# PYRETHRUM GROWERS MANUAL

AFA
Our Crops, Our Wealth

2019

3rd Edition

# PYRETHRUM GROWERS MANUAL
## 3rd EDITION 2019

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## FOREWORD

The last edition of the Growers Manual was published in 1998. Since then there has been a growing need to update the information collected and accumulated over time based on technological development on pyrethrum in various fields of research including breeding, agronomy, crop protection, and economics. This edition has been produced to provide revised and additional information on pyrethrum cultivation to growers. New pyrethrum cultivars developed since the publication of the 1976 edition are included together with their potential productivity.

Since the generation of technical information through research is a continuous process, we expect that there will continue to be a steady inflow of new and relevant research findings, which will be included in future editions.

This manual provides adequate information to pyrethrum growers and extension workers. It is recommended therefore that where there is a need for further information, the grower gets in touch with the nearest office of Pyrethrum Processors or that of the County Department of Agriculture.

## INTRODUCTION

### History

The first record of the pyrethrum daisy was 2000 years ago at the time of China's Chou Dynasty. The flower appears to have been traded along the Silk Route and eventually was grown in the Dalmatian region. There are reports that French soldiers used crushed flowers to control fleas and body lice during the Napoleonic Wars (1804-1815). In 1860, pyrethrum powder was introduced to the United States, but whole flowers later replaced the powder as the desired imported product. In 1881, pyrethrum cultivation was introduced to Japan from England and when World War I broke out in 1914, Japan became the principal supplier of pyrethrum flowers to the United States.

Japan was supplying 82% of pyrethrum flowers sold to the United States in 1926 and by 1931 they were supplying 91% of the US needs. In 1928, pyrethrum cultivation was introduced to Kenya and by 1932 commercial production of pyrethrum flowers began. By December 1933 the first commercial crop from the country was sold abroad. Kenya pyrethrum was very high quality. It therefore quickly replaced the Japanese pyrethrum on the world market by around 1941.

The majority of pyrethrum growers today are small scale growers with less than 5 acres of land. In most cases, the area occupied by pyrethrum averages a quarter of an acre to three acres. Pyrethrum is grown in the following counties in Kenya: Nakuru, Uasin Gishu, Elgeyo Marakwet, Nandi, Baringo, Kericho, Bomet, Narok, Laikipia, Trans Nzoia, West Pokot in the highlands of Rift Valley; Kisii and Nyamira in Nyanza; Kiambu, Nyeri and Nyandarua in Central; Meru and Embu in Eastern and Bungoma in Western region.

Kenya enjoyed being the leading producer in the '80s but recent statistics indicate that the global market is dominated by Botanical Resources Australia at 80% of the market. Other countries that produce pyrethrum include Tanzania, Rwanda, Uganda, Ecuador, Papua New Guinea.

Pyrethrum is used to make natural insecticides. Its demand has continued to rise in the world market because pyrethrum is not harmful to human beings and other warm-blooded animals. It is therefore preferred for use as an insecticide in and around the

household. Pyrethrum has advantages over other insecticides in that it has a repellent effect on insects, exhibits rapid "knockdown" and is non-persistent in the environment.

## CLASSIFICATION

Pyrethrum belongs to the genus Tanacetum in the family Asteraceae. It is a cross-fertilizing diploid species (2n=18) with a sporophytic self-incompatibility.

## DISTRIBUTION

Tanacetum cinerariaefolium viz. is a hearty perennial that thrives in interesting and challenging environments. It is presently grown in Kenya, Uganda, Tanzania, and Rwanda in East Africa,Tasmania in Australia, Ecuador and Papua New Guinea.

## 1. PLANT AND ITS ENVIRONMENT

Botany

Pyrethrum (Tanacetum cinerariaefolium L.) is a white flower headed, tufted perennial herbaceous plant possessing deeply lobed leaves, with numerous and fibrous shallow root system (30 cm). The plant has numerous fairly rigid stems that grow up to 50 to 80 cm in height with blue-green deeply divided leaves that are covered on both sides by dense wooly material.

## 2. ECOLOGICAL REQUIREMENTS

Soil requirements

Pyrethrum requires deep soils that are rich in phosphorus; calcium and magnesium with a soil PH of 5.0 – 6.5. The soils should be fertile and well drained with reasonably good texture and structure. A good structure ensures proper water infiltration and controls erosion. Structure and texture of soils frequently damaged by repeated weeding and trampling which cause rapid breakdown of the soil. Such soils require rehabilitation by addition of humus in the form of the farmyard manure or compost manure (coffee husks, cereals trash, etc).

In newly cleared forest areas where the vegetation has greatly enriched the soils, there may be some incidences of root rot. Soil testing for the root rot causing organisms like nematodes is recommended before planting pyrethrum.

Rainfall and water requirement

Pyrethrum requires a minimum of 750mm (30 inches) of rainfall well spread over the season. In warmer areas, where evaporation is high, precipitation of 1000 to 1125mm (40 to 45 inches) well distributed per season is preferable. When there is adequate rainfall at the beginning of the season there is an immediate flower flush. Excessive rains may encourage root rot and bud diseases which drastically reduce yields. A persistent drought of four months and above will greatly reduce yields while short dry spell enhances a higher flower production.

Altitude and temperature

In Kenya, there are clones and varieties suitable for high altitude, above 1980 meters (approximately 6,500 feet) and for low altitudes below 1980 meters (approximately 6,500) down to 1760 meters (approximately 5,770 feet) above sea level. Best flowering is easily achieved at and over 2130 meters (7,000 feet) above sea level.

In Kenya, the recommended clones and varieties belong either to low, medium and high altitude. A grower is advised to choose the clones and varieties based on the altitude.

The pyrethrins content is affected by changes in temperatures i.e. the mean temperature falls, the content rises. Flower initiation also increases as the temperature falls during the onset of rains. The flower initiation is reduced by high temperatures which prevail in low altitudes while heavy frost, which can occur at high altitudes, causes a reduction in yield due to wilting of tillers. Pyrethrins content is, however, not reduced by mild frost. Under irrigation, frost may have no effect on the crop.

## 3. MANAGEMENT PRACTICES

3.0 Land Preparation

The land should be well tilled to allow easy penetration by roots. All weeds such as Couch grass, sedge (Watergrass or Nutgrass), Star grass, Kikuyu grass, oxalis, and portulaca should be removed as they are difficult to clear later without damage to the plant. Ploughing the land during dry months helps to destroy stubborn weeds. Pyrethrum should occupy the land for three or at most four years. New planting should not be on land which has grown pyrethrum for the past three to six years. Grass and cereals are good rotation crops with pyrethrum. Steep slopes must be terraced or be avoided altogether.

3.1 Ridging and drainage

Pyrethrum cannot tolerate waterlogging. In such a situation, planting should be done on ridges of 2.5 to 3 feet (approximately 0.75 to 0.90 meters) wide. Ridges help to confine trampling to bottom of furrows. This can save young plants from damage during weeding and may lead to higher yields than on the flat field.

3.2 Time of Planting

Pyrethrum should be planted as early in the main rains as possible; planting later leads to poor establishment and poor yields in the first year, although subsequent yields are unaffected. An exception to this rule occurs in Kisii and Kericho highlands where there is high rainfall which is so well distributed such that any month, except January, is suitable for planting pyrethrum.

3.3 Planting

3.3.1 Planting splits

There should be at least 4-6 inches (100mm-150mm) of moisture in the soil before planting splits. Take good size splits, cut the roots to a length of approximately 4 inches (10cms) with a sharp knife, and remove the old thick woody roots, leaving a young root system on the split. Cut off any young flower shoots, leaving approximately 6 inches (15cms) of green vegetative top on the split.

Make the planting hole 4-6 inches (10-15cms) deep and add a teaspoonful of triple superphosphate and mix with the loose soil in the planting hole. Place the split in the planting hole with roots straight down. **NEVER PLANT WITH THE ROOTS OF THE SPLIT BENT SIDEWAYS OR UPWARDS.**

The base of the plant, where the roots and stems meet, should be at ground level, with all the roots below the ground level and all leaves above ground.

Fill one third of the hole with soil and press the soil firmly with the fingers. Fill the remainder of the hole with soil and again press firmly, pressing the soil and again press firmly, pressing the soil into the roots from the side, not from the top (the pressing is only applicable when the soil has low moisture). A well planted split should be firm in the soil and should require an appreciable tug to pull it out.

On a small acreage, plant lines can be laid out by hand. A row of pegs is put in at each end of the terrace, and strings or chains stretched the length of the terrace between them. Along these lines the planting holes are then made by use of a panga.

On a large scale, planting lines can be laid out by tractor-drawn implements (apart from ridgers) or a hand drawn marker. If gaps or blind plants appear, they should be replaced as soon as possible in the first years follows.

Dig the planting hole, then take a sharp spade and cleave at least one third of an adjacent, vigorous plant. Press the soil around the roots against the spade and transfer into the new hole with minimum disturbance of the roots. Fill in and firm down the soil around both plants. The splits can be dipped in a solution containing nematicide and fungicide to control nematodes and fungi.

3.3.2 Planting seeds in seedbeds

Seeds should be evenly sown on beds of finely tilled soil, at ten seeds to the inch in rows half an inch deep and six inches between rows. After sowing, the rows should be covered with grass and well watered. A few days after germination, which takes upwards of 10-14 days, depending on altitude, the grass should be removed, taking care not to uproot the young seedlings.

Seedlings take about three to four months between germination and planting out, and should generally be sown three to four months prior to onset of long rains. Shading of the seed beds is not generally recommended, except in very hot dry conditions, and even then the shade should be removed as soon as possible. Regular watering is essential. Given careful handling, one kilogram of seed should provide sufficient plants for five acres (two hectares).

**3.3.3 Transplanting seedlings**

Seedlings from seedbeds should also be transplanted when the soil is well moistened. Holes for planting seedlings should be shallower than those for splits because seedlings are smaller. All other planting operations are as for planting splits. Generally seedlings survive better in cases where moisture is low in the soil.

3.4 Spacing and plant population

The spacing of 30 cm intra-row (between plants) and 60 cm inter-row (between lines) should be used, but in drier places spacing of 30cm between plants and 90 cm between lines is recommended. The spacing of 30x60 cm would give a population of approximately 22,000 plants per acre (55,000 plants per hectare) and spacing of 30x90cm would give a population of approximately 14,000 plants per acre (36,000 plants per hectare).

Approximately 4,000 mature plants would be required to raise enough splits to plant an acre or 10,000 plants for a hectare. In drier places with spacing of 30x90 cm, only 3,000 plants are required to split into approximately 14,000 splits to plant an acre or 7,000 plants for a hectare. Mechanization in production of pyrethrum is possible in large scale farms.

3.5 Fertilizers and manures

Phosphate fertilizers are recommended for use in pyrethrum growing. Triple superphosphate (T.S.P) (46% P) should be applied in each planting hole at the rate of one teaspoonful per hole. This is about 125-150kg/ha (or 2.5-3 bags of 50 kg/ha). The fertilizer should be mixed thoroughly with soil in the hole before planting, to avoid scorching of the plant roots by the fertilizer.

Farm yard manure (FYM) may be used at the rate of 4 tonnes per acre or 10 tonnes per hectare on poor soils. A marked increase in yield is realized after application. The FYM, should be applied three months before planting of the crop. It should be worked into the soil to allow adequate decomposition. If, however, the manure is well decomposed it can be applied at planting time placed in planting holes and mixed up with the soil. Use about 200 grams per hole.

Top dressing with nitrogenous fertilizers on pyrethrum has not proved to be beneficial and is currently not recommended.

## 4. PYRETHRUM CROP IN ROTATION

Pyrethrum clones should remain in the ground for three to four years after which they should be uprooted and transplanted in a new field. Under very good management, transplanting to a new field can be deferred upto the fourth year. Pyrethrum plants raised from varieties should not be replanted at the end of the rotation period. These should be discarded and new seed used to plant the next field.

If pyrethrum is left in the same field for more than

three years, flower yield declines to an uneconomical level in subsequent years due to accumulated effect of pathogens, pests and nutrient depletion.
To restore soil structure and reduce soil pests and diseases of pyrethrum, the land should be rested under grass or bush fallow. A clean-up crop, for example, cereals such as maize, wheat, oats or barley or grasses such as weeping love grass, guinea grass, guatemala grass may be used for rotation.

## 5. PYRETHRIN CONTENT AND YIELDS

Pyrethrins content and dry flower weight are the most important components of pyrethrum that determine income to a grower. Pyrethrins yield per hectare is made up of dry flower weight multiplied by pyrethrins content of the flowers. Pyrethrins content determines the rate of payment per kilogramme of flowers. Plants of low pyrethrins content should therefore, be avoided. Currently,the Pyrethrum Processing Company of Kenya and National Pyrethrum Research Center, KALRO provides clones and varieties which give high yields and content. Clones with high pyrethrins content, above 2% and flower yield above 1,000 kgs/ha per year are available. Good cultivation, correct picking and drying, and prompt delivery will maintain high content. Proper planting, correct spacing, elimination of gaps, good field management and regular picking will give high yield.

## 6. PLANTING MATERIALS

Pyrethrum plants may be grown from seed or propagated vegetatively by splitting up clonal plants. Planting material derived from the splitting up of one original plant is known as a clone, whilst plants grown from seed are known as a variety. There are three sources of planting material:

a) Certified clones
b) Certified seeds
c) Tissue culture material

6.1 Recommended commercial clones and varities
Through plant breeding and trials programmes, pyrethrum breeders provide recommended clones of known performance. Clones are tested for about seven to nine years process before the best are recommended to growers. Many clones with weaknesses are eliminated during the course of these trials. Since each clone is the result of multiplication by splitting of one single plant, the characteristics of all plants in the clone are identical. High yield and pyrethrins content, resistance to diseases, insect pests and drought, good establishment and upright

growth habit are important characteristics of a good clone.

Clone Ma/71/1013 (High altitude clone)

Clone Mo/75/223 (Medium altitude clone)

Ks/75/313 (Low altitude clone)

**Table1: Recommended high quality clones**

| Clone | Potential flower yield (kg/ha) | Mean pyrethrins Content (%) | Recommended Altitudes (metres) |
|---|---|---|---|
| SB/66/107 | 900-1000 | 2.00 | High (Above 2200) |
| Ks /70/64 | 1000-1100 | 1.90 | Low/Medium (1760-2100) |
| Ma/70/1013 | 1000-1200 | 1.90 | High (above 2000) |
| Ks/71/6 | 900-1000 | 1.70 | Low/Medium (1800-2100) |
| L/72/26 | 1100-1200 | 2.10 | High (above 2200) |
| Kr/74/122 | 900-1000 | 2.10 | Lowe/Medium (1800-2100) |
| Mo/74/443 | 1000-1100 | 1.80 | Allpyrethrumgrowingareas |
| Mo/74/223 | 900-1000 | 1.95 | Low/Medium (1800-2100) |
| Ks/75/336 | 900-1000 | 1.80 | Low/Medium (1760-2100) |
| L/75/477 | 900-1000 | 1.80 | High (above 2100) |
| L/75/487 | 1000-1100 | 1.85 | High (above 2100) |
| Ma/75/4 | 1000-1100 | 1.80 | High (above 2100) |
| Ks/75/313 | 1100-1200 | 1.60 | Low/Medium (1760-2100) |

6.2 Recommended varieties

Curently,there are three recommended varieties which give high quality pyrethrum. Their yield potential, average pyrethrins content and recommended altitudes at which they should be grown are shown in Table 2.

**Table 2: Recommended varieties**

| Variety | Yield Potential (Kg/ha) | Av. Pyrethrins content (%) | Recommended suitable Altitude |
|---|---|---|---|
| P4 | 600 - 800 | 2.00 | High (above 2200m) |
| K218 | 900 - 1100 | 2.10 | All pyrethrum growing areas |
| K235 | 600 – 800 | 1.90 | All pyrethrum growing areas |

### 6.2.1 Source of seed material

All the pyrethrum seed material can be obtained from seed merchants.At the moment,these are available at the Pyrethrum Processing Company of Kenya (former PBK).

Growers should never harvest seed from their own plants. Instead, seed should be purchased from seed merchants.

6.2.2 Cost of seed and Seed Rate

At present, seed is packed in packets of 125g A grower requires to purchase 2 packets which contain enough seeds to plant an acre.

## 7. CROP MAINTENANCE

After a pyrethrum crop is established, it is necessary to give it adequate attention in order to achieve high production. Several operations are recognized in pyrethrum farming.

7.1 Weed control

When weeding, the soil should be drawn around the base of the plants. On large scale basis, a ridger can be used for cultivating between rows. This will help to control weeds but it should be followed up with fork jembes to cultivate in the intra-row spaces and draw soil around the plants. All the uprooted weeds should be removed from the field and be placed on contour terraces to avoid re-growth especially rhizomatous weeds such as couch grass, sedge, Kikuyu grass and portulaca.

7.1.1 Hand weeding

Pyrethrum fields must always be kept clean, particularly when plants are young. Weeds can drastically reduce flower yields by interfering with tiller development. If the weeding is not carried out for three months, the weeds may kill the pyrethrum crop. Weeding should therefore be carried frequently (every 4 weeks) using small forked jembes to avoid

root damage. If the roots are damaged, they may result in die-back of the plants.

Figure 1 oxalis

Figure 2 Portulaca

Sedge grass

Fig. 3: Some important weeds in pyrethrum fields

When weeding, the soil should be drawn around the base of the plants. On large scale basis, a ridger can be used for cultivating between rows. This will help to control weeds but people should follow with fork jembes to cultivate in the intra-row spaces and draw soil around the plants. All the uprooted weeds should be removed from the field and be placed on contour terraces to avoid re-growth especially rhizomatous weeds such as couch grass, sedge, Kikuyu grass and portulaca.

7.2 Cutting back

Pyrethrum plants should be cut back once a year, towards the end of the dry season, after picking the flower flush. A sickle (never a panga) should be used to remove all the stalks, but not the leaves(cutting should be slanting to allow spilage of water). Stalks should be burned. If left, they can be troublesome during weeding, and can harbor pests and diseases. Do not delay cutting back until after the rains have started, if so yields will be reduced. Weed the fields and earth up the plants immediately after cutting back.

**Figure 3 cutting back using a sickle**

7.3 Frost, Hail storm and drought hazards

The performance of pyrethrum is fairly sensitive to weather changes. Heavy frost can affect crops grown in depressions. If the crop is grown under irrigation, it will not be affected by frost since irrigation water is warmer than the frost. Plants in nursery beds can be shaded with material such as hessian cloth, coffee drying cloth or polythene to avoid the damage of young plants by frost.

Hail storm causes dark bruises on the flower discs and shedding of some of the white petals. The bruised areas may fail to develop further, resulting in a loss of pyrethrins Long extended. Drought can lead to plant death and reduces yields. Flowering is either reduced or ceases altogether. If however, there is any flowering, the flowers are tiny and with low pyrethrins content.

## 8. PESTS AND DISEASES

There are many types of pests and diseases that affect pyrethrum. These reduce flower yields and quality both in nurseries and in growers' fields. These include insects, fungi, nematodes and mites.

8.1 Insects

A number of insects have been identified to be of economic importance in pyrethrum cultivation. These include pyrethrum thrips, onion thrips and green peach aphids.

8.1.1 Pyrethrum Thrips (Thrips nigropilosus)

These are tiny insects first observed in Kenya in 1957 and since then have spread in all pyrethrum growing areas. The insects measure 0.1 inches

(approximately 2-3 mm) long and are yellow in colour. They are not of economic importance until there is an outbreak usually during a dry spell.
Collectively, thrips can feed on growing tips, flowers buds, petals, pollen, new and old leaves and stems, some species feed in specific areas.

Feeding on older leaves may cause relatively mild damage including the formation of silvery patches that turn brown as the cell tissues dry up beneath the epidermis. This happens because the thrips suck plant cells from many garden plants, flowers, fruits, and shade trees.

Pyrethrum thrip (Thrips nigropilosus)

Thrips larvae and adults feed on various plant parts, pupal stages do not.

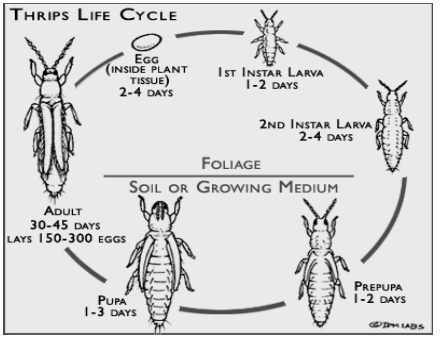
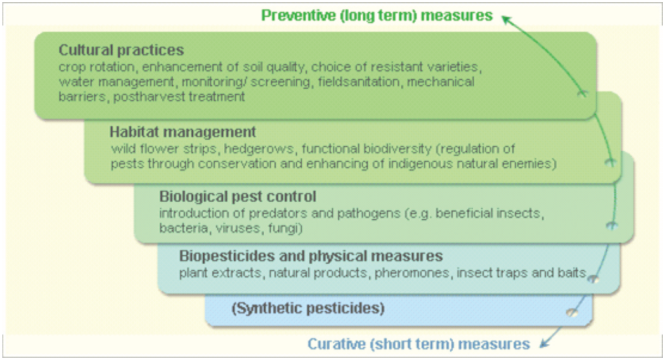



Figure 4 Lifecycle of thrips

## Management



Pyrethrum thrips can be controlled using insecticides formulated with the following active ingredients;

| Active ingredient | Insecticide class |
|---|---|
| **Abamectin** | Avermectin |
| **Permethrin** | Pyrethroid |
| **Acetamiprid** | Neonicotinoid |
| **Spinosad** | Spinosyn |
| **Cyantraniliprole** | Anthranilicdiamide |
| **Methomyl** | Carbamate |
| **Spirotetramat** | Tetramic acid |
| **zeta-Cypermethrin** | Pyrethroid |
| **Methyl parathion** | Organophosphate |
| **Permethrin** | Pyrethroid |
| **Spinetoram** | Spinosyn |
| **lambda-Cyhalothrin** | Pyrethroid |
| **Alpha-cypermethrin** | Pyrethroid |
| **Acephate** | Organophosphate |
| **Deltamethrin** | Pyrethroid |
| **Beta-cyfluthrin 2.5%** | Pyrethroid |

List of insecticides registered for thrips management in Kenya.

8.1.2 Green peach aphids (Myzus persicae)

Green peach aphids attack young shoots, leaves and stems. They suck juice from the plants and their secretion covers the leaves interfering with photosynthesis. Aphids can be controlled using the same chemicals as for thrips.

Green peach aphid (Myzus persicae)

8.2 Mites

8.2.1 Red spider mites (Tetranychus hudeni)

These are yellow in young stage but dark red in old stage. Population of ites can increase to large numbers especially during dry season and may cause plant death if they are not controlled. Thiodan 35% or Metasystox may be used to control them at the same rates as for thrips.

Red spider mite (Tetranychus hudeni)

8.3 Nematodes

A number of nematodes affect pyrethrum roots, stems, leaves and flowers. The most important nematode of pyrethrum is the root knot nematode.

8.3.1 Root knot nematodes

The root knot nematode is a common microscopic parasitic nematode of pyrethrum. Its presence is easily detectable by the appearance of knots on the roots. The parasite lives in the soil where it infests plant roots. If infested plants are transplanted to a clean field, they introduce the pests in the field. Use of infested plants for propagation should therefore be avoided. It is difficult to assess the damage done by the nematode, as many infested plants appear quite healthy and continue to flower, but diseased plants suffer more severely during dry periods.

There is no complete cure for root knot nematode, so long as the pyrethrum is in the ground. However, many recommended clones and varieties are tolerant to nematode attack. Infested land can be cleaned by growing grass or cereals on it for not less than three years. These crops are immune to nematodes attack, so the pest dies out for lack of a host plant. Good results have also been reported from heavy dressings of compost. Some nemicides may be used tocontrol the nematode but their widespread use appears costly.

**Moles**

Moles are major pests in pyrethrum fields that cause damage by digging tunnels underground and attack roots of the crop from below the soils.

Mole

They can be controlled by trapping or by use of bait or fumigant rodenticides

8.4 Diseases

8.4.1 Bud Disease

Two types of bud diseases have been identified; a true and a false bud disease. The true bud disease is caused by a group of fungi (Ramularia bellunensis, Alternaria sp. and Aschochyta sp).These attack young buds and young flowers. Epidemic outbreaks occur during prolonged foggy and rainy weather conditions. Flower buds dry up and turn brown or purplish grey. When flowers are attacked on one side, the growth of flowers is retarded on that side while the other continues growing normally resulting in a deformed bud or flower which bends over to the diseased side.

Figure 6 False bud disease

The false bud disease which was thought to be a physiological nature, as no casual organism had been isolated from the infected plant parts, as now been shown to be caused by flower nematode, Aphelenchoides ritsema-bosi.

The nematode attacks flower buds which then dry up completely along with a few millimeters of the stem. The affected buds die off and bent showing a "Shepard's Crook" formation.

Control

There is no known control for bud disease. However, through the selection of resistant material during breeding programme, it is possible to reduce the incidence of the outbreak effectively. During planting, diseased plants should not be used for splits and after the end of the season, plants should be cutback and the discarded stalks burned.

8.4.2 Root rot

Root rot disease is caused by several fungi mainly of the Fusarium , Rhizoctonia, Sclerotinia and Aschochyta sp. Of these the most common fungus is Sclerotinia minor. Root rot causing fungi are spread by extension of Mycelia from infected plants to adjacent plants. The fungi can also be transferred with the soil, especially during splitting. Infected plants slowly wilt and the leaves dry up, followed by ultimate death. In less severe cases, partial recovery of the plants may occur. Diseased plants are generally weak and easy to uproot due to the rotting of the roots.

Control
The root rot disease spreads rather slowly in established fields. The main danger is in the use of diseased plants for splitting as these increases the spread of the fungi. To avoid this, only healthy plants should be used for splitting. Dipping of splits in a fungicide such as Ridomil will reduce the spread of the disease.

8.4.3 Wilt
Wilt is a wide spread disease in many pyrethrum growing areas in Kenya. It is mainly a big problem in the lower altitude areas where the temperatures are comparatively high. Although the causative agents have not been fully identified, Rhizoctonia solani, Sclerotinia sp. and Fusarium sp. have been found in infected plants.

Some nematodes species have also been thought to be associated with the wilting disease. In dry weather, wilting of pyrethrum tends to occur rather rapidly particularly in the presence of high nematode infestation. The wounds that occur during splitting and also those caused by nematode are thought to be the probable entry points for fungi that cause wilting.

**Figure 7 Pyrethrum wilt disease**

Control
The use of crop rotation to reduce the accumulation of causative mechanism and dipping of splits in a fungicide such as Ridomil at planting is recommended. However, always use healthy plants for replanting new fields.

## 9. PYRETHRUM FLOWER PICKING

The flowers are harvested manually and the stage of the harvest is a key determinant of pyrethrin content.

9.1 Pyrethrum picking interval
Correct picking interval is 2-3 weeks since most flowers will have reached maximum pyrethrin content.

9.2 Stages of flower development

There are eight growth stages from bud stage to seed stage and pyrethrin content increases with growth stages.

It is advisable that flowers are picked when the ray florets have opened to horizontal position and approximately three rows of the disc florets are open. Flowers with all the disc florets open and those at the early overblown stage should also be picked as they still contain appreciable amounts of pyrethrins. Young flowers contain little pyrethrins and if picked in large quantities will lower the pyrethrins content. Flowers picked with excessive moisture are liable to ferment resulting in losses of pyrethrins. It is recommended, therefore, that growers allow dew and rain water to fall off before picking.

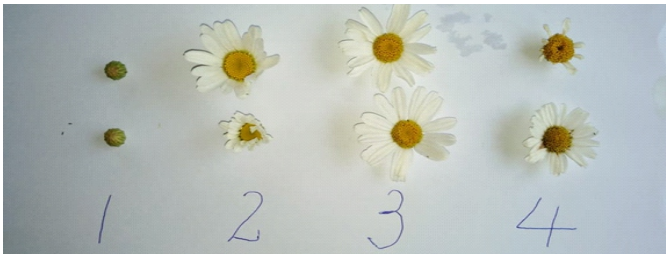



**Figure 8 Diagram showing different flower development stages.**

Avoid picking flowers with flower stalks because stalks have little pyrethrins and therefore cause reduction in pyrethrins content of the flowers. The best picking is achieved by holding the flower between the first and the second finger and jerking the flower head with the thumb.

## 10. DRYING OF PYRETHRUM FLOWERS

Efficient drying is an essential part of pyrethrum production; mistakes at this stage can cause serious reductions in the pyrethrins content. Drying is necessary not only to prevent fermentation and the associated loss of pyrethrins but also to enable the flowers to be ground into fine powder at the factory.

10.1 Sun drying

Almost all smallholders dry their flowers in the sun. This method involves very little capital expenditure and no running costs. The great disadvantage of sun drying is that the growers are entirely at the mercy of the weather; drying may not be possible at certain times of the year.

A typical growers' practice is drying flowers either on some material or on bare ground outside a homestead. This leads to flower spillage, soiling,

fermentation, transportation and storage losses.

10.2 Enhanced Solar Drying

Drying flowers in the sun can be improved by use of solar dryers. Different types of solar dryers constructed of simple material have been developed by former Pyrethrum Board of Kenya. These are; Shed roof, Gable roof with open sides, Gable roof with ridge vent and enhanced solar collector with any of the roof shapes.

These dryers are efficient and flowers take about three days to dry during sunny days but may take slightly longer during sunny days but may take slightly longer during rainy and overcast days.

One does not need to keep flowers indoors at night or when it rains as the dryers are waterproof.

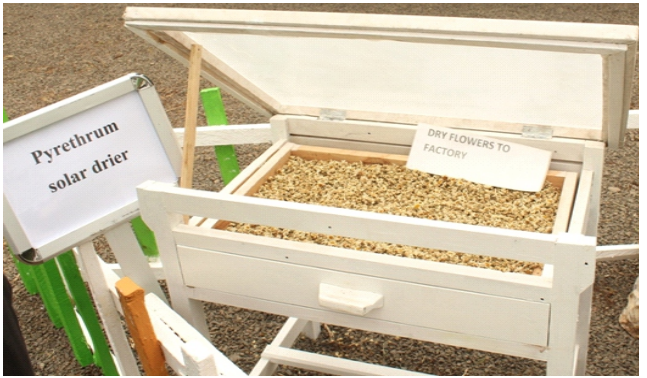
A solar drying unit consists of a wooden framework that holds trays for placement of the flowers.The framework has a provision for a polythene sheet (1000 gauge) to be used for covering the flowers when there is rain and also at night.

The new open coffee trays are equipped with a loose polythene paper which is only used when it is raining and at night.

The structure has a lifespan of up to 5 years with a seasonal replacement of the polythene cover every 6 months.

### 10.2.1 Solar Dryer Advantages

- Faster drying ending with clean dry flower
- Reduced loss of flowers
- Reduced fermentation and better flower quality
- Higher pyrethrins content thus better pay
- Reduced splashing and scattering by domestic animals thus reduced flower loss
- Allows a grower to handle parallel activities
- Reduced drudgery and hence low labour demand
- Appropriate for rainy seasons by capturing and utilizing short sunshine interludes
- Affordable since construction materials are locally available and easy to construct.



## 11. PACKAGING, STORAGE AND DESPATCH

As soon as the flowers have cooled, they should be packed into gunny bags, each containing no more than 30 kg of dry flowers. Packaging should be done gently to avoid the breaking of flowers during transit. Bags must be sent to the factories as soon as possible, making sure that they are well protected from rain. The pyrethrins content falls at the rate of 3-6% per month during storage so the flowers must be dispatched as soon as possible.

In case of any incidental delay, flowers in bags should be kept in dry, cool and well ventilated places on raised racks.

## 12. ANALYSIS OF PYRETHRINS CONTENT

On arrival at the factory, samples of each consignment are taken and immediately analysed. In case of several consignments from each society or individual grower, the total pyrethrins content and weights are computed at the end of each delivery period.

## 13. PAYMENT TO GROWERS

An interim pool payment is made a month after the end of the delivery period each month. This payment is calculated on the basis of weight of dried flowers delivered and the pyrethrins content, as obtained by laboratory analysis. After the end of the pool year when the Annual Accounts have been prepared, any surplus funds are paid as a final pool payment.

Every pyrethrum grower will endeavor to derive maximum income per unit area of his land from the crop. The Agriculture and Food Authority's role is to assist him realize these expectations. This, the authority does by providing the necessary resources and infrastructure for appropriate crop development, promotion, marketing and regulation for improved productivity and income.

## 14. INSECTICIDAL PROPERTIES OF PYRETHRUM

Pyrethrum is a contact insecticide. It has several unusual properties which have led to its continued demand in the face of competition from synthetic insecticides:

1. **Safety**

Pyrethrum has an outstanding safety record when used on or near humans. This is in marked contrast to many synthetics

2. **Flushing action'**
Disturbs insects so that they move out of their hiding places and expose themselves to the insecticidal spray. Pyrethrum has greater 'flushing' power than any other commercial insecticide.

3. **Fast knockdown and kill**
Against insects, it has a very rapid paralytic action, knocking them down followed by kill.

4. **Repellency**
Pyrethrum is repellent to insects at very low concentrations, a property used in the protection of stored grain, the preparations of insect resistant packaging, and in deterring mosquitoes, both by spray-on repellents and mosquito coils.

In addition, the smoke from Pyrethrum-based mosquito coils will inhibit mosquitoes from biting.

5. **Biodegradeable**
Pyrethrum is rapidly degraded by sunlight into harmless breakdown products, but at the same time it can be safely stored for years in suitable containers.

6. **Minimal Insect resistance**
Despite its long history of use, very few cases of insects resistance to Pyrethrum have been discovered, and these have mainly arisen as a result of cross-tolerance conferred by the insects developing resistance to another insecticide. This is in strong contrast to synthetic insecticides where innumerable cases of resistance have been discovered throughout the world.

7. **Broad spectrum of activity**
Pyrethrum is effective against a wide range of insect pests including mosquitoes, cockroaches, fleas, flies, aphids, etc. Thus a single can of a suitably formulated aerosol can be safely used against any insect found in the house or garden.

## 8.0 References

IRACMoA, Insecticide Resistance Action Committee mode of action classification http://www.irac-online.or/) and www.pcpb.or.ke

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