PYRETHRUM CULTIVATION IN KENYA *

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The cultivation of pyrethrum in Kenya has expanded very rapidly within recent years as illustrated by the figures appended below :—

Output of Kenya Pyrethrum (1934-42).

Years		Tons
1934	...	54.5
1935	...	321.6
1936	...	1,078.2
1937	...	989.2
1938	...	1,864.1
1939	...	2,869.3
1940	...	5,859.9
1941	...	5,763.3
1942	...	5,469.4

The expansion of the pyrethrum industry in Kenya is in large measure due to the high toxicity of the Kenya flowers which has enabled them to secure a premium on the world's markets, together with high average yields per acre and efficient methods of preparation and marketing of the product.

The crop will grow under a wide range of conditions in Kenya, but yields best at the higher altitudes over 7,500 ft. where the rainfall is fairly evenly distributed throughout the year, without a prolonged dry season. In such areas the crop can be regarded as of permanent value occupying

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an important place in the economy of the farm, whereas at altitudes below 7,500 ft. it is a valuable sideline, but it is doubtful whether its cultivation under 7,000 ft. is justified except during periods of exceptionally high prices or where other factors, such as heavy rainfall and low temperatures may in part compensate for the other disadvantages of a low elevation. Unlike most other plantation crops pyrethrum can be established at a comparatively low cost per acre and can easily be eradicated if prices or other factors cease to justify cultivation, and for this reason there is always likely to be a considerable fluctuating acreage of marginal land devoted to the crop, in addition to those areas at the higher elevations where it will probably occupy a permanent place in the economy of the farm.

The crop flourishes on a very wide range of soils throughout the Colony but on land where water-logging is likely to occur due to hard pan close to the surface or its low-lying character, the plants will rapidly die out during the rainy season. Soils which are very loose in character and on which rooting is difficult, such as rich humus forest soils where the land has been recently cleared, do not give such high yields owing to the difficulty of maintaining a good stand of the plants and a tendency to grow vegetation rather than to produce flowers. Furthermore, the weed-growth on such soils is likely to be very heavy and constant weeding tends also to reduce the stand of the plants.

The highest yields in the Colony have usually been obtained on the top of the open ridges in the high altitude areas in which the soil is a medium loam, free-draining and easy to cultivate and where the weed-growth is not usually very heavy and in such areas yields as high as 1,200 lb. per acre of dry flowers per annum have been recorded over considerable acreages.

The value to the farm of a crop producing a high return per acre with relatively low initial capital expenditure cannot be overstressed since in those areas where it is likely to prove of permanent value it will tend to reduce the economic size of the farm and also provides a rotation crop in areas where few such exist. While it may seem paradoxical to state that a plantation crop can be regarded as occupying a place in a crop rotation, yet it will be shown that it is definitely desirable to replant a percentage of the acreage annually and hence it can occupy a place in a crop rotation. In those high altitude areas where wheat has hitherto been the predominant cash crop, the advantage of pyrethrum to rest land which may have become infected with "Take-all" disease cannot be overstressed.

The chief conditions necessary for the successful cultivation of pyrethrum may be summed up as follows :—

1. High altitude — over 7,500 feet, with evenly distributed rainfall of 40-45 inches.
2. Soils on which weed-growth is not excessively heavy, and on which the plants can obtain a firm root-hold.
3. Absence of conditions likely to produce water-logging.
4. Moderate fertility — excessive fertility in the soil is likely to produce heavy weed-growth, and growth of leaf at the expense of flowers, but some growers have made the mistake of planting the crop on poor soils with the idea of reducing weeding costs. This is, of course, a mistake as it will lead to reduced yields.
5. Control of soil erosion. The crop is likely to suffer considerably from the effects of soil erosion and it is essential to take the necessary

preventative measures such as contour ridging etc. more particularly where the soil is shallow.

6. The establishment of a good stand in the field. An indifferent stand will never produce a full crop. When the stand becomes reduced, it is necessary to plough out the plantation and replant.

8. Clean Weeding. This is absolutely essential both within the plants themselves and in the rows between the plants.

Cultivation of the Crop.—Thorough cleaning and preparation of the land is essential, since it is not possible to perform thorough cultivation after the crop has been established and delayed attempts to eradicate couch usually involve the removal of a considerable number of plants. For this reason hand-decouching and burning should be performed if necessary and several crops of couch may be removed by repeated ploughing, cultivation with spring-tinned cultivators, collection and burning before the land is finally cleaned. In the case of old wheat lands germination of weed seeds by thorough cultivation should be effected. Deep cultivation (in excess of 6-8 ins.) does not appear to be necessary for the crop which is shallow-rooted by nature and a reasonably firm bed is desirable before planting out so as to secure a good stand. When the land has been cleaned, it should be contour-terraced prior to planting in order to prevent erosion of the soil. This is best effected by the construction of narrow-base ridges which are on the usual variable grade recommended for arable crops, but in the case of exceptionally absorbent soils level base terraces may be employed. The banks should be approximately 5-6 feet wide and about 18 to 25 inches high with a shallow drain 3 feet wide on the upper side. Pyrethrum can be planted over the banks and their shape should be maintained when cleaning by drawing the soil upwards. It is estimated that a native can contour 30 yards of such bank daily by hand with a jembie and shovel, so that the cost of protection per acre is relatively small.

It should again be emphasised that it is only advisable to construct level base terraces provided the soil is absorbent and heavy storms are not experienced. In an area of low rainfall the level base terrace is an advantage since its construction ensures that all the rain will remain on the field.

It is essential in the case of variable grade terraces to construct suitable outlets at the edge of the field to carry away the water which runs off and in the construction of the terraces it is necessary to build them up well if they cross former gullies so that they may not break away during heavy rains.

Planting should be carried out in the main general direction of the contour ridges but provided the land has been adequately protected by ridges there is no need to plant exactly on the contour. By following the general line of the contours cultivation up and down slopes will be avoided.

Manurial Requirements.—Experiments on the application of fertilisers to pyrethrum have been in abeyance due to the war but farming opinion is still divided on this question. Applications of superphosphates have in some cases been followed by increased weed-growth with a consequent increase in weeding costs and a reduction in stand due to these frequent weeding. In other cases farmers have found that such applications gave an increase in the numbers of flowers, individual flower size, and an increase in yield of the plantation.

On poorer soils, or on land which has been under pyrethrum for a few years and which has been cleared and ploughed for replanting, preliminary trials with dusting the holes with bonemeal or guano at the

time of planting indicate that the young plants make a better and more vigorous growth.

The pyrethrum crop does not remove heavy quantities of plant foods. A 1,000 lb. crop of dried flowers removes 17 lb. nitrogen, 25½ lb. potash, 5½ lb. phosphoric oxide and 4½ lb. lime, amounts that would be supplied by 85 lb. sulphur of ammonia, 30 lb. superphosphate and 51 lb. sulphate of potash or, taking wartime fertilisers, 175 lb. hoof-and-horn meal and about 200 lb wood ash.

Planting Material.—The two types of planting material used are either seedlings or root divisions from existing plants. A considerable diversity of opinion exists as to which are the best to use, but it would appear that it is usually easier to establish a field with seedlings since they have a better root system and withstand transplanting better under unfavourable conditions than root divisions. At the same time, a considerable amount of labour and supervision is required for tending the seed beds and seedlings do not come into flower so quickly after transplanting as root divisions. At the lower elevations, however, where a percentage of non-flowering or low-producing plants are usually found in cultivations established from seedlings, it may be possible to eliminate these by selection of plants for root divisions which have shown ability to flower and yield well under the particular conditions prevailing.

A. SELECTION OF ROOT DIVISIONS

It is important to select material for root divisions carefully from high-yielding plants, and this applies particularly at the lower elevations. The common practice of removing every plant over a certain area for purposes of obtaining root divisions should not be encouraged, but more attention should be paid to the selection of planting material. The non-flowering or dark-green coloured "cabbage" looking plants should be discarded completely, and, generally speaking, the more silvery coloured and feathery-leafed plants will be found the most desirable type to propagate. Material to be used for splitting should have all flowering stems cut off before it is dug up and attempts should not be made to obtain too many root divisions from one plant. Small spindly divisions with little or no root system will be found difficult to establish and replanting and patching subsequently will be necessary. Care should be taken to ensure that every split (division) when planted has part of the root system of the parent plant and contains a due percentage of foliage. A large number of individual plants should be used to establish a plantation and attempts should not be made to establish a plantation from one or two high-yielding plants propagated repeatedly by root divisions. The reason for this is that the pyrethrum plant is self-sterile and it is necessary to have a large number of individuals in the field so as to ensure adequate pollination which is necessary in order to obtain a high pyrethrin content in the flowers. Also it is necessary to guard against selection of plants having flowers of of low pyrethrin content.

B. SEEDLINGS

A considerable number of farmers will continue to plant their plantations from seedlings on account of the greater ease with which they can be established in the field more particularly during unfavourable conditions and also the high cost of obtaining splits if it is necessary to buy when plants are not already available. *It is of importance to use seed the origin of which is known and which has been harvested from carefully selected material.* Limited supplies of seed from selected high pyrethrin content plants are now being produced by the Department of Agriculture and these are distributed by the Pyrethrum Board of Kenya. Farm seed plots should be established from a large number of individual plants selected in the field for

such characters as flower size (size of centres), number of flowers, upright non-straggling habit and high pyrethrin content and these should be planted all together in a plot by themselves and used for seed production. A large number of plants should be used for this purpose, so as to avoid any possibility of partial sterility through lack of sufficient numbers of individuals for cross-pollination.

The seed should be harvested when the disc florets have died and tend to fall off the flower head, exposing the greyish-brown seed. The seed should not be stored for long periods as it loses its viability fairly rapidly. One pound of seed is usually adequate to plant one to three acres in the field according to the spacing. The seed does not usually germinate more than about 50 per cent in the seed-bed and germination is slow and irregular, taking about 12-14 days.

Seed Beds.—The seed beds should be made on well-drained soil which is carefully and evenly levelled. Owing to the slow rate of germination of the pyrethrum seedlings, it is desirable to obtain a thorough germination of the weed seeds first before the pyrethrum seed is planted. Overhead shade should be provided for the seed-beds and it is advisable to thatch the soil itself with a light covering of grass until the seedlings have germinated. The seed should be scattered lightly over the beds and covered with a very thin layer of soil and watered daily. The grass covering will be removed at about the 12-14th day when the majority of the seed has germinated. If any signs of damping off appear, the shade should be removed and plants watered with water tinted with permanganate of potash. Pricking out of the seedlings about 3 ins. by 3 ins. apart is to be recommended, as this stimulates root development and will hasten the time at which they will come into bearing when transplanted into the field. Although this operation increases the labour costs, it is doubtless well worth while since a return is secured much more quickly. It is important that the seedlings should be well grown before they are transplanted into the field and should have at least 10-12 leaves. If smaller seedlings are transplanted, they frequently become buried with soil when heavy rain falls at the time of transplanting into the field, and flowering will of course be delayed.

Transplanting into the Field.—A considerable amount of experimental work has been carried out on the correct spacing for pyrethrum and it would appear that in the high altitude areas a square spacing of 2 ft. by 2 ft. is likely to give the most satisfactory results. On rich forest soils, however, where rooting is loose and weeding expensive, it is advisable to adopt a somewhat wider spacing between the rows, spacing the plants closer together in the rows. In this manner more mechanical cultivation with oxen and donkeys can be performed and there is less danger of loosening the roots of the plants. Under such conditions spacings of 2 ft. 6 ins. or even 3 ft. between the rows, and 16 ins. to 18 ins. between the plants in the rows are recommended. Latterly however, many farmers are adopting a narrower spacing in the row coupled with a wider inter-row spacing of 1½ ft. by 3 ft. planted on the contour. This spacing makes for ease of cultivation, cheapens weeding costs and lessens soil erosion.

The approximate numbers of plants required per acre of the more common spacings are as follows :—

2 ft. × 2 ft.	11,000	plants per acre.
3 ft. × 1½ ft.	10,000	,, ,, ,,
3 ft. × 2 ft.	7,400	,, ,, ,,
3 ft. × 3 ft.	4,900	,, ,, ,,

At the lower altitude (7,000 ft. to 7,500 ft.) where growth is not so vigorous a square spacing of 20 by 20 ins. is recommended, except for rich forest soil condi-

tions when the spacings adopted should be similar to those previously recommended.

The fields should be carefully marked out prior to planting and it may be desirable to leave paths at intervals to facilitate handling the crop. If, however, wide spacings between the rows have been adopted, this will not be necessary, and even with a 2 ft. by 2 ft. spacing is not essential.

If the field is being planted with splits, an entrenching tool should be used for digging the holes prior to planting out. Great care should be exercised in splitting up the plants to ensure that each split has a part of the parent root system and the plants should be firmly planted in the ground and the soil well tamped round them. *Carelessness in firming the soil round the roots of the plant is a frequent cause for a poor stand subsequently due to high mortality.* In the case of seedlings. the holes can be prepared with a pointed stick, but care should be taken to ensure that the roots point properly downwards and soil is well consolidated round the plants. Approximately 10 to 14 boys will plant 1 acre daily, but it is work that requires the closest supervision and should not be unduly hurried. Failure to secure a good stand will result in low yields and a short life of the plantation. A certain percentage of plants, more particularly on the looser soils are, however, likely to die due to defective root system or other causes and such gaps should be replanted as soon as possible before the rest of the plantation has commenced to flower. If attempts are made to patch up fields which have come fully into bearing, the results are never likely to be satisfactory owing to the difficulty of establishing the replanted material and the slow rate at which they will come into production, due to the competition from mature plants.

Fields established from splits should, at the high altitudes, commence to flower approximately 14 weeks after they have been planted, while seedling material will probably take about 8-12 weeks longer. These periods are increased somewhat at the lower elevations where a percentage of the plants established from seedling material may even remain for a period of one year before commencing to flower, and the same may apply to a percentage of the root divisions unless these have been very carefully selected. There is a considerable difference of opinion as to the advisability of cutting off the flowering stems when the young plants begin to flower in order to stimulate their vegetative growth. Provided, however, good sized seedlings or splits have been used originally, there is no particular advantage in adopting this practice and picking of the flowers should commence as soon as possible.

Cleaning and Harvesting.—As previously mentioned it is absolutely essential to keep the crop clean both from weeds between the plants and in the plant themselves. A certain amount of mechanical cultivation can be performed with small ox cultivators pulled either by an ox or a donkey, the latter being more suitable for work between fairly close rows. While the plants are young, the majority of the weeding can be done in this manner, but care should be taken to remove all weeds growing in the plants themselves. The worst of such weeds is probably the Sorrel (*Oxalis* spp.) which grows up in the plant and eventually kills it, thus shortening the life of a plantation considerably and it is important to take care when planting from root divisions that these are free from the weed. Indigenous clovers also grow up in the plant and are extremely difficult to eradicate. On forest soils, where weed-growth is heavy it may be necessary to weed as frequently as every 14-17 days during the rains, but as a general rule the period varies from a month to six weeks or more. The use of a Dutch or turnip hoe as opposed to the jembie for weeding is encouraged since it does not do so much damage and

it is quite effective for the work, provided weeds are not allowed to grow much beyond the seedling stage, which is essential if the plantation is to yield well. Some farmers use Planet Junior hoes pushed by hand for weeding. These are quite effective for performing the work, particularly in the early stages of the life of a plantation, but should not be used exclusively owing to their tendency to encourage the formation of a pan. It is desirable that an established plantation should be given at least one cultivation with ox cultivators annually to burst up the soil on the surface which has become packed owing to the frequent treading during picking, etc. and the operation is best performed immediately after the plantation has been cut back. The cultivators should penetrate about 2½ ins. below the surface but not deeper, otherwise they would tend to loosen the plants in the soil.

Weeders often make the common mistake of drawing the soil away from the plant when hand weeding with a jembie, until eventually the plants tend to sit on a small cone of soil; this type of weeding should be prevented since it exposes the root. Beneficial results have been obtained by lightly running a ridging plough between the lines of plants along the contour; this has the effect of throwing the soil back to the base of the plants and also tends to prevent erosion.

Failure to keep pace with weed-growth will sooner or later necessitate thorough deep weeding, which removes a large percentage of the plants. The acreage of pyrethrum which will be grown on any farm is therefore likely to be limited by the amount of labour available for cleaning and picking. Under average conditions one boy is continuously employed in cleaning approximately 5 acres, although this figure will vary very widely.

Picking.—It is important that flowers should be picked when there is no external moisture on them, either dew or rainfall, which is likely to cause heating before the flowers are dried. Such heating would be deleterious to the colour and appearance of the dried product and also to its pyrethrin content. For these reasons picking should not be commenced early in the morning until the dew has dried off the flowers. The flowers should be picked into wickerwork baskets which permit of access of air at the sides so as to prevent heating and if they are not removed to the drying plant for sometime, should be spread out on tarpaulins when the baskets have been filled. The average amount of flowers picked per day varies from 25-30 lb. wet flowers depending on the size of the crop and the nature of the labour employed and amounts considerably in excess of this may be picked during periods of heavy flush. While during the dry season the amount may fall to 12-15 lb. daily.

Observations carried out showed that pickings may range as low as 9 lb. per acre of dried flowers per picking to 250 lb. per acre dried flowers per picking during the heaviest flush periods in high altitude pyrethrum growing areas.

Great care should be exercised over the picking operations so as to ensure that flowers only at the correct stage of maturity are harvested, *i.e.*, when at least 3-4 rows of disc florets are fully open, and that the picking of immature flowers and buds, which would result in the lowering of the pyrethrin content, is avoided. The flowers should not be packed tightly in the receptacles into which they are picked, but allowed to fall in loosely. Payment for picking is usually made on the basis of weight and varies from ¾-1 ct. per pound of wet flowers, although the work can often be performed slightly more cheaply by the employment of monthly labour at a fixed wage who are given a minimum task of 25 lb. of wet flowers daily, picking in excess of this amount being paid extra depending on the amount picked. Picking is performed roughly at fortnightly to

three weekly intervals throughout the flowering season which may continue for 8-9 months of the year. It is important, however, always to examine the flowers carefully in the field before commencing to pick rather than to attempt to follow any definite time interval.

Flowers should be removed to the drier as rapidly as possible after picking. Artificial driers of the Ainabkoi type are the most popular at the present time, although these are being continually improved to make them more efficient and to produce a uniform sample of high pyrethrin content.

Cutting Back.—At the end of the flowering season the pyrethrum plants have a large number of dead flowering stems and it is desirable to cut these back before the onset of the next growing rains. The level to which the plants should be cut back has been a matter for dispute and for this reason experiments have been carried out to determine the correct method. The treatments adopted were as follows :—

1. Control — Uncut.
2. Cut high — Flowering stems only removed.
3. Intermediate — Half foliage cut in case of tufted plants and remainder of plants cut half through.
4. Cut to ground.

Half of the area was also again cut in the middle of the flowering season to test whether it was possible to alter the time of flowering by cutting at periods other than before the onset of the rains. Results of this indicated that it is definitely inadvisable to try to alter the time of flowering by cutting at season other than the normal dry or dormant season. Results of the trials of different methods of cutting back are appended below :—

	Cut once in dry season lb. dry flowers per acre	All cut high again during rains lb. dry flowers per acre
Control	1,555.5	417.0
Cut High	1,612.6	521.2
Intermediate	1,213.7	424.6
Cut to ground	877.1	294.0

The plants which are cut to the ground have never grown to the same size and it would appear that this treatment would only be desirable if it were intended to rejuvenate an old plantation in order to permit of more thorough cultivation.

Yields.—Yields vary very greatly throughout the pyrethrum growing areas, but are influenced largely by altitude and nature of the soil, the highest yields being obtained at altitudes over 8,500 on soils which are of a medium loam character Under these conditions, yields of 900 to 1,000 lb. of dry flowers per acre per annum are sometimes obtained while at lower elevations down to 7,000 feet yields in the neighbourhood of 500 to 600 lb. of dry flowers can be obtained. On rich forest soils with a very high humus content the yields will be lower, say in the neighbourhood of 550 lb. per acre at 8,000 ft.

Though the foregoing yields are commonly obtained, yields for the Colony have been on a lower scale. It is not possible to give exact figures because a proportion of newly-planted acreage is always included in the statistics, but the average appears to have varied generally between 300 and 600 lb. per acre in different years, the overall acreage to date being in the region of 400 lb. per acre per annum.

Life of a Plantation.—The useful bearing life of a plantation will vary considerably with soil, altitude, rainfall and other factors. Except, however, in the highest altitudes the life of the plantation will probably be from 3-5 years since considerations of weeding, reduction in stand, compaction of the soil will probably render it desirable to replant before this age is reached. The chief indication of a need for re-establishment is a reduced stand with consequent severe reductions in yield and increased weeding costs. It is essential therefore that a definite replanting programme should be adopted every year, the percentage to be replanted being based on the average useful life of a field for the particular conditions obtaining. Thus on a loose forest soil where the useful life may be only three years it will be necessary to replant about 33 per cent of the acreage annually, whereas in the high altitude areas on the tops of the ridges 15 to 20 per cent will be sufficient for annual replanting. It is highly problematic if in a well-looked after pyrethrum plantation the pyrethrin content decreases with increasing age. Flowers taken from a plantation eleven years old compared extraordinarily well in pyrethrin content with flowers from an adjacent new plantation. At the Scott Agricultural Laboratories in a plot six years old, there has been no significant loss in pyrethrin content. It has also been widely stated that flowers from splits have a lower pyrethrin content than the parent plant. This is one of the many untrue legends pertaining to the growth of pyrethrum. Flowers from splits are as good as the flowers from the parent plant. There is one proviso covering these statements — they apply to good farming practice. If a field is allowed to become weedy, then one may expect with increasing age, a decrease in the pyrethrin content — the plants are not healthy. Again, if splits are badly planted and not looked after, then a lower pyrethrin content will accrue.

It is suggested that when pyrethrum has been removed from a plantation, it should not be replanted immediately but other crops such as peas or cereals should be planted for a period of one year or more so that weed such as sorrel can be effectively destroyed and also other types of weed largely prevalent in pyrethrum.

This article deals with the cultivation of pyrethrum only and not with the drying of the crop. An article on the latter was published in the *East African Agricultural Journal* for January, 1937, and plans and specifications of the Ainabkoi Drier, the type recommended by the Department of Agriculture and the Pyrethrum Board, are obtainable from the Kenya Farmers' Association (Co-operative) Ltd., Nakuru.