1990 with a sufficient fertilizer in-put - pointed out that

- the dried flowers yield per hectare can fluctuate from 850 to 1.750 K, most of the results being between 1.000 and 1.200 K,
- pyrethrin content can fluctuate from 1,8% to 2,4%,
- pyrethrin content can reach 2% if rains have been sufficient (with a required minimum of 1.000 mm/year).

In other respects, Kenya published (cf. Pyrethrum Post 1990) that they succeeded in multiplying clones through tissue culture method, with view to be able to realize sowing when they want : it seems that this work remain experimental.

Flowers purchasing price at the growers level

In 1962, in Kenya, 1.000 m² of pyrethrum culture was bringing to the growers 10 £ per year as revenue - at the same time, the average yearly earning of the agricultural people in Kenya was 18 £ : this explain the interest taken at that time by the farmers to this profitable cultivation.

Purchase price stayed practically unchanged during the 1970 years under pressure of the buyers - although in Kenya along the same years other cultivations became more attractive.

As a following to the exceptionally large 1982 crop, one part of which having not been taken by PBK, growers disaffection was immediate : PBK has been obliged to double the purchase price 1989 (27 sh/K) and to reach 50 sh/K in 1990 for interesting growers again and hoping a renewal of the cultivations with a crop objective of 12.000 T.

N.B. - This price policy - which has been also applied in other African countries - appear to be finally very baneful : it induces important production fluctuations as a suddenly increased price attract fickle cultivators solely interested by speculative crops.
Supporting of faithful growers is the only way for yields improvement, as this is a progressive result directly related to the experience of the cultivation.

N.B. - In Kenya, grower is paid according to the dried flowers weight remitted, with price scale depending upon the pyrethrin content.

Extraction capacities (cf. Pyrethrum Post 1979)

The initial factory (1956) was built for 3.000 T per year of dried flowers extraction capacity.

A second extraction line, working with solvent, built in 1961, double the capacity - which so reached 6.000 T/year.
At the same time the processing facility has been completed by a refining equipment.

In 1974, Kenyan extraction capacity was extended to 12.000 T/year :
Extraction using hexane in a counter-current process, starting from grists (coarsely ground flowers). The equipments include an inert gas generator, used for avoiding the fire risks during handling or during hexane recovery.

Presently, Kenya appears to refine the equivalence of 9.000 tons per year of dried flowers.

It has been reported that average extraction recovery yield in Kenya was as high as 1,25% face to the dried flowers weight put into processing.

12.2 TANZANIA

Tanzania was so far the second world producer, with about 20% of the world production.

Agricultural production

Tanganyika (or Tanzania) Pyrethrum Board - which own an extraction unit at Iringa (the extraction plant located at Arusha-Kilimanjaro having been closed) organize pyrethrum cultivations mainly in Iringa and Mbeya districts.

As in Kenya, quantities produced fluctuated largely depending the years, partly as a following to a fall of the world demand and of a price decrease applied to the flowers paid to growers, but mainly due to a turn of the growers to other, more profitable cultivations (as maize in low hills and potatoes in higher altitude).

TANZANIA - PYRETHRUM FLOWERS PRODUCTION (dried flowers)												
1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1992	1993	1994
T 4000	T 3300	T 4800	T 4000	T 3300	T 2900	T 1500	T 1600	T 2000	T 1900	T 1800	T 1500	T 1500

(estimation)

Purchasing flowers price at the growers level

The recent years statistics for Tanzania having not been received, it is of interest nevertheless to consider and to keep for memory in this document the evolution of the past available years.

TANZANIA - PURCHASE PRICE DRIED FLOWERS					
QUALITY	PYRETHRIN CONTENT	1979/80	1980/81	1981/82	1982/83
Grade 1	> 1,4%	7,50 sh/K	11 sh/K	13 sh/K	13 sh/K
Grade 2	1,3 - 1,39%	7 sh/K	9,50 sh/K	12 sh/K	12 sh/K
Grade 3	1,2 - 1,29%	6,50 sh/K	8,50 sh/K	11 sh/K	11 sh/K
Grade 4	1,1 - 1,19%	6 sh/K	7,50 sh/K	10 sh/K	10 sh/K
Grade 5	< 1,1%	5,50 sh/K	6,50 sh/K	9 sh/K	9 sh/K

These prices - expressed in Tanzanian Shillings per kilo of dried flowers - were reported by ROBBINS in his June 1984 report

N.B. - Prices for 1981/82 and 1982/93 were equivalent to 95 US\$ per kilo of pyrethrins 100% contained - at the same time, prices for refined pale extract began to drop.

(Prices equivalent to 292 US\$ per kilo pyrethrins 100% in refined extract were reported in February 1983 and even more price 175 \$ was quoted mid-1983).

Price paid to the grower is therefore corresponding to an important part of the final selling price of the extract.

N.B. - It will be noticed that, as in Tanzania as in Kenya, the growers are paid according to the pyrethrins content :

It has not been possible to the author to understand how analytical pyrethrin content can be validly done, except if analysis is effected on very large size batches corresponding to joint deliveries of several growers, possibly on the average content of each drying center.

Extraction capacities

- . In 1960, the plant was the property of Mitchell Cotts - UK.
- . A plant formerly located at Arusha - Kilimandjaro is now closed : production has been centralized at Mafinga near Iringa, at proximity of the cultivations areas of Iringa and Mbeya.
- . In 1983, the plant was only producing crude extract grade, with 29-30% pyrethrin content (at that time, a project for a refining unit has been studied, but finally delayed).
- . Tanzanian productions reached 118 T of crude extract in 1976, but afterwards they declined very hard and now the plant works far below its nominal capacity.

Sales of pyrethrum flowers powder and marcs

Traditionally, Tanzania had a regular market for pyrethrum powder :
Since 1979, a large part of these exports are sent to neighbouring African countries, notably for domestic productions of mosquitos coils. It differs from the past, as till 1976-1977, 400 to 500 tons were regularly exported to China, Japan and South East Asian countries. Sometimes sales to USA are identified, with a possible re-export to Latin America and the Caribbean Islands.

Besides these powder exports, Tanzania was exporting much larger quantities of pyrethrum marcs :
Up to 1983, Japan imported 1.500 tons per year but this market collapsed and Tanzania is reduced to sell the marcs to local producers of mosquitos coils or even as cattle feeding.

Sales of pyrethrum extract

Tanzania remain a regular supplier for crude extract : American refining processors maintain interest for and Tanzanian exports to USA are in the range of 20 to 30 tons per year, with a price frequently slightly lower than Kenya extract price (this is related to the fact that these exports are crude grade before refining and also because Tanzania is not supplying the 50% grade appreciated by a part of the users).

12.3 RWANDA

Rwanda was considered as the 3rd important producer, with a market share approaching 5 to 10% of the world production :
Unhappily, insecurity and war conditions in the cultivations areas disorganize a large part of the crops from 1990 to 1994.
 When peace returns, everyone hope that Rwanda will recover its position on the international market.

Agricultural production

In Rwanda, pyrethrum cultivation is handled by a large number of small growers (about 7 to 8.000) ; they are

- . either independent farmers, growing only pyrethrum on lands granted by Government to the Rwanda Pyrethrum Office (= Office du Pyrèthre du Rwanda - OPYRWA). In 1990, these growers cultivated 760 hectares, all of them with pyrethrum,
- . or farmers having joined a cooperative organization named "paysannats" : in this system, the lands granted by Government are allocated 1,80 hectare for each farmers family - with a contractual obligation to keep for pyrethrum 40% of the land (i.e. 72 ares).
 In 1990, 2.645 hectares (on the total Rwandese cultivation of 3.405 hectares) were cultivated, in the frame of the "paysannats".

N.B. - Real average areas cultivated for pyrethrum in the "paysannats" are only about 42 ares, i.e. a little below 60% of the contractual engagements (it is the consequence of food crops cultivations, essentially potatoes which would provide a revenue 4 times higher - and lack of constraints against failing growers).

The panel below recall the history of pyrethrum cultivations in Rwanda.

RWANDA - PYRETHRUM CULTIVATIONS								
1976	1977	1978	1979	1980	1981	1982	1983	1984
3.234 H	2.816 H	2.512 H	2.435 H	2.529 H	2.669 H	2.828 H	2.631 H	2.468 H
1985	1986	1987	1988	1989	1990	1991	1992	1993
2.360 H	2.019 H	2.244 H	2.295 H	2.797 H	3.405 H	3.478 H	4.018 H	2.389 H

Fresh flower yields per hectare are largely related to the efficiency of the agricultural advisors acting in the growing areas (their number and their attendance have been increased since 1987).

RWANDA - FRESH FLOWER YIELDS / HECTARE							
1975	1976	1984	1986	1987	1988	1989	1990
2.550 K	2.600 K	2.329 K	1.463 K	1.155 K	1.313 K	1.464 K	1.616 K

N.B. - It will be a must for Rwanda to renew rapidly with the yields obtained from 1975 to 1984 :
The present yields are not sufficient to interest growers to maintain pyrethrum cultivations in future.

Pyrethrum flowers purchasing price at growers level

In Rwanda, the flowers are bought to the growers per kilo of fresh flowers, with a theoretical moisture content of maximum 80% :
For Rwanda, production figures are accordingly expressed in fresh flowers weight, which differs from figures recorded for Kenya or Tanzania.

RWANDA - PRODUCTION PYRETHRUM FLOWERS (fresh flowers)								
1975	1976	1977	1978	1979	1980	1981	1982	1983
8.765 T	7.500 T	5.680 T	4.598 T	4.092 T	4.808 T	4.814 T	5.526 T	5.979 T
1984	1985	1986	1987	1988	1989	1990	1991	1992
5.745 T	3.928 T	2.954 T	2.593 T	3.012 T	4.086 T	5.503 T	4.527 T	6.350 T

N.B. - 1993 crop has been estimated at only 3.500 T, due to insecurity in the cultivations areas.

N.B. - In order to compare the different statistical datas and to obtain an approximate value for the crop expressed in dried flowers weight, it is usual to consider that, after drying, the final dried flowers weight is equivalent to 20% of the fresh flowers weight put in the drier.

Flowers purchase price is therefore fixed per kilo of fresh flowers, without a real moisture control and also without any possible evaluation of the pyrethrin content.

RWANDA - PURCHASE PRICE FRESH FLOWERS PER KILO								
	before 1975	1975	1982	1987	1988	1989	1990	1991
Rwandese Francs	9 RF	12 RF	17 RF	17 RF	17 RF	18 RF	20 RF	21 RF
US \$								0,18 \$

N.B. - Based on 125 K fresh flowers → 25 K dried flowers → 1 K crude extract, the purchase price of the flowers was, in 1990, representing more than 50% of the extract cost price.

Development of new high yield strains

Climatic conditions existing in Rwanda would be particularly favourable to high pyrethrins content : several authors reported contents up to 1,5%.

It has to be noted that in Mr. Le Mouel report, some special clones have given in 1991, in collection small parcels, 7.000 K fresh flowers yields per hectare and some others reached 2% pyrethrins content (instead of 1,3 - 1,5% as usually reported).

In reality, these figures can be largely surpassed in Rwanda - as, in 1982, Dutch specialists from ILACO company (acting under contract FED/EEC) have made selections and first multiplications for exceptional clones, with 3 to 3,5% pyrethrins content and providing crops as high as 1.600 K dried flowers per hectare (# 8.000 K fresh flowers). These figures surpassing the best results reported by the Australians in their section works, it shows that Rwanda has at its disposal an exceptional asset to be considered and not neglected.

Flowers drying

- Theoretical yield at the end of the drying operation have to be

Fresh flowers	80% moisture 20% dry matters
Dried flowers	20% dry matters 2,2% moisture (= 10% of the final weight)

i.e. is equivalent to 22% of the fresh flowers weight put into drying process.

. The expected yield is to recover 20% as dried flowers from the fresh flowers weight put into the drying process.

- . The effective yield frequently is very lower :

RWANDA - YIELD DRYING FLOWERS					
Theoretical yield	Standard yield	effective yield			
		1987	1988	1989	1990
22 %	20 %	19,24%	19,35%	19,97%	19,04%

(cf. Report Le Mouel 1991)

N.B. - At drying stage, 15% of the whole pyrethrins would be thus lost. It is impossible presently to confirm this assumption, as long as there are no moisture content evaluations at the reception of the flowers and at the end of the drying. The use of simple moisture testers ought to allow a better control and a sure improvement of yield.

Extraction recovery yield

The factory has been designed for providing a standard yield of 4,5% pyrethrin extract (titrating 31% pyrethrins content), this 4,5% being expressed with regard to the in-put weight of dried flowers.

This yield was regularly reached in 1980 - 1982 with a rigorous, well-trained and supervised staff.

Extraction yields fell later and are not kept under satisfactory control since that time - but would be possible to improve again as soon as the new staff will have been trained for :

RWANDA - EXTRACTION YIELD / DRIED FLOWERS							
STANDARD	1980	1985	1986	1987	1988	1989	1990
4,5%	4,57%	3,31%	3,93%	4,02%	4,10%	4,34%	4,20%

Quantities produced in pyrethrum extract

The factory was built for processing 3.000 T dried flowers per year and for turning them into 130 T pyrethrum extract (titrating 31% pyrethrins content) : the quantities obtained are far below and this production plant, over-sized compared to the present agricultural crops, is under-employed.

RWANDA - PRODUCTION CRUDE EXTRACTS (in tons)						
1975	1976	1977	1978	1979	1980	1981
95 T	59 T	60 T	35 T	38 T	39 T	28 T
1982	1983	1984	1985	1986	1987	1988
39 T	0	55 T	22 T	62 T	21 T	30 T
1989	1990	1991	1992	1993		
34 T	32 T	31 T	45 T	30 T		

N.B. - A refining equipment unit exists at OPYRWA factory but has never been operating in a satisfactory way : Rwanda, for this reason, exports only pyrethrum crude extract.

In 1993-1994, UNIDO decided to let survey the equipments of the refining plant always unused and to ask vegetal extraction specialists for studying and suggesting an economical and workable process, in order to enable Rwanda to offer the refined extract (named pale extract) as the world market for this quality is much more open.

12.4. PAPOUASIA - NEW GUINEA

Agricultural production

Pyrethrum cultivation was initiated in Papouasia - New Guinea, in 1960, developed till 1970, before returning to an annual 200 - 300 tons dried flowers level, produced by many small growers.

PAPOUASIA - NEW GUINEA - PRODUCTION PYRETHRUM FLOWERS					
1970	1970-75	1978	1979	1980	1983
450 T	315 T	153 T	159 T	200 T	300 T

(expressed in dried flowers weight)

Pyrethrum content in Papouasia - New Guinea flowers, would be high, in the range of 1,4 to 1,7%.

Extraction capacities

Papouasia - New Guinea maintains a small crude extract production, exported formerly to UK and now mainly to USA for refining purpose (about 10 T/year).

The centralized extraction unit - which worked till 1984 - ought to be replaced at that time : it seems that finally Papouasia - New Guinea would have decided to turn now into mobile units utilizing for flowers extraction a modern technology, avoiding to operate through a central factory costly to operate with and overdimensioned.

N.B. - This information deserve to be corroborated, as - generally speaking - mobile units are frequently badly adapted for an efficient extraction work, particularly if solvents are to be used : Mobile units were most often set aside except for extractions using water as solvent and in the particular case of raw material to be extracted is plenty available at a low cost (as in this case it is possible to admit to extract uncompletely with the mobile units and to compensate by treating larger quantities.)

12.5 ECUADOR

Agricultural production

Contrary to African producers countries, Ecuador cultivate pyrethrum on large scale farming but it seems that production fall is a consequence of local salaries increase and petroleum price.

ECUADOR - PRODUCTION PYRETHRUM FLOWERS		
1965	1975 - 1980	1992
2.000 T	200 à 350 T/year	300 - 400 T estimation

(expressed in dried flower weight)

There are poor hopes for an important revival of pyrethrum cultivation in Ecuador (cf. Robbins 1984).

Pyrethrum content in Ecuador flowers would be rather high, in the range of 1,4%.

Extraction capacities

The extraction plant, located near Quito, include equally a refining unit : the plant has been designed for treating 2.000 tons per year, according to the level of the 1965 productions ; it is therefore unused for a large part of its capacity.

The extract produced by Ecuador is considered as of good quality, but more expensive than the African productions : nevertheless, it is regularly exported to Latin America and particularly to USA (when African producers fail to deliver).

Pyrethrum extract production

No recent precise statistical datas are available about Ecuador production, but it seems that the present production remain in the range of the quantities exported from 1975 to 1980, i.e. 15 to 20 tons per year.

ECUADOR - EXPORTATIONS PYRETHRUM EXTRACT					
1975	1976	1977	1978	1979	1980
24 T	17 T	27 T	16 T	15 T	16 T

12.6 AUSTRALIA

Australia decided to study and develop the pyrethrum mechanized cultivation adapted on large fields, in Tasmania, since 1980 - with the support of the Hobart University (which undertook an important research work program on development of new high-yield strains).

Agricultural production

AUSTRALIA - PRODUCTION PYRETHRUM FLOWERS				
1990	1991	1992	1993	1994/95
10 T	900 T	≠ 1.500 T	2.200 T	2700-3000 T Estimation

(expressed in dried flowers weight)

N.B. - The actual production, recorded at 2.200 tons in 1993, corresponding to a 3 to 4.000 hectare cultivated area - confirms the Australian objective to become the 2nd world producer, in a very near future, with 10 to 15% of the world market.

It is reported that Australia would have solved the mechanization of this culture, with production of small seedlings in green-houses, mechanized plantation of the seedlings in the fields, chemical hoeing through herbicides, selective mechanized harvesting of the flowers (this has been made possible through the cultivation of selected strains with homogeneous height, with not so many flowers per plant but located at the top of the plant - all these elements making easier a crop limited to the upper part of the plant, with minimum of stem length and maximum of flowers).

N.B. - Harvesting in Australia is done in a single crop operation (which differs from Africa, where flowering season is spread quite all along the year) : it is an advantage for Australia to benefit with well differentiated seasons, as it enables the coming out of the buds grouped together, just at the end of the cold season .

Development of new high-yield strains

- . As soon as 1986, 2 scientists BHAT and MENARY (cf. Pyrethrum Post 1986 - 16.2. 61) have well differentiated the genotypic and phenotypic correlations to be considered for realizing a fruitful pyrethrum selection work.
- . In 1986, they have identified and isolated a very performant clone (named H 80014) - whose yield extrapolated to the hectare would provide 2.416 K dried flowers, with a 2,02% pyrethrin content - i.e. a theoretical yield of 48 kilos pyrethrins per hectare. This strain has been officially recorded with the name of HYPY PYRETHRUM (CROP Sci - 1984.24.619-620).

It is therefore realistic to consider that this new variety is certainly now multiplied, with the hope to obtain an agricultural yield far superior to those obtained by African producers :

This would enable Australia to produce pyrethrum extract with a final competitive cost price, in spite of high industrial structure costs and profitability requirements (contrary to African competitors, whose prices are frequently fixed according more to political or socio-economical reasons).

Extraction capacities

For producing pyrethrum crude extract, it is likely that extraction will be carried out through a job-processor agreement with one of the Australian factories already equipped with solid-liquid extractors used part-time for producing poppy concentrate.

Refining of the crude extract is certainly done under direct control of the CIG Pyrethrum company, a branch of the Commonwealth Industrial Gases Ltd Cy, using a technology involving super-critic gases (liquefied CO² or butane or propane).

12.7 SOUTH AFRICA

No precise information or datas are available about development work in South Africa in terms of pyrethrum culture or extraction experiments.

Nevertheless it has been recorded in various customs statistical datas that South African exportations to USA exist, in the range of 1 to 1,5 tons of pyrethrum extract annually, for the years 1978 - 1979 and 1981 : for this reason, it is likely that experimental cultivations are developed in South Africa, in areas possibly reaching 50 to 100 hectares.