KENYA AGRICULTURAL AND LIVESTOCK RESEARCH ORGANIZATION

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FACTSHEET FOR TECHNOLOGY INNOVATORS WORKING WITH SMALL HOLDER FARMERS IN KENYA

PYRETHRUM CROP

INTRODUCTION

- Pyrethrum (*Chrysanthemum cinerariaefolium* Vis) is a perennial crop which possess white flowers with a daisy-like appearance having insecticidal properties.
- It is cultivated commercially solely for the production of six closely related esters called pyrethrins used as natural insecticides. Pyrethrum was first introduced in Kenya in 1928 from Europe, commercialization and the first export started in 1933.
- In the period between 1960s to late 1990s, Kenya was the world's leading producer of natural pyrethrum, providing more than 70% of the global supply, with peak production of 18,000 tons during the 1981/82 pool year.
- In Kenya, pyrethrum grows well in high altitude areas between 1500 and 3000 m above sea level, within 19 Counties, namely: Nakuru, Kiambu, Nyandarua, Nyeri, Laikipia, Meru, Embu, Baringo, Elgeyo Marakwet, West Pokot, Trans Nzoia, Bungoma (Mt. Elgon), Uasin Gishu, Nandi, Kericho, Bomet, Narok, Nyamira and Kisii.
- Altitude greatly influence pyrethrum yields and pyrethrin content, hence it is recommended that growers plant clones and varieties best suited to their agro- ecological zones which are grouped to either low, medium or high altitude.

*Fig. 1: Pyrethrum Crop (*Chrysanthemum cinerariaefolium *Vis)*

Soils:

- Pyrethrum requires deep soils that are rich in Phosphorus, Calcium and Magnesium with a pH of 5.0-6.5

Ecological conditions

Rainfall:

- Pyrethrum production is favoured by high rainfall of at least 750mm well distributed throughout the growing period. In warmer areas where evaporation is high precipitation of 1000-1125mm is preferable

Altitude:

- The crop grows well in areas within 1700 -3000m above the sea level, very high altitudes may experience heavy frost which cause reduction in yield due to wilting of tillers

Temperature:

- High yields are favoured by cool temperatures of less than 18°C for at least 6 weeks in order to initiate flowering.
- Temperature also influences pyrethrin content; as mean temperature decreases pyrethrin content increases

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Land preparation

- Plough the land early during the dry spell to allow stubble enough time to dry.
- Plough deeply to allow for ease of root penetration, growth, establishment and to facilitate water infiltration,
- During ploughing ensure the ground is not too wet to cause soil compaction, and subsequent soil erosion.
- Remove all weeds especially the perennials like Couch grass (*Digitaria scalarum*), Kikuyu grass *(Pennisetum clandestinum*), Star grass (*Cynodon dactylon*) and Sorrel (*Oxalis latifolia*), effective herbicide can also be applied two weeks before ploughing
- In small fields land preparation can be done by digging and breaking up the clods using a hoe/jembe, and tilling the soil until an even minimum depth 15-30 cm is attained.
- For large fields two ploughs and one harrowing with a disc harrow is recommended to give a fine seedbed.

Planting

- Establish pyrethrum through seeds, splits of mature plants or seedlings from tissue culture.
- Plant one split or seedlings vertically in a dug hole of 10cm wide and 15cm deep at a spacing of 30cm × 60cm or 30cm × 90cm.
- At planting apply Triple superphosphate (T.S.P) (46% P_2O_5) in each planting hole at the rate of 125 – 150 kg/ha or 2.5 –3 bags of 50kg/acre.
- In poor soils add a handful of well decomposed organic manure in the planting holes (4 tons/acre or10 tons/ha).
- Recommended fungicides and nematicides can be applied where necessary

Recommended clones and varieties

- A pyrethrum clone is a group of plant population obtained by continuous vegetative propagation of single plant allowing the entire population to be genetically homogeneous with similar growth characteristics.

- A pyrethrum variety is a heterogeneous plant population obtained from seed produced through the hybridization of two or more clones allowing the offspring plants to possess distinct characteristics from both parent materials.

VARIETY	POTENTIAL FLOWER YIELD (KG/HA/YEAR)	PYRETHRIN CONTENT %	RECOMMENDED ALTITUDES (METERS)
P4	900-1000kg	2.0	Above 2200 Molo, Timboroa, kuresoi, Keringet
K2 18	1100-1200	2.0	2000-2200 Oljo ororok, Ol kalau, Limuru Naivasha
K2 35	1100-1200	1.9	1500-2000 Keroka, Kisii, Gucha, Nyamira

CLONE	POTENTIAL FLOWER YIELD (KG/HA/YEAR)	PYRETHRIN CONTENT %	RECOMMENDED ALTITUDES (METERS)
SB/66/107	900-1000	2.00	High (above 2200)
MA/70/1013	1100-1200	1.90	Low/medium (1760-2100)

MA/71/423	1000-1100	1.80	High (above 2200)
MA/75/4	900-1000	1.90	High (above 2100)
M0/70/1124	900-1000	1.90	High (above 2100)
L/75/477	1000-1100	2.10	High (above 2100)
L/75/487	1100-1200	2.10	High (above 2100)
MO/74/443	1000-1100	2.10	All pyrethrum growing areas
KR/74/122	900-1000	2.10	Low/medium (1800-2100)
KS/70/62	1000-1100	1.90	Low/medium (1760-2100)
KS/71/6	900-1000	1.70	Low/medium (1800-2100)
KS/75/313	1100-1200	1.60	Low/medium (1760-2100)
KS/75/336	1100	2.00	Low/medium (1760-2100)
MO/74/223	900-1100	1.95	Low/medium (1800-2199)

Propagation of planting material

- Propagate pyrethrum clones through splits and tissue culture seedling, varieties can be propagated through seeds.
- Seeds propagation is easy but takes a long time (1year) from planting to flower maturity.
- Splits give a uniform population but are expensive in terms of transporting and their establishment is highly weather dependant.
- Rapid multiplication through tissue culture is fast and efficient but requires heavy initial capital investment.

1. Seed propagation

- Make raised beds about 1.5- 2.0 meters wide of any convenient length.
- Make straight furrows 16cm apart and about 1.25 deep on the raised beds.
- Place the seeds in furrows at a rate of ten seeds spread evenly on 2.5cm length of the furrow.
- Cover the seedbed with seedless dry grass, not soil and water thoroughly.
- Germination takes 10-18 days, after which the grass mulch should be removed in stages to allow the tender seedlings to acclimatise and become strong
- Top-dress with CAN (26%N) at 400 kg/ha 3 months after germination
- Transplant seedlings to commercial fields after 5-6 months in the nursery, when they are about 15cm tall and have well-established root system.

Fig. 2: Pyrethrum seed propagation to seedlings

2. Split propagation

- Preferably use plants that are actively growing to prepare splits for planting and should be sourced from a pest and disease free nursery.

- Trim mature woody plants at the level of the top most leaves.
- Trim excessively long roots to allow splits to fit into the planting holes.
- Shake off all the soils attached to the splits before planting.
- Splits from actively growing plants have no old flower stalk or excessive root system hence separate up easily into splits with little damage to the root system.

		
Pyrethrum plant ready for preparing splits	*Uprooted pyrethrum plant ready for making splits*	*Prepared splits ready for planting*

Fig. 3: Pyrethrum split propagation

3. Tissue culture seedling propagation

- Tissue culture propagation is currently applied in pyrethrum industry to rapidly produce parental material for establishment of seed and seedlings to meet national requirements of clean pure clonal and varietal planting material within a shorter time than conventional methods.
- Rapid multiplication of pyrethrum consists of 5 (five) stages, viz shoot initiation, shoot multiplication, rooting, acclimatization and transplanting

	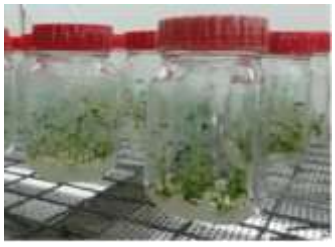	
Initiation of pyrethrum plant tissues to growth media	Pyrethrum tissue culture plantlets growing in media	Young seedlings in acclimatization stage

Fig. 4: Pyrethrum tissue culture seedlings propagation

Soil and water conservation measures

Poor soil and water conservation measures lead to land degradation which results to a decline in pyrethrum production.

Agronomic measures which growers can use to conserve water and soil include;

- Ploughing and planting within contours.

- Planting agroforestry trees along the boundaries as wind breaks.
- Aligning stalks between the rows after crop cut back, this improves water retention and soil physical/chemical properties.
- Intercropping with legumes at the early pyrethrum growth stage, useful for weed control, nitrogen fixation, moisture retention and soil erosion control
- Use of environmentally friendly pesticides for the control of pests and diseases in pyrethrum e.g pyrethrum based products.

Soil fertility requirements & management

Growers are advised to conduct soil tests to guide in the application of manure, fertilizer and soil amendments

- Phosphate fertilizers are recommended for use in pyrethrum growing.
- Triple super phospates (TSP) should be applied in each planting hole at the rate of one teaspoonful per hole. Approximately 125-150kg/ha (2.5 – 3 of 50kh/ha)
- The fertilizer should be mixed thoroughly with the soil in the hole before planting to avoid scotching of the plant roots.
- Addition of farm yard manure is beneficial especially in soils with poor soil structure, water retention and fertility.

Routine crop management practices

Weeding

To achieve high flower yields and pyrethrin content, routine crop management practices are essential.

- Under small scale one can carry out weeding through tillage using simple tools like a fork jembe.
- Remove all the weeds to avoid competition for crop growth requirements in the field.
- Drawn soils towards the base of pyrethrum plants in order to promote the development of tillers and increase water retention around the roots
- Weeding should start from the first month of crop establishment and there after frequently (every 3- 4 weeks) until the crop covers the ground and can be able to suppress weeds through shading effect.
- Avoid damaging roots, when the roots are damaged they may result in die-back of the plants.
- Large scale growers can use a Ridger for cultivating
- Chemical weed control can also be done using herbicides such as Sencor (Metribuzin), Venzar (Lenacil), Ronstar and Illoxan (Dicoflop methyl)

Fig. 5: Recommended proper weeded pyrethrum plot

Earthing up:

- Carry out earthing up 2-3 months after planting to encourage tillering.

Cutting-back:

- Cut-back crop stalk every year towards the dry season.
- Cut only stalks not leaves using a sickle not a panga, to avoid crop damage.
- Weed and earth- up after cut back, followed by application of 250-300kg TSP per hectare.

Crop rotation:

- Rotate the crop once within 3-4 years growing period by growing any other crop not related to pyrethrum.

1.Pyrethrum thrips

- These are tiny insects measuring approximately 2-3mm long, yellow in colour.
- They are of economic importance when there is an outbreak usually during a dry spell.

Chemical control:

Metasystox at the rate of 1.0 litre per hectare in 400 litres of water

2. Onion thrips

- Onion thrips infest flowers during dry period causing petals and florets to turn brown

Chemical control:

- They can also be controlled by using Metasystox

3. Green Aphids

- Aphids are a constraint to pyrethrum during the dry season where they feed on leaves, flower disc and flower petals causing reduction in fresh flower yield and thus decrease the pyrethrins content.
- The pest attack young shoots, leaves and stems
- They suck juice from the plants causing stunting, twisting and finally death
- Secretions from these pests predisposes the crop to growth of sooty moulds which cover the leaves thereby interfering with the photosynthesis

Chemical control:

- Aphids can be controlled using - Nimbecidine and Metasystox

4. Mites

- Red spider mites are yellow in young stage but dark red in old stage
- With increased population especially during dry spells, mites can cause plant deaths

Chemical control:

- Similar chemicals used for thrips can be used to control mite

5. Nematodes

Root knot nematode

- The parasite lives in the soil where it infests plant roots making it show symptoms appearing to have knots (root knots).
- If infested plants are transplanted to a clean field, they introduce the pests in other field.

Cultural control:

- Avoid use of infested plants for propagation

Crop rotation:

- Rotate with grass or cereals for 3 to 5 years since these crops are immune to nematodes, the pest will die due lack of a host plants.
- Plant antagonistic plants such as *Tagetes minuta* in the field to control nematodes.

Resistant varieties:

- Plant clones and varieties that are tolerant to nematode attack

Chemical control:

- Apply nematicides like Vydate, Nemacur and Temik in planting holes Chemicals should be applied strictly observing manufacturers guidelines
- In established fields nematicides are placed around the plants.

Soil fumigants:

- Apply fumigants in the soil before planting
- Commonly used fumigants are Vorlex, Basamid granular and Ethyl Dibromide (EDM)
- Fumigants are appropriate and practical in multiplication nurseries

DISEASES

1.Fusarium wilt (*Fusarium graminearum*, *Fusariumoxysporum*, and *Fusarium solani*

- This is a root rot pathogen, wilts caused by fusarium in pyrethrum are characterized by a sudden wilting, drying of leaves and eventual death of infected plants.
- Fungal mycelia and numerous sclerotia around the root system of the plant are usually associated with Sclerotinia wilt
- It causes stand decline in pyrethrum fields, death of the root system and
- subsequently the symptoms spread to the crown, tillers and leaves eventually causing wilting and drying of the whole plant.
- The disease causes yield losses estimated at 50%
- This disease occurs in many pyrethrum growing areas of Kenya but more prevalent in the lower altitude areas where the temperatures are comparatively high

Cultural control:

- Always use health plants (splits, tissue culture) when planting new fields

Crop rotation:

- Rotate pyrethrum with crops that are none hosts to the pathogens to eradicate or reduce accumulation of causative organisms

Chemical control:

- Dip splits in fungicides such as metalaxyl products to reduce the spread of the disease

2.Rhizotonia spp

- This is a root rot pathogen
- Root rot severity and damage is influenced by environmental and soil
- conditions, number and type of pathogen present and active in inciting the disease under the given conditions

Cultural control:

-

Crop rotation:

- Crop rotation reduces the accumulation of causative organisms in the soil in many areas

3.Bud disease (*Ramularia bellunensis*, *Alternaria spp*, and *Asychocyta spp)*

- The fungi attack young buds and flowers.
- Epidemic outbreaks occur during prolonged foggy and rainy weather conditions
- Flower buds dry up and turn brown or purplish grey
- Flower growth is retarded resulting in deformed buds or flower which bends over to the diseased side
- The fungi can also be transferred during plant propagation (splits)

Control

- There is no control of bud disease its incidence can be reduced by selection of resistant material in breeding programmes
- During planting, diseased materials are discarded and at the end of the season plants should be cut back and stalks burned

- This is a root rot pathogen
- Disease effects vary considerably among pyrethrum clones both in the same growing areas and from region and to another
- Symptomatology and damage result from the direct and indirect effects
- of prevailing environmental and soil conditions
- High altitude clones are more susceptible than the low altitude clones

Cultural control:

Crop rotation: Rotate pyrethrum with crops that are not hosts of this pathogen to eradicate or reduce accumulation of causative organisms

4. Aschocyta spp

- This is a root rot pathogen
- The fungus spreads by extension of the mycelium to adjacent plants and through soil, especially during splitting
- Infected plants wilt slowly and the leaves dry up, followed by death of the plant

Cultural control:

- Only healthy plants should be used for planting new fields

Crop rotation:

- Rotate pyrethrum with crops that are not hosts of this pathogen to eradicate or reduce accumulation of causative organisms
- In less severe infestations, partial recovery of the plant may occur
- Diseased plants are generally weak and easy to uproot due to the rotting of the plant roots

5. Pythium *spp*

Crop rotation:

- Rotate pyrethrum with crops that are not hosts of this pathogen to eradicate or reduce accumulation of causative organisms

Harvesting

- Pyrethrum yields are determined by the number of flowers in the plant, flower size, dry matter content and the pyrethrins content of the flower when dried.
- To get maximum pyrethrin content, pick flowers once every 2-3 weeks when ray florets are horizontal and about 3 rows of disc florets are open.

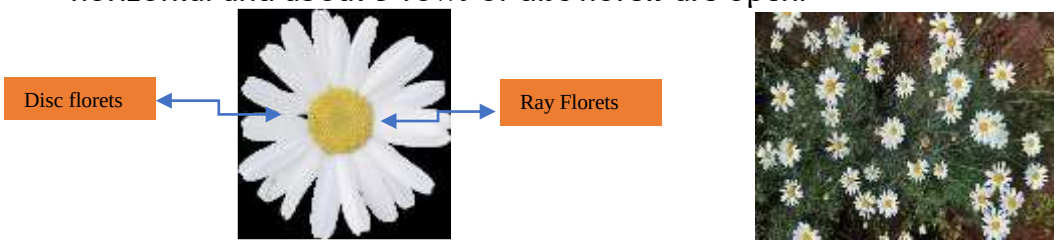

Fig. 6: Recommeded Pyrethrum harvesting stage

- Young flowers contain low pyrethrin and if picked in large quantities will lower the pyrethrin content.
- When picking is delayed, all overblown flowers should be picked first since they contain appreciable amounts of pyrethrins.
- When overblown flowers are left on the plant they reduce the formation of new flower buds.
- Do not pick pyrethrum with flower stalks, the best picking is achieved by holding the flower between the 1st and the 2nd finger and jerking the flower head with the thumb.

	
The bug stage - Pyrethrins content at 0.5% w/w	**Ray florets vertical -** Pyrethrins content at1.1% w/w
	
Disc florets open - Pyrethrins content at 2.2% w/w	**Overblown flowers -** Pyrethrins content at 1.1% w/w

Fig. 7 : Pyrethrum growth stages and related pyrethrin content

Post-harvest handling

After harvesting pyrethrum flowers proper drying, packaging, storage and transportation protocols should be followed.

Drying

- Immediately after flowers are harvested they should be dried to maintain quality and pyrethrin content.
- Dry flowers to about 13% moisture content (sun drying).
- Confirm effective drying by picking dry flowers randomly, 4 out of 5 flower heads picked should shatter easily if squeezed between thumb and fore finger.

Drying methods

- Open sun drying
- Combustion drying
- Flue dryer
- Solar dryer

Fig. 8: KALRO improved solar drier recommended for pyrethrum flowers

Packaging

- After drying and cooling pyrethrum flowers, pack in well-ventilated gunny bags.
- Packing should be gentle to avoid flower losses during transit.
- For ease of transportation bags should carry 25-30 kg of dry flowers.

Fig. 9: Example of a recommended packaging for pyrethrum dry flowers

Storage

- Send packed flowers immediately to the factory as prolonged storage causes loss of pyrethrins through degradation and spillage.
- In case of any incidental delay, bagged flowers should be kept in dry, cool and well-ventilated places on raised racks.

VALUE ADDITION

- Pyrethrum crop is cultivated for production of pyrethrins which are used to formulate insecticides.
- Synergised pyrethrins have exceptional biological properties such as; very rapid and powerful activity against crawling (cockroaches, bugs, lice and ticks) and flying (mosquitoes, flies, fleas and mites) insects.
- Pyrethrins have an unusual selectivity against target pests and no significant resistance in insect species.
- Pyrethrins are the **safest** insecticide because of their **low mammalian toxicity** and **lack of environmental persistence**.
    - **Rapid knockdown -** Pyrethrum's knockdown effect attacks insects' nervous system rapidly killing target insects.

- **Low mammalian toxicity -** Pyrethrins can be used domestically on animals and pests because of their low toxicity.
- **Environment friendly -** Pyrethrins easily degrades in light and air and do not pose any environmental hazard
- **Broad spectrum usage -** Pyrethrins can be applied in various environmental conditions.
- **Resistance -** No resistance to pyrethrum products has been reported worldwide for more than 150 years.

Formulations prepared from pyrethrins may be grouped according to use as follows.

- **Aerosols**–To control flying and crawling insects mainly in dwelling places, utilities and processing plants.
- **Agricultural sprays** -Formulated to control pests on crops in the field.
- **Livestock sprays** -Formulated to control livestock pests.
- **Food stores/warehouses/fogs** - controls storage pests.
- **Public health sprays** -Controls flies, mosquitoes and cockroaches
- **Dusts**
  - Poultry house dusts -controls red mites
  - Pet liquid/dusts -controls fleas, keds, lice and ticks on dogs and cats
- **Powders**
  -Controls lice, cockroaches, storage pests and crop pests
- **Other products**
  - Agricultural sprays and fogs
  - Storage dusts, powders and fogs
  - Livestock sprays and grasses
  - Pet sprays, dusts
  - Lotions, shampoos and gells
  - Mosquito coils
  - Animal feed (py mac)
  - Manure (by-products

Markets

- Pyrethrum flowers are bought by processors who extract the pyrethrins for formulation of aerosols, repellents, storage powders, pet products, veterinary products, crop sprays and animal feeds.
- Growers are paid based on the weight of flowers and the pyrethrin content once tested.
- Pyrethrum processors in Kenya include;
  - Pyrethrum processing company of Kenya. (PPCK)
  - Kentagra Biotechnology
  - HighChem East Africa
  - Agrichem Botanicals
  - Orion EPZ
  - Maj-Chemie
  - Junglechem Limited

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