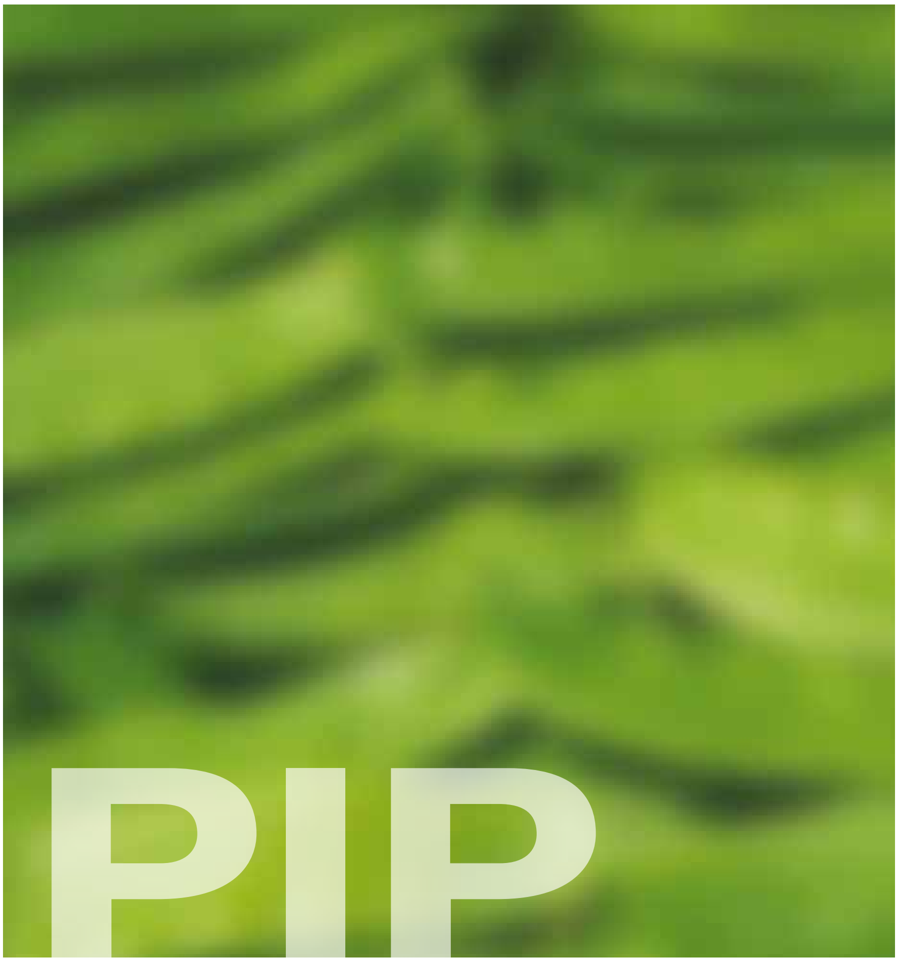


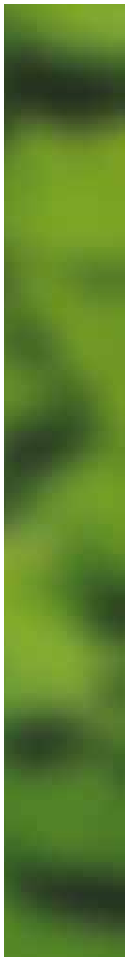

CROP PRODUCTION PROTOCOL

PEA (*PISUM SATIVUM*)

PIP

FOR SUSTAINABLE DEVELOPMENT OF THE ACP HORTICULTURAL INDUSTRY

COLEACP is an international network promoting sustainable horticultural trade.

PIP is a European cooperation programme managed by COLEACP. It is financed by the European Development Fund and implemented at the request of the ACP (Africa, Caribbean and Pacific) Group of States.

In accordance with the Millennium Development Goals, the global objective is to: "Maintain and, if possible, increase the contribution made by export horticulture to the reduction of poverty in ACP countries".

www.coleacp.org/pip

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Disclaimer

The document « Technical Itinerary » (fruit or veg.) describes all the agricultural practices linked with the (fruit or veg) and suggests control of pests and diseases based mainly on active substances supported by the pesticides manufacturers in the European Directive 91/414 review and due to comply with European pesticides residues limits . Most of these active substances have been tested through a field trials programme and the residue level of each active substance has been measured. The pests and diseases control suggested is therefore dynamic and will be adapted continuously integrating all information gathered by the PIP (see the web site www.coleacp.org/pip). Nevertheless, each grower has the possibility to select among the products listed a set of active substances of no conce rn regarding residues.

It is obvious, that usage is allowed only for those formulations which have been legally registered in the country of application. It is each grower obligation to check with the local registration authorities whether the product he/she wishes to use is mentioned on the list of registered products.

The PIP's crop protocols and guides to good phytosanitary practices are regularly updated. For further information, see the PIP website www.coleacp.org/pip

PIP
FOR SUSTAINABLE DEVELOPMENT OF THE ACP HORTICULTURAL INDUSTRY

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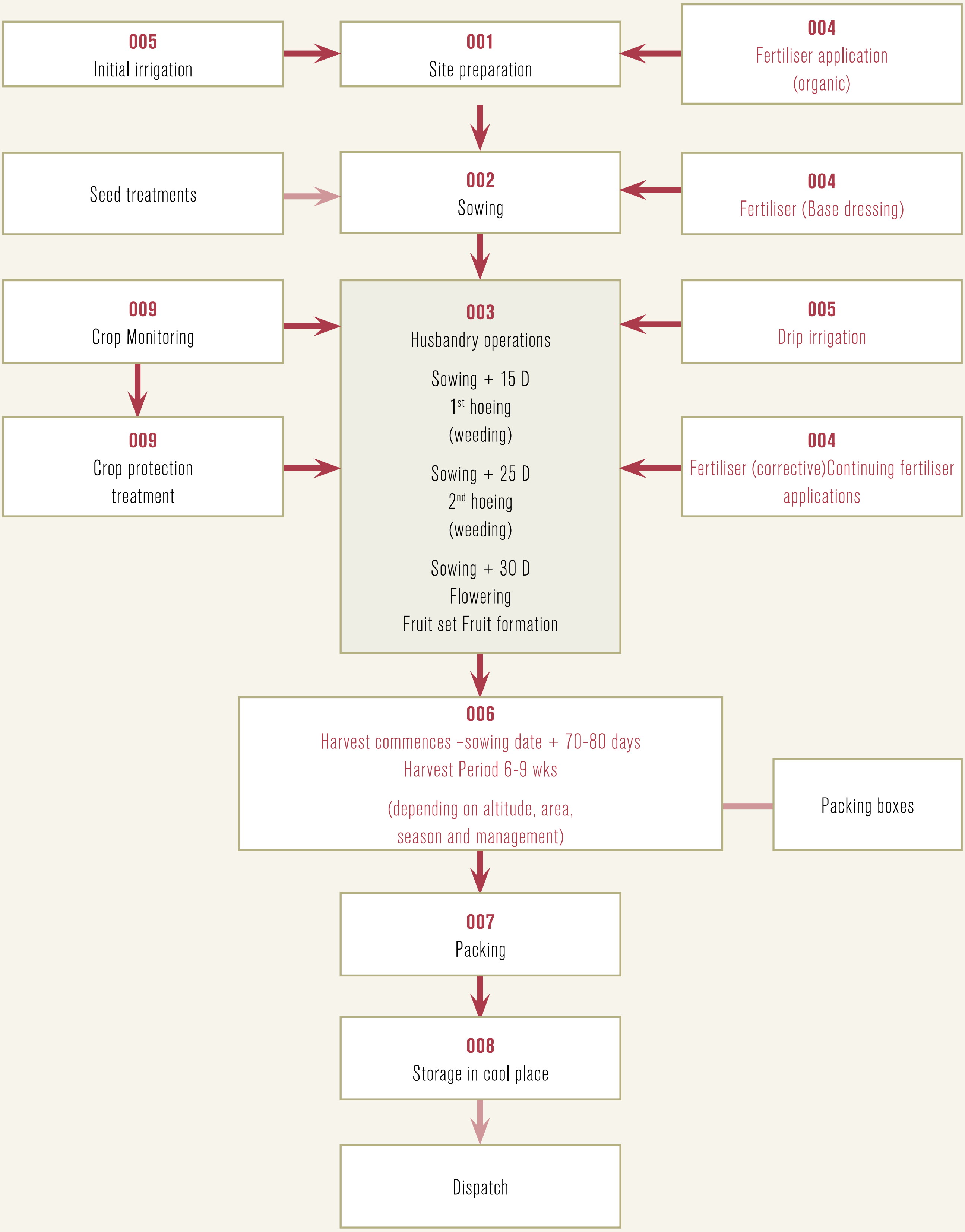
Production process

(numbers refer to paragraphs in the text where details are given)

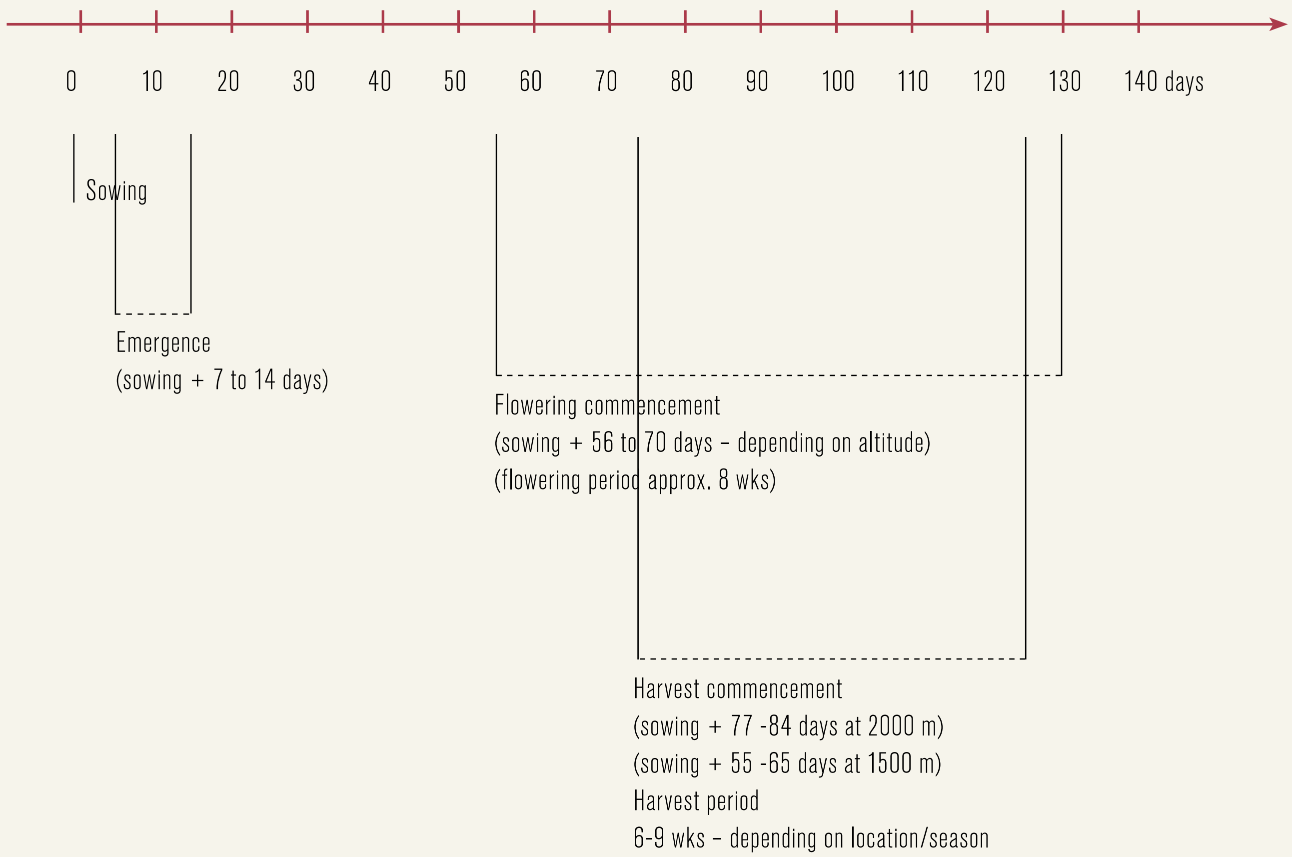


I. Crop cycle

Kenyan pea crops are produced all year round due to the climate available on the Equator with all-year round growing conditions. Peas are very sensitive to heat stress and yieldsare reduced if the crop is grown at lower altitudes where temperatures are often higher. Higher yields are obtained if pea crops are grown at higher altitudes and a minimum of 1500 m is advisable.

Due to the range of climates in the areas where peas have been grown, there is a wide range of periods between sowing and commencement of flowering or harvest.Similarly, the length of the harvesting period depends on the location, variety and specification of the pea depending on type of pea (mangetout, sugar snap or garden pea).

Peas have either a 'determinate' or 'indeterminate' grow thhabit. Determinate types are shorter and flower over one period – these were bred for once over mechanical harvesting. However, an 'indeterminate' type grows taller,requires more plant supports and flowers over a longer period in two or three flushes.



II. Site preparation

1. Soil characteristics

Peas can provide good returns on a wide range of soils (sandy clay loam, sandy loam etc.) but they prefer a heavy soil. Silty soils that tend to form a crust impede germination due to lack of oxygen and emergence. Soil type and soil profile should be uniform throughout the field to ensure even crop development and harvest.

Soil conditions required for good yields are:▪ sufficient top soil depth (40 to 50 cm);

- uniform soil structure;
- fast draining (waterlogged soils increase risk of root and collar rot, and seed asphyxia at the germination stage);
- optimum pH 6.5 (minimum pH 5.8)
- pH < 5.8: reduces peas yields
- pH > 7,5: yields gradually decline as alkalinity increases
- relatively stable structure;
- salinity: peas are sensitive to as little as 1mS/cm, which reduces yields. Avoid saline soils and saline water. On soils with a low cation exchange capacity (CEC), fertiliser applications should be split up and applied in several instalments to avoid excess doses of salts.

2. Recommendations for previous crops in rotation

Crop rotation plays an important part in the health of the pea crop, which is susceptible to *Fusarium* and root knot nematode and other soil borne pests and diseases. Peas should not follow crops which are hosts to pests and diseases which attack peas (see table below); in particular, other legume crops such as runner beans, fine beans and peas should be avoided.

Ideally, the same land should not crop peas more than one crop in every three crops. In between the pea crop, a minimum of one and preferably two 'recommended crops' should be grown to actively manage soil health and optimise peas yields. Yields of peas will decline if no rotation is practised. Poor rotation will also build up levels of pests and diseases in the soil, which may be difficult to 'remove' by the use of chemical treatments. Crop rotation is the most cost effective means of maintaining soil health and crop yields.

TO BE AVOIDED AS PRECEDING CROPS	NOT USEFUL AS PRECEDING CROP	RECOMMENDED AS PRECEDING CROP
Peas, beans African eggplant Eggplant Melon, Cucumber, Zucchini, Watermelon lettuce Okra	Groundnut Pepper, Celery, Lettuce Carrot Onion, Garlic, Shallot	Cereals (maize, sorghum, millet, fodder grass) Cabbage, kale, sukumawiki, pakchoi etc Baby corn, Turnip, bulb onions Cassava Sweet potato /potato

Incorporation of crop debris from cabbage-family crops provides useful partial soil sterilisation as the debris decomposes; it gives of gases similar to the active ingredients in certain chemical soil fumigants. Care should be taken if herbicides have been used in previous crops as crop debris can sometimes contain residues of the herbicides, which interfere with subsequent crop emergence and development (e.g. atrazine in maize). If root knot nematode is a problem, it is possible to reduce the levels present by a short rotation with dwarf Mexican marigold (see notes in annex 7).

3. Soil preparation – field preparation

- Pea crop requirements:

A soil of uniform structure, tilled to a depth of 30 to 50 cm. The seed bed should have a fine structure and be well-aerated. Field preparation should allow the root system to establish easily throughout the top 15 – 60 cm, providing the plant with a good supply of water and minerals via its very delicate lateral roots. It is necessary to keep the soil well structured, slightly packed down and well prepared. Soils that tend to cap should be watered to field capacity and then tilled just before sowing. They should not be watered again until after crop emergence.

Very well rotted, composted organic matter and basal fertiliser dressing should be incorporated at the time of soil preparation. Excessive organic manure just before sowing is to be avoided because this increases susceptibility to disease (rot) and pests (nematodes, seed fly). Under no circumstances should fresh anure be applied to pea fields before planting due to the risk of contamination with *E.coli* bacteria when the cropping cycle from planting to picking is so short. If in doubt, cover the rotted manure with polythene to ensure that the temperature of the heap reaches at least 55° C for 3 days before application to the field.

The ground should be well levelled to prevent water from gathering in hollows, asphyxiating the plants or causing disease. The field should be perfectly flat and not too stony; this will enable greater sowing precision and subsequently facilitate harvesting.

Fields should be fenced to keep out livestock. It is unwise to let livestock into a peas field to graze on crop residues, as they may introduce weed seeds and disseminate nematodes. Fresh manure left by grazing animals is a potential source of *E.coli* in peas planted immediately afterwards. At least 6 months should elapse after application of fresh manure before peas are planted to reduce risk of contamination. Alternatively remove cop debris and feed animals off the growing site. The manure can then be composted with other crop debris before returning it to the planting site.

III. Sowing operations

Seed requirements, records and inspections	All imported seeds used must have a plant health certificate. If the exporter supplies seeds, the seed lot number can be recorded in the Crop Records with reference to the health certificate number. Seed treatments must be recorded in the Pesticide Application Records (PAR) for a crop (including any treatments, which were applied by the seed producer in compliance with import requirements into the country – usually thiram). If seeds are additionally treated in the country (for *Fusarium* prevention etc) this must also be recorded in the PAR. Ideally, seeds should be planted immediately after seed treatment with insecticide or fungicide. Delays can result in reduced efficacy of the seed treatment and even deterioration of seed quality. Do not use self-saved seed as this increases the risk of seed borne diseases such as *Fusarium* and *Ascochyta*. Inspect seeds before planting to ensure they are not physically damaged, shrivelled (old seed stock). Do not plant suspect seeds. If necessary grade-out poor quality seeds before planting. If seeds have been treated with pesticides, ensure planting teams are provided with protective gloves. Exporters who distribute seeds obtained from an importer, should first check germination percentage is > 95% before distributing seeds to growers. The planting density varies depending on the vigour of the variety and whether the pea is a 'determinate' or 'indeterminate' type. Drip irrigation allows more of the land to be cropped and the number of plants to aim for is 225,000 – 280,000 per ha of land. Average seed requirement: 75 kg/ha (range 50 – 80 kg/ha depending on planting system and type of pea).
Sowing pattern	The sowing pattern will depend on: ▪ the abundance of foliage of the variety used; whether maintenance operations are mechanised (passage of horse or tractor); type of irrigation (furrow, sprinkler or drip); ▪ sowing density should be lower during the rains to increase air circulation and ensure leaves dry more quickly. This will reduce the risk of *Ascochyta* affecting yields in the rainy seasons. Recommended sowing pattern: Mangetout and sugar snap benefit from being planted under protection from the rain in polytunnels, as they suffer less from *Ascochyta* if leaves are not constantly wet. Sufficient space should be provided for access of spray equipment, to control powdery mildew in crops grown in tunnels. A central tractor path with three rows of peas on either side will fit into a 6.25 meter wide tunnel. In the above system, a double row of seeds would be planted along the beds. The double row is about 8-10 cm apart using a staggered planting pattern to allow some airflow when the plants a re young. The beds would be about 50 cm apart, to allow access for pickers. Plant one seed every 6 – 8 cm along the rows. Increase the spacing in rainy periods. If crops are planting outside and not under cover, they will be prone to Ascochyta during the rains and should have a wider spacing so that leaves can dry out more quickly after rains and pickers re not always rubbing past foliage and spreading disease. A spacing of 50 cm between rows and 10 cm between seeds is recommended.

Sowing depth	Seeds must be sown uniformly for uniform emergence and ripening. As the pea has epigeal germination (the cotyledons emerge above ground), easy emergence of the seedling must be ensured: ▪ in sandy soils: sowing depth between 3 and 5 cm; ▪ in heavy soils: 2- 3 cm depth (no irrigation before emergence). Anything that favours asphyxiation (heavy soils, too much water, compacted soil, and seeds sown too deep) will compromise emergence; emergence will be irregular and seedlings will be susceptible to root and collar diseases. Do not plant too deep during cool wet periods or the seeds will rot.
Sowing dates	Peas can be sown and harvested all year round in Kenya. In other countries, peas sown in ground that has warmed up germinate faster and emerge more uniformly. This advantage continues right to harvest, with pods ripening more uniformly. Numerous other factors that must be taken into account in planning sowing dates, e.g. shipping capacity and duration of crop cycle is 18 to 20 weeks for mangetout and sugar snap and 22 wks for garden peas.

IV. Cultural operations

Bed making

- Under polythene rain covers (Haygrove Tunnels) there are six beds made – in two sections of three beds, with a space in the centre for the passage of a tractor mounted sprayer (about 1.5 m wide).
- The beds are spaced one meter apart, from bed centre to bed centre (60-cm bed and 40 cm pathways).
- Beds are usually made by hand. A fine seedbed will ensure faster germination and more uniform emergence. Heavy clods should be broken up.
- In the Haygrove system, a double row of seeds, about 8 – 10 cm apart, is planted. It is best to plant seeds near to the drip irrigation emission holes and in a zig-zag pattern to increase air circulation. Turning on the drip irrigation ahead of planting will form wet patches indicating the position of the drip emissions. This will help in the positioning of seeds.
- If rain covers are not used, and the crop is not being sprayed with a tractor-mounted sprayer, the beds should be about 50 cm apart and a single line of seeds planted in the bed at 6-8 cm between seeds in the row.

Stringing up

- Plant supports must be in place as soon as the crop is 20 cm high. Delays in providing plant supports will result in loss of yield and quality due to disease.
- A series of wooden posts, about 20 meters apart in the row are positioned to support double strands of strings at 20 cm intervals. The first set of strings will be 10 cm above the ground and the other sets of strings about 20 cm apart. End posts, which secure the top wire (high tensile 12.5 gauge) should be buried at least 45 cm into the ground.
- The crop is gently tucked into these strings to prevent the plants from touching the ground, improving spray penetration, ventilation and light into the crop.

Weeding

- Ideally, a stale seedbed should have been prepared to reduce weeds before planting peas.
- Peas benefit from weeding due to reduced competition for water, sunlight and nutrients. Spray penetration of the pea canopy is improved if weeds are removed. Some weeds also host pea pests such as thrips, spider mite and nematodes and should be removed.
- If necessary, combine with hoeing.
- Weeding must be shallow to avoid damaging pea roots.

Incorporation/removal after harvest

- Providing there are no serious *Ascochyta* problems, incorporate crop remains with roots. If there is weed infestation, remove weed plants complete with roots to avoid contaminating subsequent sowings and leaving residue that may harbour soil pests.
- Do not allow livestock to graze fields after harvest, to avoid contamination of succeeding crops with *E.coli.*
- Incorporate organic matter.

V. Fertilisation

General remarks	Fertiliser applications must be planned with precision so that the dosage of each nutrient is appropriate to actual conditions in each field (this requires a soil analysis every 3 years). Records should be kept of any soil analysis undertaken which justifies fertiliser applications in order to comply with certification bodies. The crop's requirements will be established as accurately as possible to avoid any excess. Peas develop root nodules that fix nitrogen, but for maximum yield, this does not replace mineral nitrogen inputs. Commercially available *Rhizobium* seed treatments are obtained from the University of Nairobi in Kenya. If *Rhizobium* inoculants are used, the initial fertiliser applications should have reduced nitrogen content, as excess N will reduce development of the *Rhizobium* in the pea roots. Healthy *Rhizobium* nodules are pink inside and appear to be attached to the outside of the root. These should not be confused with the gall of root knot nematode which are smaller, not as round and appear to be within the structure of the root. Roots, which are well endowed with *Rhizobium* nodules, are less susceptible to root knot nematode. As peas are sensitive to salinity, fertiliser applications should be divided up and applied in several instalments. Top dressings must be applied without touching the leaves, to avoid burning them. They will then be lightly incorporated (hoeing at same time to reduce losses due to volatilisation). Alternatively soluble fertilisers can be applied down drip irrigation lines, or foliar feeds can be sprayed onto foliage. Do not apply in the peak heat of the day, to avoid scorching leaves.
Organic manure	Organic manure must be well rotted. It is wisest to apply this input to the previous crop. However, ensure the total N does not exceed 250 kg/ha/yr. Take care not to enrich P levels excessively in soils. <u>Dose</u>: 10 to 20 t/ha if possible. Aim to have up to 5% organic matter content in the soil.
Nitrogen (N)	In the UK, it is recommended not to apply nitrogen to peas, but yields suffer on the Equator without nitrogen fertiliser. To give the crop a good start, a nitrogen application is required (but never in excess) in the earliest growth stage (when there are not yet any nitrogen fixing nodes). Symbiotic N fixation begins from the 2nd trifoliate leaf. Take a soil sample to indicate the Soil Indices for NPK before devising the fertiliser programme. <u>Dose</u>: 50 to 100 kg/ha at N Soil Indices 0 and 1 respectively. High N input has little effect on yield and excess input (> 100 U N/ha) hampers node formation, makes the plant susceptible to lodging, and favours diseases and abortion. <u>Forms</u>: ureic (urea)/ammoniacal/nitric (nitrate). Nitrate of sodium is to be avoided. <u>Balance</u>: N:K20 between 1:2 and 1:3. <u>Timing</u>: nitrogen is incorporated into the soil just before sowing; basal dressing and sometimes top dressing: part of the N input (20 to 30 U) can be applied at start of flowering (25-30 days after sowing). Late application prolongs the growth cycle, reduces yield and provides favourable conditions for rust to develop.

<table>
<tr><td>Phosphorus (P205)</td><td>Phosphorus promotes firm rooting (important in sandy soils), it must therefore be present in a form which can be easily assimilated right from emergence. Phosphorous also. In mineral soils, optimum pH for P205 availability is 6.5. At 6.1 and between 6.5 and 7.4, availability declines; in these conditions, therefore, the basal dressing applications should be higher and a top dressing may be required.

Dose: depends on Soil Indices
Indices: 1 2 3 4 5 6
Kg/ha: 185 135 85 35 0 0

Forms: phosphate of ammonia, triple superphosphate.

Timing: base dressing, and top dressing in certain soils if needed. No more than half the P dose should be aplied in the base dressing. Although phosphorus is needed in smaller quantities, it is vital for plant growth. Signs of P deficiency are dark green leaf blade, upright habit, browning of older leaves followed by leaf fall. Where soil analyses give values below 12 mg, apply 50 to 60 units of P205/ha in the form of superphosphate (rapidly assimilated) just before sowing.</td></tr>
<tr><td>Potassium (K20)</td><td>Like all legumes, peas respond well to potassium. K deficiency causes dark green coloration and loss of colour between leaf veins, bases of leaves roll downward. Later, leaf necrosis and leaf fall. Potassium improves pod quality.

Dose: depends on Soil Indices
Indices: 1 2 3 4 5 6
Kg/ha: 190 140 90 (2-) 40M (2+) 0 0 0

Forms: potassium sulphate and potassium nitrate.
Avoid potassium chloride (KCl), which is unfavorable to peas).

Timing: Apply no more than half the K in the base dressing
If soil analysis reveals very high potassium content, inputs should be reduced or omitted, to avoid excessive growth of the crop. NB: 20% of total mineral input is found in the pods. Excess K is to be avoided because excessive growth of foliage will increase the risk of disease. Because peas are a short cycle crop, they must receive their minerals in a readily assimilated form.</td></tr>
<tr><td>Magnesium (MgO)</td><td>MgO deficiency can occur on acid, leached, sandy soils.

Dose: Dose: depends on Soil Indices
Indices: 1 2 3 4 5 6
Kg/ha 100 50 0 0 0 0

Forms: magnesium sulphate, potamag (potash magnesium sulphate), patentkali. Decomposed organic matter also provides magnesium.

Timing: base dressing, drip irrigation, foliar spray.</td></tr>
<tr><td>Calcium (CaO)</td><td>Provided by the soil, organic matter, superphosphate and phosphogypsum. Thomas slag, phosphal and natural phosphates also provide CaO and can be used for medium-term action (not immediate).</td></tr>
<tr><td>Essential trace elements</td><td>Can be applied through drip irrigation system.

Deficiencies of the following can occur:
• manganese: application of Thomas slag can reduce manganese deficiency in soils of pH > 7;
• zinc: this can be remedied by low-pressure foliar spraying (at sowing + 25 d, 40 d and if necessary 60 d) of a 1% solution of zinc sulphate neutralised by 0.5% lime;
• molybdenum: mainly in leached, acid sandy soils;
• copper: if possible, use a foliar fertiliser containing calcium.</td></tr>
</table>

VI. Irrigation

Irrigation is indispensable for maximum output. Peas require a minimum of 3,000 to 8,000 m^3/ha. If this amount is delivered using drip irrigation, the water application is more efficient, however, if overhead or furrow irrigation is sued, this could go up to 14,000 m^3/ha.

Crops are either drip irrigated or irrigated by sprinklers.

Drip irrigation, conserves valuable water resources, by delivering water directly to the plant root zone. There is no evaporation loss, as the water is contained within a tube. Drip lines need to be secured in a straight line with the holes facing upwards, so that they do not block. Care must be taken to ensure that dirty water does not block the drip holes. In some cases filters may be required to prevent drip lines from blocking. Maintenance of drip lines and filters is essential if the full benefit from this system is to be obtained.

Simple drip irrigation systems are available in Kenya for small scale farmers.

If available soil water reserves are not sufficient, the field should be watered before sowing. Watering after sowing is generally not recommended, as it encourages only shallow root development. However, soils that tend to crust should first be watered abundantly (to field capacity), then tilled just before sowing.

Drought before flowering has a significant detrimental effect on final yield. From start of flowering, fields should be irrigated regularly according to need, continuing until pods are filling. Pods that receive sufficient water are of better quality (less string etc).

If sprinkler irrigation is used, in very hot periods, it should be applied early in the day to avoid heat stress, burning of leaves, flower abortion and the formation of a microclimate that encourages disease (e.g. powdery mildew)

Irrigation instructions

Water requirement	Between 4,000 and 10,000 m^3 per ha of actual crop area. On sandy soils, irrigation should be more frequent than on heavier soils.
Water quality	Avoid saline water, which will cause an immediate drop in yield. Avoid irrigating directly with chlorinated water.
Watering regularity	From the moment of emergence, the plant must never be subjected to water stress. The emergence and flowering/pod formation stages are particularly sensitive.
Frequency of irrigation	To encourage the establishment of the root system, do not water too often until the crop has begun to put down roots (to encourage deeper rooting). To avoid *Pythium* root rot diseases, irrigation should be prudent and not excessive before emergence, in sandy soil.
Timing of irrigation	With overhead irrigation, water in the morning to reduce the risk of prolonged high relative humidity on leaves and root collar, and avoid water stress in very hot weather. With sprinkle irrigation, do not irrigate after applying a foliar treatment.

VII. Harvest

Method	Manual, with the pod stalk Preliminary sorting in the field (reject pods that are perforated, damaged, marked, twisted, etc.)
Precautions	Pick and handle with great care. Lay in a rigid but aerated container and do not pile more than 20 cm deep. Regularly bring harvested peas into shade (ideally every 10 minutes) Bring harvest to packing centre as quickly as possible (every 30-45 minutes). If pods are to be sorted and packed later, store them in a cool place. A 'charcoal cooler', made of charcoal between chicken wire mesh, is useful if electricity is not available. The charcoal cooler should be designed to ensure all air passing into the cooler passes through the charcoal (no gaps in the charcoal walls). The charcoal should be kept wet to enhance the cooling effect. This can be achieved using a drip line at the top of the charcoal wall, fed from a water tank on the roof. Maintain product traceability throughout all operations from picking to storage and shipping.
Frequency	During hotter periods, the crop will grow faster and picking may have to be done more frequently to avoid losses due to growth over specification (over-specs). Customers will provide picking specifications.
Harvest Period	Harvest will commence from 70 days after sowing for mangetout, about 85 days for sugar snap and 95 – 100 days for garden peas. The harvest will continue for 7-9 wks depending on the altitude, variety and seasonal climate. Start picking as early in the morning as possible to avoid harvesting wet pods or in hot sun.
Labour force	To comply with the above, pickers must be trained and aware of the crop's importance. Pickers must be supervised. They can harvest 40 – 180 kgs in an 8hr day per person, depending on calibre, type, time of the season and number of pickings.

VIII. Packing

The packing premises should be well-lit, cool, well-ventilated and clean. As soon as peas reach the packing station from the harvest field, they should be sorted:

- reject pods that are perforated, twisted, broken, injured or rotten, over grown, underspec or have pest damage (especially leafminer and *Helicoverpa* as these are EU notifiable pests);
- reject fragments of leaf, stem, flower, plant waste and other waste.

Obtain customer specifications for exported peas, as there are no sizing regulations in the EU for peas, however, customers will have very specific requirements themselves.

The EU marketing legislation is Summarised below

European legislation imposes quality standards for peas sold in the EU (See COMMISSION REGULATION (EC) No 2561/1999 of 3 December 1999) laying down the marketing requirements.

According to the type of consumption, peas are classified in two groups:

- shelling peas (round peas, wrinkled peas) intended for consumption without the pod,
- mangetout peas and sugar snap peas intended for consumption with the pod.

Minimum requirements

In all classes, subject to the special provisions for each class and the tolerances allowed:

(i) intact; however mangetout and sugar snap peas that have had their ends removed are allowed,
(ii) sound; produce affected by rotting or deterioration such as to make it unfit for consumption is excluded,
(iii) clean, practically free of any visible foreign matter (including parts of the flowers),
(iv) free from hard filaments or films in mangetout peas and sugar snap peas,
(v) practically free from pests, practically free from damage caused by pests,
(vi) free of abnormal external moisture,
(vii) free of any foreign smell and/or taste.

In addition, shelling peas must comply with the following and the seeds must be:

(i) fresh,
(ii) sound; produce affected by rotting or deterioration such as to make it unfit for consumption is excluded,
(iii) practically free from pests,
(iv) practically free from damage caused by pests,
(v) free of any foreign smell and/or taste, normally developed in shelling peas.

The development and condition of peas must be such as to enable them:

- to withstand transport and handling, and;
- to arrive in satisfactory condition at the place of destination.

Calibre

Sizing is not compulsory for peas.

Tolerances

Tolerances in respect of quality shall be allowed in each package for produce not satisfying the requirements of the class indicated.

(i) Class I10 % by weight of peas not satisfying the requirements of the class, but meeting those of class II or, exceptionally, coming within the tolerances of that class.

(ii) Class II10 % by weight of peas satisfying neither the requirements of the class nor the minimum requirements, with the exception of produce affected by rotting, progressive diseases or any other deterioration rendering it unfit for consumption.

Presentation

Uniformity

(i) The contents of each package must be uniform and contain only peas of the same origin, variety or commercial type, and quality.
(ii) The visible part of the contents of the package must be representative of the entire contents.
(iii) Notwithstanding the preceding provisions in this point products covered by this Regulation may be mixed, in sales packages of a net weight of less than three kilograms, with different types of fresh fruit and vegetables on the conditions laid down by Commission Regulation (EC) No48/2003 (1).B.

Packaging

(i) Peas must be packed in such a way as to protect the produce properly. The materials used inside the package must be new, clean and of a quality such as to avoid causing any external or internal damage to the produce.

(ii) The use of materials, particularly of paper or stamps bearing trade specifications is allowed provided the printing or labelling has been done with non-toxic ink or glue. Packages must be free of all foreign matter.

(iii) Stickers individually affixed on product shall be such as, when removed, neither to leave visible traces of glue, nor to lead to skin defects.

Marking

Each package must bear the following particulars, in letters grouped on the same side, legibly and indelibly marked, and visible from the outside:

(i) **The name and the address of the packer and/or the dispatcher** This mention may be replaced:– for all packages with the exception of pre-packages, by the officially issued or accepted code mark representing the packer and/or the dispatcher, indicated in close connection with the reference 'Packer and/or Dispatcher' (or equivalent abbreviations);– for pre-packages only, by the name and the address of a seller established within the Community indicated in close connection with the mention 'Packed for:' or an equivalent mention. In this case, the labelling shall also include a code representing the packer and/or the dispatcher. The seller shall give all information deemed necessary by the inspection body as to the meaning of this code.

(ii) **Nature of produce**– 'shelling peas', 'mangetout peas', 'sugar snap peas', or equivalent denominations if the contents are not visible from the outside,– 'trimmed', 'topped and tailed' or other indications, for mangetout or sugar snap peas that have their peduncle and/or blossom end removed, where appropriate.

(iii) **Origin of produce**– Country of origin and, optionally, district where grown, or national, regional or local place name.

(iv) **Commercial specifications**– Class.

(v) **Official control mark** (optional) Packages need not bear the particulars mentioned in the first subparagraph, when they contain sales packages, clearly visible from the outside, and all bearing these particulars. These packages shall be free from any indications such as could mislead. When these packages are palletised, the particulars shall be given on a notice placed in an obvious position on at least two sides of the pallet.

IX. Storage

For export, storage in a cold room is obligatory.

Optimum conditions:

- 4°C and 80% RH (or 6°C and 90-95% RH) can ensure 6 to 7 days' shelf-life from harvest to sale (high RH = mould);
- do not reduce temperature below 4°C (blotches appear);
- at 12°C and 90-95% RH, the harvest-sale interval is only 4 days;
- moderate ventilation to prevent pods from drying out;
- the harvest-to-refrigeration interval must be as short as possible;
- avoid any rupture of the cold chain between packing station and retail sale.

X. Crop protection

1. GENERAL REMARKS

Crop protection is governed by "Good Agricultural Practice" (GAP), following general recommendations such as those in the EUREPGAP Protocol. The goal is to provide a product that is sound, high-quality (i.e. complies the **Quality Standards**) and affordable. It is essential to combine the specific crop protection methods recommended below with all available husbandry methods (variety choice, rotation, staggered sowings, tillage, precision fertilisation, etc.) to obtain optimum protection **(Integrated Production and Protection)**, making full use of agronomic and ecological factors.

To limit pressure from parasites and certain pests:

> use crop husbandry methods of pest control as far as possible;
> avoid sowing peas near another crop that is infested by pests that may attack peas;
> avoid sowing peas in a field where peas have been grown recently (a 3-year rotation is regarded as the minimum; ideally, rotations of 5 or 6 years are recommended for land infected with soil fungi or nematodes). However, see provisos in section on Rotations above.

The effect of any operation(s) carried out must be subsequently assessed from all angles, to establish the "costbenefit" balance of the operation(s):

> effectiveness and profitability for the farmer;
> selectiveness for the crop and for non-target organisms;
> compliance with MRLs (consumer safety);
> side effects for operators and domestic and wild animals;
> effects on the environment (soil, water, vegetation, air);
> effects on husbandry methods;
> social consequences (e.g. reduced labour requirement where chemical herbicides are used). to prevent these pathogens from spreading.

Methods of control of pests and diseases of peas

Crop Protection principle	spider mite	aphids	Thrips	root knot nematode	caterpillars	leaf spots	powdery mildew	downy mildew	root diseases
Choice of land preparation									
Rotation				✓					✓
Soil cultivation (e.g. deep loughing post harvest, etc)			✓						
Avoid planting near susceptible plants or infested crops	✓	✓	✓		✓	✓	✓	✓	
Avoid land which is badly drained									✓
Avoid shade						✓			
Cultivation methods									
Adapt irrigation methods (e.g. use drip irrigation or overhead)	✓					✓		✓	
Use protective covers – plastic tunnels etc						✓			
Adapt planting density						✓		✓	
Cultural controls									
Use straw mulches			✓						✓
Organic manure applications				✓					✓
Regular weed control	✓		✓	✓					
Avoid wet foliage for long periods						✓		✓	
Use trap plants or green manures		✓	✓	✓	✓				
Care and attention of plants									
Remove infected parts of plants					✓				
Remove and destroy crop debris	✓	✓	✓	✓	✓	✓	✓	✓	✓
Do not damage plants in normal husbandry									✓
Crop Protection methods									
Biological controls	✓	✓	✓		✓				✓
Chemical controls						✓			
Physical controls (oils, detergents starches)	✓	✓	✓				✓	✓	
Botanical insecticides/repellents		✓	✓	✓			✓	✓	

✓ : Control method for the pest or disease

2. CONTROL TREATMENTS

Control treatments will be preventive or preferably in the light of intervention thresholds.

> When there is no threshold, treatments must be done only if risks are medium or high for the area of growing (see appendix 7 Pests and diseases sheets).

> When a threshold exist, treatments must be applied when the threshold is reached or exceeded, taking into account the presence of natural enemies (See Appendix 3 for IPM Scouting methods and Appendix 4 and 5 for sensitivity of natural ennemies to pesticides).

3. PESTICIDES

Pesticides are recommended for green peas, but the following must be taken into account:

- marketing authorisation, in compliance with authorised uses and approved dosages;
- obligatory precautions for use (application period, pre-harvest interval, maximum authorised dose, existence or not of untreated areas, protective equipment) and any restrictions on use;
- any Maximum Residue Limit (MRL) for the crop/pesticide combination in question. If the crop is exported, account must be taken of the MRL on the market where it is to be distributed (national MRL, European harmonised MRL or MRL set under the Codex Alimentarius).

In annex 1 we give the list of active substance that can be used on peas in Kenya according to information available at PIP. Efficacy on main pests and diseases is also given. The tables of appendix 2 show:

- the position of the active substance with regard to European regulations (status in Directive 91/414, existing MRLs);
- GAP that should comply with current MRLs. Since there are often several trade names for the same active substance and because registrations change regularly, producers have to check those which are valid in their country at the time of using crop protection products, for instance, by consulting the PCPB web site for Kenya (http://www.pcpbkenya.org). In Kenya, products with general authorisation for use on horticultural crops, vegetables can also be used on peas.

Some of the approved products contain active substances or live organisms which leave no residues. A non-exhaustive list of these products follows:

- *Bacillus thuringiensis,*
- garlic-based product,
- parasites or predators insects or mites.

The producer must first and foremost follow the instructions (doses, interval between treatments, number of applications and Pre-Harvest Interval) provided on the labels of locally authorised products. Following such instructions, however, does not necessarily guarantee compliance with MRLs currently in force in the European Union countries. To comply with European regulations on pesticide residues, it is recommended that the producer uses pesticides only within the limits of the Good Agricultural Practices tested by the PIP, which are critical GAPs. Any change to one or more elements of these GAPs indicated in Appendix 2 (increase in dose, frequency of application and number of applications; final application closer to harvest than the recommended Pre-Harvest Interval) may result in a failure to remain within the MRL.

4. TRACEABILITY

As with other husbandry operations, it is important to organise full traceability for crop protection operations, by recording at least the following data for each treatment:

- pest or disease to control;
- date of application (+ days after sowing date, + days before planned harvesting);
- development stage;
- product used (full name, supplier, formulation, batch number, etc.);

- dose actually applied;
- volume of water used;
- type of application (equipment, nozzle, volume/ha, width of work, speed, wind, etc.).

APPENDIX 1 : STATUS OF PESTICIDES FOR USE ON PEAS

Tables below give known registrations in Kenya. Efficacy given are based on existing registrations, documents on peas production and information from pesticides companies. Remarks : This information should be tallied with the legislation in force locally in each area of production.

Table 1 of main insecticides, miticides and nematocides on peas

Active substances	Registrations in Kenya				Efficacy								
	Snow and sugar snap peas	Peas	Vegetables	Horticulture	Caterpilars	Bollworms	Mites	Leafminers	Beetles	Aphids	Thrips	Army worm	Nematodes
abamectin	✓		✓				✓	✓					
acephate			✓						✓	✓	✓		
acrinathrin							✓				✓		
alpha cypermethrin			✓		✓	✓			✓	✓	✓	✓	
amitraz			✓				✓						
azadirachtin	✓			✓				✓			✓		✓
Bacillus thur. var kurs-taki thur. var kurstaki				✓	✓	✓							
beta-Cyfluthrin			✓			✓				✓		✓	
bifenthrin	✓		✓	✓	✓	✓	✓		✓	✓	✓		
carbaryl				✓	✓	✓			✓				
carbofuran			✓								✓		✓
chlorpyrifos-ethyl			✓	✓	✓	✓			✓	✓		✓	
chlorpyrifos methyl			✓		✓	✓				✓	✓	✓	
cypermethrin			✓	✓	✓	✓			✓	✓	✓	✓	
cyromazine	✓		✓				✓						
deltamethrin	✓	✓	✓		✓	✓			✓	✓	✓	✓	
diazinon			✓	✓	✓					✓	✓	✓	
dicofol		✓	✓				✓						

Table 2 of main insecticides, miticides and nematocides on peas

Active substances	Registrations in Kenya				Efficacy								
	Snow and sugar snap peas	Peas	Vegetables	Horticulture	Caterpilars	Bollworms	Mites	Leafminers	Beetles	Aphids	Thrips	Army worm	Nematodes
dimethoate		✓	✓	✓						✓	✓		
ethoprophos			✓										✓
fenitrothion		✓		✓	✓				✓	✓	✓	✓	
fenpyroximate							✓						
hexythiazox			✓				✓						
imidacloprid			✓							✓	✓		
indoxacarb	✓				✓	✓						✓	
lambda - cyhalothrin	✓	✓	✓		✓	✓			✓	✓	✓	✓	
malathion			✓		✓	✓			✓	✓	✓		
metam sodium			✓										✓
methomyl			✓	✓	✓					✓	✓	✓	
methoxyfenozide					✓	✓						✓	
oxamyl								✓			✓		✓
oxydemeton methyl				✓			✓			✓			
pirimicarb			✓							✓			
pirimiphos methyl		✓								✓	✓		
propargite				✓			✓						
pymetrozine			✓							✓	✓		
pyrethrin	✓	✓	✓		✓	✓				✓	✓	✓	
spinosad		✓	✓		✓			✓			✓		
sulphur			✓				✓						
tetradifon			✓				✓						
thiamethoxam	✓	✓							✓	✓	✓		
thiocyclam hydrogenoxalate				✓				✓	✓	✓	✓		

Table 3 of fungicides and bactericides on peas

Active substances	Registrations in Kenya				Efficacy						
	Snow and sugar snap peas	Peas	Vegetables	Horticulture	Downy mildew	Botrytis	Bacterial Blight	Ascochyta Blight	Powdery mildew	Anthrachnose	Rust
azoxystrobin		✓				✓		✓	✓	✓	✓
benomyl			✓					✓	✓	✓	
bitertanol		✓	✓					✓	✓		✓
bupirimate				✓					✓		
captan			✓		✓	✓					
carbendazim	✓					✓		✓		✓	
chlorothalonil	✓	✓	✓			✓		✓		✓	✓
copper		✓	✓		✓		✓	✓	✓	✓	✓
cymoxanil + famoxadone	✓				✓				✓		
cyproconazole											✓
difenconazole	✓	✓						✓	✓		
dithianon			✓		✓			✓		✓	✓
fosetyl aluminium	✓		✓		✓						
iprodione			✓			✓		✓			
mancozeb	✓	✓	✓	✓	✓		✓	✓		✓	✓
metalaxyl-M	✓				✓						
myclobutanil			✓						✓		✓
propineb			✓		✓			✓		✓	✓
propamocarb hydrochloride			✓		✓						
pyrazophos			✓						✓		
sulphur			✓						✓		
tebuconazole			✓					✓	✓		✓
thiophanate methyl			✓	✓		✓		✓	✓	✓	
triadimefon			✓						✓		✓
trifloxystrobin								✓	✓		✓

APPENDIX 2 : STATUS IN DIRECTIVE 91/414 AND MRL

The tables in this annex show the status in the European Directive 91/414, updated on January 2009, of the active substances listed in annex 1 of this document.

European MRLs on peas with pods and peas without pods (EU or National of EU countries) are also indicated in these tables. If MRL is the same on both types of peas, we have given only the common value. If MRLs are different the first value is for peas with pods and the second one is for peas without pods.

Since, in Europe, extrapolation of MRLs is possible from beans with pods to peas with pods (this mean that expected amount of residues on peas with pods must be more or less the same than amount found on beans with pods) , for each active substance, MRLs on peas with pods has been compared to PIP residues results on French beans (bean with pods). The tested GAP that give residues complying with current MRLs on peas with pods is indicated in the tables. When MRLs on beans with pods are higher than on peas with pods we have anlysed the necessity to request an extrapolation from beans with pods to peas with pods.

Note on the European MRL harmonisation:

The DG Health and Consumers (DG SANCO) has undertaken an MRL harmonisation process on the European level and has established a new EC MRL regime under EC Regulation 396/2005 and its annexes, which was published afterward as separate Regulations.

A list of national MRL was gathered by DG SANCO in June 2005 and submitted to EFSA (European Food Safety Authority) for verification and approval.

When no specific MRL exists for a crop, a default MRL is set at 0,01 mg/kg. These default EU MRLs as well as the EU MRLs based on measured residues could only be set after the publication of Annex I to the Regulation, establishing the list of food and feed products (Regulation (EC) No 178/2006 of 1st February 2006).

Towards the end of 2007 EFSA submitted the conclusion report of the MRL evaluation and recommendation to the Commission for final decision on the setting of harmonised EU MRLs.

These EU MRLs are listed in the annexes ,II,III and IV of the EC Regulation which were established by the Regulation (EC) No 149/2008 of 29 January 2008. The annexes were updated for the first time in March 2008 and the MRLs were entered into force on September 1st, 2008 and are available on the website http://ec.europa.eu/sanco_pesticides/public/index.cfm

Table 4 of main insecticides, miticides and nematocides on peas

Active substances	European regulations		
	DIR 91/414 status	European MRL	GAP
abamectin	Annex 1	0.01	The following GAP, tested by PIP in French beans residues trials, comply with current EU MRL on peas with pods: **Number of applications:** 3; **Interval between applications:** 14 days; **Dose active substance:** 10 g/ha; **PHI:** 3 days An MRL revision (0,05) has been requested by PIP in order to alllow a more critical GAP on French beans (reduced interval between applications). Extrapolation of this MRL to peas with pods has been requested by PIP
acephate	Withdrawn	0.02	PIP residues trials results on French beans have shown that residues cannot comply with current MRL. It is recommended to not use on peas with pods
acrinathrin	Not included in Annex1*	0.05	Not tested by PIP

alpha cypermethrin	Annex 1	0.05	The following GAP, tested by PIP in French beans residues trials,comply with current EU MRL on peas with pods: **Number of applications:** 3; **Interval be-tween applications:** 7 days; **Dose active substance:** 37.5 g/ha; **PHI**: 1 day
amitraz	Withdrawn	0.05	Not tested by PIP
azadirachtin	Not included in Annex1*	1	According to residues trials of PIP in French beans, no residues detectable with a 1 day PHI
Bacillus thur. var *kurstaki*	Annex 1	/	No residues concern
beta-cyfluthrin	Annex 1	0.05	Not tested by PIP
bifenthrin	Notified List 3A	0.1 / 0.05	The following GAP, tested by PIP in French beans residues trials,comply with current EU MRL on peas with pods: **Number of applications:** 3; **Interval between application**: 7 days; **Dose active substance:** 37.5 g/ha; **PHI**: 1 day
carbaryl	Withdrawn	0.05	Not tested by PIP
carbofuran	Withdrawn	0.02	The following GAP, tested by PIP in French beans residues trials,comply with current EU MRL on peas with pods: **Number of applications:** 1 (soil application before sowing); **Dose active substance:** 2500 g/ha
chlorpyrifos-ethyl	Annex 1	0.05	Not tested by PIP
chlorpyrifos methyl	Annex 1	0.05	The following GAP, tested by PIP in French beans residues trials comply with current EU MRL on peas with pods: **Number of applications:** 1; **Dose active substance:** 1000 g/ha; **PHI**: 3 days
cypermethrin	Annex 1	0.5 / 0.05	Not tested by PIP
cyromazine	Notified List 3B	5 / 0.05	The following GAP, tested by PIP in French beans residues trials comply with current EU MRL on peas with pods: **Number of applications:** 3; **Dose active substance:** 225 g/ha; **PHI**: 7 days
deltamethrin	Annex 1	0.2	The following GAP, tested by PIP in French beans residues trials comply with current EU MRL on peas with pods: **Number of applications:** 3; **Interval between applications:** 7 days; **Dose active substanc**e: 20 g/ha; **PHI**:1 day
diazinon	Withdrawn	0.01	Not tested by PIP
dicofol	Withdrawn	0.02	PIP residues trials results on French beans show that residues cannot comply with current EU MRL on peas with pods. It is recommended to not use on peas with pods.
dimethoate	Withdrawn	1 / 0.02	The following GAP, tested by PIP in French beans residues trials comply with current EU MRL on peas with pods: **Number of applications:** 2; **Interval between applications:**14 days; **Dose active substance:** 800 g/ha; **PHI**: 14 days
ethoprophos	Annex 1	0.02	Not tested by PIP

* Not included in Annex 1 for the time being and the EU Member States have the possibility to maintain authorisations until 31 December 2010.

fenitrothion	Withdrawn	0.01	Not tested by PIP
fenpyroximate	Annex 1	0.05	Not tested by PIP
hexythiazox	Not included in Annex1*	0.5	The following GAP, tested by PIP in French beans residues trials comply with current EU MRL on peas with pods: **Number of applications:** 2; **Interval between applications:**14 days; **Dose active substance:** 50 g/ha; **PHI**: 7 days
imidacloprid	Annex 1	0.05	The following GAP, tested by PIP in French beans residues trials comply with current EU MRL on peas with pods: **Number of applications:** 3; **Interval between applications:**7 days; **Dose active substance:** 202 g/ha; **PHI**:10 days
indoxacarb	Annex 1	0.02	The following GAP, tested by PIP in French beans residues trials, comply with current EU MRL on peas with pods: **Number of applications:** 4; **Interval between applications:** 7 days; **Dose active substance:** 37.5 g/ha; **PHI**: 10 days
lambda - cyhalothrin	Annex 1	0.2	The following GAP, tested by PIP in French beans residues trials, comply with current EU MRL on peas with pods: **Number of applications:** 4; **Interval between application:** 7 days; **Dose active substance:** 25 g/ha; **PHI**: 1 day
malathion	Withdrawn	0.02	The following GAP, tested by PIP in French beans residues trials, comply with current EU MRL on peas with pods: **Number of applications:** 2; **Interval between applications:** 7 days; **Dose active substance:** 750 g/ha; **PHI**: 7 days
methomyl	Withdrawn	0.05	The following GAP, tested by PIP in French beans residues trials, comply with current EU MRL on peas with pods: **Number of applications:** 4; **Interval between applications:** 7 days; **Dose active substance:** 600 g/ha; **PHI**: 7 days
methoxyfenozide	Annex 1	0.02	The following GAP, tested by PIP in French beans residues trials, comply with current EU MRL on peas with pods: **Number of applications:** 2; **Interval between applications:** 14 days; **Dose active substance:** 120 g/ha; **PHI**: 14 days A higher MRL (0.2) is set on beans with pods. In order to have a PHI of 3 days for peas with pods, PIP has requested an extrapolation of this MRL to peas with pods
oxamyl	Annex 1	0.01	The following GAP, tested by PIP in French beans residues trials, comply with current EU MRL on peas with pods: **Number of applications:** 1; **Dose active substance:** 2000 g/ha; **PHI**: 21 days
pirimicarb	Annex 1	1	Not tested by PIP
pirimiphos methyl	Annex 1	0.05	Not tested by PIP

* Not included in Annex 1 for the time being and the EU Member States have the possibility to maintain authorisations until 31 December 2010.

propargite	Not included in Annex1*	0,01	Not tested by PIP
pymetrozine	Annex 1	1	Not tested by PIP
pyrethrin	Annex 1	1	The following GAP, tested by PIP in French beans residues trials, comply with current EU MRL on peas with pods: **Number of applications:** 3; **Interval between applications:** 7 days; **Dose active substance:** 135 g/ha; **PHI**: 1 day
spinosad	Annex 1	0.5 / 0.3	The following GAP, tested by PIP in French beans residues trials, comply with current EU MRL on peas with pods: **Number of applications:** 2; **Interval between applications:** 7 days; **Dose active substance:** 160 g/ha; **PHI**: 1 day
sulphur	Notified List 4H	50	The following GAP, tested by PIP in French beans residues trials, comply with EU National MRL on peas with pods: **Number of applications:** 3; **Interval between applications:** 7 days; **Dose active substance:** 3200 g/ha; **PHI**: 1 day
tetradifon	Withdrawn	0,05	Not tested by PIP
thiamethoxam	Annex 1	0.2	The following GAP, tested by PIP in French beans residues trials, comply with EU National MRL on peas with pods: **Number of applications:** 3; **Interval between applications:** 14 days; **Dose active substance:** 100 g/ha; **PHI**: 3 days
thiocyclam hydrogenoxalate	Withdrawn	0,05	The following GAP, tested by PIP in French beans residues trials, comply with current EU MRL on peas with pods: **Number of applications:** 2; **Interval between applications:** 14 days; **Dose active substance:** 500 g/ha; **PHI**: 7 days

* Not included in Annex 1 for the time being and the EU Member States have the possibility to maintain authorisations until 31 December 2010.

Table 5 of fungicides and bactericides

Active substances	European regulations		
	DIR 91/414 status	European MRL	GAP
azoxystrobin	Annex 1	0.5 / 0.2	The following GAP, tested by PIP in French beans residues trials, comply with current EU MRL on peas with pods: **Number of applications:** 3; **Interval between applications:** 7 days; **Dose active substance:** 125 g/ha; **PHI**: 3 days
benomyl	Withdrawn	0.1	Not tested by PIP
bitertanol	Not included in Annex1*	0.05	The following GAP, tested by PIP in French beans residues trials, comply with current EU MRL on peas with pods: **Number of applications:** 2; **Interval between applications:** 14 days; **Dose active substance:** 180 g/ha; **PHI**: 10 days
bupirimate	Withdrawn	0.05 / 0.5	Not tested by PIP
captan	Annex 1	0.02	The following GAP, tested by PIP in French beans residues trials, residues comply with current EU MRL on peas with pods: **Number of applications:** 3; **Interval between applications:** 7 days; **Dose active substance:** 2400 g/ha; **PHI**: 21 days
carbendazim	Annex 1	0.2 / 0.1	Not tested by PIP
chlorothalonil	Annex 1	2 / 0.3	With the following GAP, tested by PIP in French beans residues trials, comply with current EU MRL on peas with pods: **Number of applications**: 3; **Interval between applications:** 7 days; **Dose active substance:** 1440 g/ha; **PHI**: 7 days
copper	Notified List 3A	20	The following GAP, tested by PIP in French beans residues trials, comply with current EU MRL on peas with pods: **Number of applications:** 3; **Interval between applications:** 7 days; **Dose active substance:** 120 + 90 g/ha; **PHI**: 3 days
cymoxanil + famoxadone	Annex 1	0.5 / 0.05 and 0.02	The following GAP, tested by PIP in French beans residues trials, comply with current EU MRL on peas with pods: **Number of applications:** 3; **Interval between applications:** 7 days; **Dose active substance:** 120 + 90 g/ha; **PHI**: 3 days
cyproconazole	Withdrawn	0.05	The following GAP, tested by PIP in French beans residues trials, comply with current EU MRL on peas with pods: **Number of applications:** 3; **Interval between applications:** 7 days; **Dose active substance:** 30 g/ha; **PHI**: 7 days
difenoconazole	Annex 1	1	The following GAP, tested by PIP in French beans residues trials, comply with current highest EU MRL on peas with pods: **Number of applications:** 4; **Interval between applications:** 14 days; **Dose active substance:** 125 g/ha; **PHI**: 3 days
dithianon	Withdrawn	0.01 / 0.6	Not tested by PIP

* Not included in Annex 1 for the time being and the EU Member States have the possibility to maintain authorisations until 31 December 2010.

fosetyl aluminium	Annex 1	2	Not tested by PIP
iprodione	Annex 1	2 / 0.3	The following GAP, tested by PIP in French beans residues trials, comply with current EU MRL on peas with pods: **Number of applications:** 2; **Interval between applications:** 7 days; **Dose active substance:** 1000 g/ha; **PHI**: 7 days
mancozeb	Annex 1	1 / 0.1	The following GAP, tested by PIP in French beans residues trials, comply with EU MRL on peas with pods: **Number of applications:** 3; **Interval between applications:** 7 days; **Dose active substance:** 2000 g/ha; **PHI**: 7 days.
metalaxyl-M	Annex 1	0.05	The following GAP, tested by PIP in French beans residues trials, comply with EU MRL on peas with pods: **Number of applications:** 3; **Interval between applications:** 7 days; **Dose active substance:** 2000 g/ha; **PHI**: 7 days
myclobutanil	Not included in Annex1*	0.02	The following GAP, tested by PIP in French beans residues trials, comply with current EU MRL on peas with pods: **Number of applications:** 2; **Interval between applications:** 7 days; **Dose active substance:** 100 g/ha; **PHI**: 10 days A higher MRL (0.5) is set on beans with pods. In order to have a PHI of 3 days for peas with pods, PIP will request an extrapolation of this MRL to peas with pods
propineb	Annex 1	0.05	The following GAP, tested by PIP in French beans residues trials, comply with the current EU MRL on peas with pods: **Number of applications**: 3; **Interval between applications:** 7 days; **Dose active substance:** 1750 g/ha; **PHI**: 14 days
propamocarb hydrochloride	Annex 1	0.1	Not tested by PIP
sulphur	Notified List 4H	50	The following GAP, tested by PIP in French beans residues trials, comply with all EU MRL on peas with pods: **Number of applications:** 3; **Interval between applications:** 7 days; **Dose active substance:** 3200 g/ha; **PHI**: 1 day
tebuconazole	Annex 1	2 / 0.05	The following GAP, tested by PIP in French beans residues trials, comply with current EU MRL on peas with pods: **Number of applications:** 3; **Interval between applications**: 7 days; **Dose active substance:** 187,5 g/ha; **PHI**: 10 day
thiophanate methyl	Annex 1	0.1	The following GAP, tested by PIP in French beans residues trials comply with EU MRL on peas with pods: **Number of applications:** 2; **Interval between applications:** 14 days; **Dose active substance**: 500 g/ha; **PHI**: 10 days

* Not included in Annex 1 for the time being and the EU Member States have the possibility to maintain authorisations until 31 December 2010.

triadimefon	Withdrawn	0,1	Not tested by PIP
trifloxystrobin	Annex 1	0.02	The following GAP, tested by PIP in French beans residues trials comply with EU MRL on peas with pods: **Number of applications**: 2; **Interval between applications:** 7 days; **Dose active substance:** 250 g/ha; **PHI**: 21 days A higher MRL (0.5) is set on beans with pods. In order to have a PHI of 3 days for peas with pods, PIP will request an extrapolation of this MRL to peas with pods

APPENDIX 3 : PEA IPM SCOUTING METHOD

Introduction

Integrated Pest Management involves the use of biological control agents (BCAs), such as predators and parasites detailed in the Pest and Disease summary sheets.

More detailed information is needed for IPM programmes than for straightforward chemical programmes because the degree of biological control is directly influenced by the balance between the numbers of beneficial insects and the pests. If there are only five pests for each beneficial present, this is a more secure position for the farmer than if there were 500 pests for every beneficial present. Therefore a means of sampling the crop to estimate the actual numbers of certain pests will be needed.

Weekly Scouting Data Sheets are completed for each field. Some of the data from these weekly sheets are transferred every week to a **Weekly Summary Sheet**. This enables the farm manager to compare progress week on week and provides objective guidance on what interventions need to be made to protect the crop, or whether progress is satisfactory.

If there were 150 pest for each beneficial in the field last week but this week the ratio had changed to 60 pest for every beneficial then the farmer will be able to measure a change in the balance in favour of the beneficial insect. This means that biological control is in progress. This may provide the evidence not to spray, but to allow the biological control programme to take it's course. The other factor that needs to be taken into account at the same time is the average number of the pest each week. It is less straight forward to just look at the average number of pest in isolation, since the average could even be going up week-on-week, whilst the ratio of the beneficial to pest is showing positive signs of coming close together.

IPM training courses are available to ensure correct scouting and interpretation of scouting data. The following information is a guide to IPM scouting and should be consolidated with IPM training from experienced service providers.

Preparation

Trained IPM-Scouts should be supplied with:

- clipboard to make recording easier,
- scouting sheets,
- piece of clean white paper for beating flowers onto (for thrips levels in flowers),
- 10 x magnification hand lens,
- pen,

- calculator,
- sample bag,
- sufficient hot-spot markers (visible red tags etc - do not use yellow - it attracts pests.

A good quality automatic counter is a useful tool which speeds up the counting process reduces mistakes and boredom.

Scouting Instructions

The area to be scouted should be as uniform as possible (slope and aspect of field, variety of crop etc). Too much variation will mean that the scouting will either over estimate or underestimate the pest or disease levels. If necessary divide the crop into sections, if they are likely to have very different pest and disease levels. The maximum area, which should be scouted as one unit, is about one hectare – unless the area is known to be very uniform.

For one hectare budget on approximately two man-hours for a trained, experienced scout to undertake IPM scouting per block. (one 'block' is twenty scouting rows).

Pests have habits of moving in and out of the crop at different times of day. The block should be scouted a minimum of once per week, ideally twice per week, preferably at the **same time of day** throughout its life - for accurate comparison of pest levels... If the scouting is not done at about the same time each week in the same field, the scout may indicate that pest levels are up, when in fact they have just hidden or flown out of the crop at that time. This is especially true of thrips.

Mark 20 station rows (these are whole rows **not marked** 'spots' in the field) at equal distances throughout the block. The scouting data will be collected whilst walking along the full length of each station row.

Walk down the alleyway path of the station row. Stop at five **observation points** whilst walking down the alleyway of the station row. The observation points should be from plant rows on alternate sides of the alley way (i.e. sampling in a zigzag pattern along the station row as the scout proceeds to the end of the row) Spread the sample points out along the full length of the row (see diagram).

The reason for the zigzag pattern is that in row crops, one side of the row could receive more sun and heat than the other or more wind and rain etc. This will effect pest and disease levels. By taking samples in a zigzag pattern along an alleyway – the scout is taking leaves from different sides of a plant row. The differences in pest and disease levels are therefore averaged.

At each observation point first make the following observations before removing a leaf from the base and top of plants for other checks. Record the total number of the following in about one meter square of the peas bed at the observation point:

- adult leafminer
- adult *Diglyphus*

Add the numbers observed in each of the five observation positions for each row and enter the total figures in the weekly scouting form. The scout may need rough paper to record a running total from each of the five observation positions before he enters the totals for the row in the weekly scouting form. When the scout has observed the above pests at each observation point, which could fly away if the leaves are disturbed too much – **he can now remove two compound leaflets** (not single leaflets) from the same area (10 leaflets per station row or 200 per block) to count:

- thrips on leaves
- spider mite

If the crop is still very young and has few leaves, the above observations can be done without removing the leaves, just by turning the lower surface of the leaf upwards. If **spider mite** is found at the same time as the above checks, these should be recorded too in the **weekly background level of spider mite**.

Otherwise, the scout should look out for **leaves with spider mite damage** as he walks along the row and check these for numbers of:

- adult *Amblyseius*
- adult *Phytoseiulus*
- adult spider mite

Normally spider mite predators are only found where there are higher levels of spider mite (is where there is spider mite damage on leaves) This is where the farmer will be recording the columns for **ratio of predators to spider** mite in the weekly scouting forms.

As soon as flowering commences, the scout will commence examining flowers for thrips. There is no need to remove the flower trusses to examine them. Place a piece of white paper below the flower truss and tap it sharply three times to dislodge any thrips within the flower truss. Examine **two flower trusses per observation point** for:

- thrips in flowers

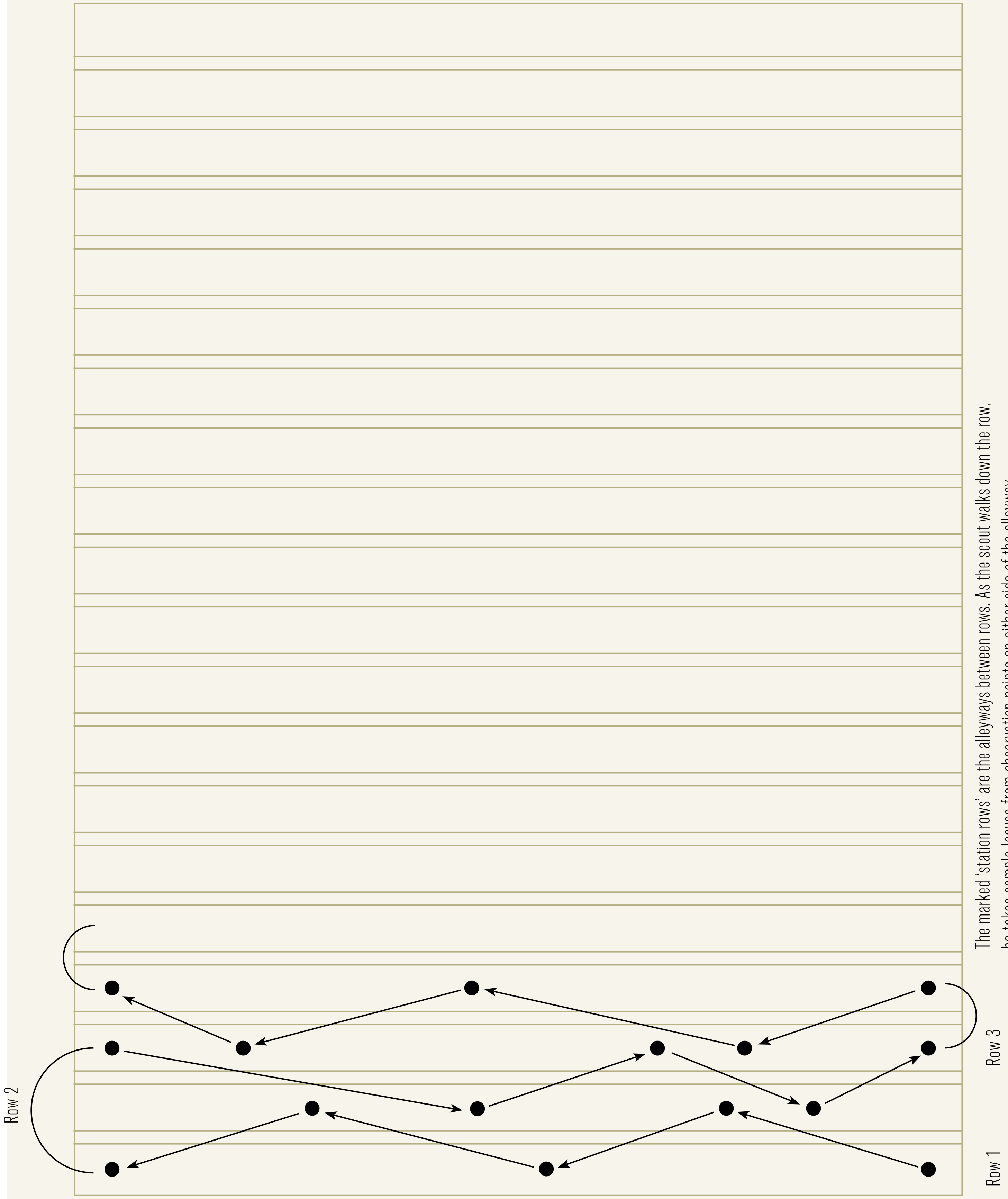
Green pea aphid tends to occur first on the outside edges of crops. Scouts should concentrated on these rows. As the scout walks the full length of the scouting row it is easy to observe disease symptoms and cutworm etc on all plants along the length of the scouting row.

- Green pea aphid **colonies** (no need to count individual aphids in the colony just number of colonies in the station row).
- total **number aphid predators** in each of the colonies (ladybirds, *Aphidius*, hoverfly etc) . No need to distinguish which predators are there. Just calculate (at bottom of column in scouting sheet) the ratio of combined numbers of aphid predators and parasites to aphid colonies in each scouting station row.
- total number of caterpillar larvae (easy to spot leaf feeding damage)
- total number of caterpillar pupae
- total number of adult moths observed
- presence of diseases (*Fusarium, Ascochyta*, etc)
- presence of cutworm, root knot nematode, etc

EXIT CHECKS

When the station rows have been scouted , the Scout will then complete an 'Exit Check' by walking up and down EVERY ROW to observe the following:

1. Clearly Mark all **new green pea aphid hot-spots** (with < 10% parasitism) with markers and mark positions on a map of the block. These will need to have spot treatments applied as soon as possible.
2. Check all previously marked aphid hot spots - if they have > 10% parasitism remove the hotspot marker.
3. Mark on the block maps any disease hotspots (blight or ***Fusarium*** etc). This will trigger instructions for hot-spot fungicide sprays for halo blight or an overall spray depending on risks (wet weather conditions and more than four halo blight hotspots per block). *Fusarium* cannot be treated but hotspots will be marked in the block history for treatment with *Trichoderma* and organic matter or soil improvement post harvest). Total the number of disease hotspots (identify type of disease) and record this in the Front of the Scouting sheet.
4. Mark on the block map any spider mite hotspots - these will need additional *Phytoseiulus* - introduction ratio at least 1:200) Make some estimates of total rsm per hotspot and enter number on Front of Scouting Sheet. Take a minimum of ten leaflet samples from the hot spot and determine the Phyto to spider ratio. Once the ratio get to less than 1:10 - the problem should be soon eliminated. Enter data for rsm hotspots on a separate scouting sheet and give each spider mite Hotspot a number. These will be scouted weekly until the problem is eliminated.
5. Note presence of live caterpillars observed during exit check (enter number on Front of Scouting Sheet). This will trigger an overall spray of *Bacillus thuringiensis* or other appropriate spray, as this pest is difficult to spot and needs to be controlled when it is at a low level.



The marked 'station rows' are the alleyways between rows. As the scout walks down the row, he takes sample leaves from observation points on either side of the alleyway.

Weekly scouting data sheets

Farm				Block		Crop age (wks)			Date scouted				Scout name (PRINT)							
Station row	***Diglyphus* adults near** five obs. point/row	**leafminer adults** near five obs. points/row	Thrips on five leaves per row	Thrips in five flowers per row	number of aphid BCAs in aphid colonies/row	number of aphid colonies in row	number of caterpillar larvae in entire row	has pupation begun? (number pupae seen/row)	total ***Phytoseiulus* adults** in five rsm/infested leaves/row	total ***Amblyseius* adults** infive rsm-infested leaves/row	total **spider mite adults** infive infested leaves/row	background adult rsm level from five random leaves per row	Powdery mildew	Downy mildew	Bacterial blight	Ascochyta	Botrytis	Fusarium	Root knot nematode	Cutworm
													presence/absence in row							
1																				
2																				
3																				
4																				
5																				
6																				
7																				
8																				
9																				
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11																				
12																				
13																				
14																				
15																				
16																				
17																				
18																				
19																				
20																				
TOTAL																				
av. per row																				
Ratio	:				Ratio	:			Ratio	:										

Use date for individual ROWS to make early spot treatments in certain rows only for pests and diseases before the problem spreads.
Transfert the date in the bold boxes to weekly summary sheet, to measure the effect of crop protection action week/on/week
Mark any rsm hotspots in field and o field map - treat early with predatory mites (check hotspots weekly to ensure predators building up)

Comments box: severitty of diseases, ID of root diseases, indicate waterlogged areas etc. Indicate treatment advised.

Comments:

Weekly scouting data sheets

Farm				Block		Crop age (wks)				Date scouted				Scout name (PRINT)			
Transfer data from bold boxes in weekly scouting Age crop (wks)	Weekly ratio Dig: LM		Thrips Weekly av. per row -on five leaves per row	Thrips Weekly av. per row - in five flowers per row	Ration of total aphid BCAs per row to total number of aphid colonies	Total wekly adult moths obs. flying over field during scouting	Total weekly caterpillar in entire row	Total weekly pupae per row	Ratio predators to rsm in infested leaves (if present)	Weekly average background level of rsm per row	Powdery mildew	Downy mildew	Bacterial blight	*Ascochyta*	*Botrytis*	*Fusarium*	Root knot nematode
1																	
2																	
3																	
4																	
5																	
6																	
7																	
8																	
9																	

Notes

Divide total number of adult leafminer by total number of adult Diglyphus each week = ratio *Diglyphus* to leafminer (aim to get below 1:5 for good control)

Scouting for thrips on leaves is essential before the flowers are present, then crop protection is applied when contact is easier (on leaves). Thrips control in flowers is difficult and there are PHI constraints.

The oldest, largest, whitefly scales (in which an *Encarsia* can develop to a blcak scale) will be on lower leaves only

Divide the total number of aphid colonies from all rows each week, by total number of aphid BCAs to obtain ratio of aphid BCAs to aphid colonies

Bacillus thurigiensis only works well on young caterpillarswhich are too difficult to find. If adult moths are present, they will be laying eggs and timely application of Bt would be soon after this period.

If most of the population of caterpillars have pupated, this life stage is not harmed by pesticides and it may be worth waiting for them to hatch and apply crop protection to the next generation.

APPENDIX 4 : PESTICIDE SENSIVITY CHARTS – KENYAN APPROUVED INSECTICIDES FOR PEAS-EFFECT ON RELEVANT NATURAL ENEMIES

insecticides active ingredients	application method	Spider mite predator			Thrips and mite predator			Thrips predator			Spider mite predator		
		Phytoseiulus persimilis			*Amblyseius californicus*			*Orius lævigatus*			*Feltiella acarisuga*		
		egg	adult	persistence (wks)	egg	adult	persistence (wks)	nymph	adult	persistence (wks)	larva	adult	persistence (wks)
abamectin	spray	?	>75%	2w	?	?	?	>75%	>75%	3w	?	>75%	?
acephate	spray	?	>75%	>3w	?	>75%	>2w	>75%	>75%	?	?	>75%	>8w
alphacypermethrin	spray	>75%	>75%	>8w	?	?	?	>75%	>75%	?	?	>75%	>8w
amitraz	spray	>75%	>75%	3w	?	>75%	3w	?	50-75%	3w	?	?	?
azadirachtin	spray	?	<25%	?	?	?	?	<25%	?	?	?	?	?
azinfos-methyl	spray	50-75%	50-75%	2w	?	25-50%	2w	50-75%	50-75%	?	50-75%	>75%	>8w
azocyclotin	spray	<25%	<25%	0w	?	?	?	?	?	?	?	?	?
beta-cyfluthrin	spray	>75%	>75%	>8w	50-75%	50-75%	?	>75%	>75%	>8w	>75%	>75%	>8w
bifenthrin	spray	>75%	>75%	>8w	?	?	?	>75%	>75%	>8w	>75%	>75%	>8w
Bt var *kurstaki*	spray	<25%	<25%	0w	<25%	<25%	0w	<25%	<25%	0w	<25%	<25%	0w
carbaryl	spray	?	>75%	2w	?	?	?	>75%	>75%	?	50-75%	>75%	
carbofuran	spray	?	>75%	>3w	?	?	?	?	?	?	?	?	?
carbosulfan	spray	25-50%	25-50%	1w	?	?	?	?	?	?	?	?	?
chlorpyrifos-ethyl	spray	<25%	50-75%	0,5w	?	50-75%	2w	25-50%	>75%	?	?	>75%	?
chlorpyrifos-methyl	spray	<25%	<25%	0w	?	25-50%	2w	>75%	>75%	?	?	>75%	?
clofentezin	spray	<25%	<25%	0w	<25%	<25%	0w	?	<25%	?	?	<25%	?
cyfluthrin (beta cyfluthrin)	spray	>75%	>75%	>8w	?	?	?	>75%	>75%	>8w	>75%	>75%	>8w
cyhexatin	spray	<25%	>75%	0,5w	?	?	?	25-50%	25-50%	?	25-50%	25-50%	?
cypermethrin	spray	>75%	>75%	>8w	?	?	?	>75%	>75%	>8w	>75%	>75%	>8w
cyromazine	spray	<25%	<25%	0w	<25%	<25%	0w	?	<25%	?	?	>75%	0w
cyromazine	drip	<25%	<25%	0w	?	?	?	?	?	?	?	?	?
deltamethrin	spray	>75%	>75%	>8w	?	?	?	>75%	>75%	>8w	>75%	>75%	>8w
diazinon	spray	<25%	<25%	1w	?	25-50%	2w	25-50%	50-75%	?	>75%	>75%	>6w
dichloropropene 1 -3	drench	?	?	?	?	?	?	?	?	?	?	?	?
dichlorvos	spray	<25%	>75%	1w	?	?	?	>75%	>75%	1w	?	>75%	<1w
dicofol	spray	50-75%	50-75%	2w	?	50-75%	?	?	?	?	<25%	>75%	?
Diglyphus isea	bio	<25%	<25%	0w	<25%	<25%	0w	<25%	<25%	0w	<25%	<25%	0w
dimethoate	spray	>75%	>75%	8w	?	50-75%	?	>75%	>75%	?	50-75%	25-50%	?
Encarsia formosa	bio	<25%	<25%	0w	<25%	<25%	0w	<25%	<25%	0w	<25%	<25%	0w
endosulfan	spray	?	>75%	2w	?	?	?	25-50%	>75%	?	50-75%	>75%	?
ethoprophos	spray	?	?	?	?	?	?	?	?	?	?	?	?

insecticides active ingredients	application method	Aphid predator			Aphid parasite			Leafminer parasite		
		Ladybird			***Aphidius***			***Diglyphus & Dacnusa***		
		larva	adult	persistence (wks)	larva	adult	persistence (wks)	larva	adult	persistence (wks)
abamectin	spray	?	>75%	1w	?	>75%	?	?	>75%	?
acephate	spray	?	>75%	>6w	?	>75%	?	?	>75%	?
alphacypermethrin	spray	?	>75%	?	?	>75%	?	?	>75%	?
amitraz	spray	?	50-75%	?	?	?	?	?	?	?
azadirachtin	spray	?	?	?	?	?	?	?	?	?
azinfos-methyl	spray	?	>75%	>6w	?	>75%	?	?	>75%	?
azocyclotin	spray	50-75%	>75%	?	?	?	?	?	>75%	?
beta-cyfluthrin	spray	50-75%	>75%	>8w	>75%	>75%	>8w	>75%	>75%	>8w
bifenthrin	spray	?	>75%	>8w	>75%	>75%	>8w	>75%	>75%	>8w
Bt var *kurstaki*	spray	?	<25%	0w	<25%	<25%	0w	<25%	<25%	0w
carbaryl	spray	25-50%	>75%	?	?	>75%	?	?	>75%	?
carbofuran	spray	?	?	?	?	?	?	?	?	?
carbosulfan	spray	?	>75%	>8w	?	?	?	?	>75%	?
chlorpyrifos-ethyl	spray	50-75%	50-75%	?	?	?	?	?	?	?
chlorpyrifos-methyl	spray	?	?	?	>75%	>75%	?	?	>75%	?
clofentezin	spray	<25%	<25%	0w	<25%	<25%	0w	<25%	<25%	0w
cyfluthrin (beta cyfluthrin)	spray	?	>75%	>8w	>75%	>75%	>8w	>75%	>75%	>8w
cyhexatin	spray	?	<25%	0w	?	>75%		?	>75%	?
cypermethrin	spray	?	>75%	>8w	>75%	>75%	>8w	>75%	>75%	>8w
cyromazine	spray	50-75%	25-50%	0w	?	<25%		?	<25%	?
cyromazine	drip	?	?	?	?	<25%		?	?	?
deltamethrin	spray	?	>75%	>8w	>75%	>75%	>8w	>75%	>75%	>8w
diazinon	spray	25-50%	25-50%	?	>75%	>75%	?	?	>75%	?
dichloropropene 1 -3	drench	?	?	?	?	?	?	?	?	?
dichlorvos	spray	?	>75%	<1w	?	>75%	?	?	>75%	?
dicofol	spray	?	<25%	0w	?	50-75%	?	?	50-75%	?
Diglyphus isea	bio	<25%	<25%	0w	<25%	<25%	0w	<25%	<25%	0w
dimethoate	spray	>75%	>75%	?	>75%	>75%	?	?	?	?
Encarsia formosa	bio	<25%	<25%	0w	<25%	<25%	0w	<25%	<25%	0w
endosulfan	spray	?	>75%	2w	50-75%	?	?	?	>75%	?
ethoprophos	spray	?	?	?	?	?	?	?	?	?

Appendix 4: Pesticide sensivity charts – Kenyan approuved insecticides for peas-effect on relevant natural enemies

insecticides active ingredients	application method (spray, drip irrigation etc)	Spider mite predator			Thrips and mite predator			Thrips predator			Spider mite predator		
		Phytoseiulus persimilis			*Amblyseius californicus*			*Orius lævigatus*			*Feltiella acarisuga*		
		egg	adult	persistence (wks)	egg	adult	persistence (wks)	nymph	adult	persistence (wks)	larva	adult	persistence (wks)
fenazaquin	spray	?	?	?	?	?	?	?	?	?	?	?	?
fenitrothion	spray	?	>75%	?	?	?	?	?	>75%	?	?	?	?
fenthion	spray	?	?	?	?	?	?	?	?	?	?	?	?
garlic	spray	?	?	?	?	?	?	?	?	?	?	?	?
garlic + pyrethrins	spray	?	?	?	?	?	?	?	?	?	?	?	?
hexythiazox	spray	<25%	<25%	0w	?	<25%	0w	<25%	<25%	0w	?	?	?
imidacloprid	spray	?	<25%	?	<25%	<25%	0w	>75%	>75%	?	>75%	>75%	?
imidacloprid	drip	?	?	?	?	?	?	?	?	?	<25%	<25%	0
indoxcarb	spray	?	?	?	?	?	?	?	?	?	?	?	?
lambda-cyhalothrin	spray	>75%	>75%	>8w	?	?	?	>75%	>75%	>8w	>75%	>75%	>8w
lindane	spray	<25%	>75%	>6w	?	?	?	?	?	?	?	>75%	>8w
malathion	spray	25-50%	25-50%	1w	?	?	?	>75%	>75%	?	50-75%	50-75%	2w
methomyl	spray	50-75%	>75%	>3w	?	?	?	>75%	>75%	>8w	>75%	>75%	>8w
methoxyfenocide	spray	?	?	?	<25%	<25%	?	>75%	>75%	?	?	?	?
mineral oil	spray	?	?	?	?	25-50%	>2w	?	?	?	?	?	?
omethoate	spray	>75%	>75%	8w	?	?	?	>75%	>75%	?	50-75%	25-50%	?
oxamyl	spray	>75%	>75%	>8w	?	?	?	>75%	>75%	>8w	>75%	>75%	>8w
oxamyl	drip	<25%	<25%	0w	?	?	?	?	>75%	?	?	?	?
oxydemeton-methyl	spray	?	>75%	1w	?	?	?	?	?	?	50-75%	>75%	?
parathion-methyl	spray	?	?	?	?	?	?	?	>75%	?	?	?	?
Phytoseiulus persimilis	bio	<25%	<25%	0w	<25%	<25%	0w	<25%	<25%	0w	<25%	<25%	0w
pirimicarb	spray	25-50%	25-50%	0.5w	?	<25%	?	<25%	<25%	0w	<25%	>75%	1w
pirimiphos-methyl	spray	>75%	>75%	>2w	?	>75%	?	?	?	?	?	>75%	?
profenofos	spray	?	?	?	?	?	?	?	?	?	?	?	?
propargite	spray	>75%	50-75%	0w	?	50-75%	?	?	50-75%	?	25-50%	<25%	?
pymethrozine	spray	?	?	?	?	?	?	<25%	<25%	?	?	?	?
pyrethrine (+ P.B.O)	spray	<25%	>75%	1w	?	?	?	?	?	?	?	>75%	>1w
spinosad	spray	<25%	<25%	?	<25%	<25%	?	25-50%	25-50%	3 days	?	?	?
sulphur	spray	50-75%	50-75%	?	25-50%	25-50%	?	25-50%	<25%	?	25-50%	25-50%	?
teflubenzuron	spray	<25%	<25%	0w	<25%	<25%	0w	>75%	<25%	?	?	?	?
tetradifon	spray	<25%	<25%	0w	?	?	?	?	?	?	?	<25%	?
thiocyclam	spray	?	25-50%	0.5w	?	?	?	?	?	?	?	?	?
trichlorfon	spray	>75%	>75%	2w	?	?	?	>75%	>75%	?	?	?	?

insecticides active ingredients	application method	Aphid predator			Aphid parasite			Leafminer parasite		
		Ladybrird			***Aphidius***			***Diglyphus & Dacnusa***		
		larva	adult	persistence (wks)	larva	adult	persistence (wks)	larva	adult	persistence (wks)
fenazaquin	spray	?	?	?	?	>75%	?	?	?	?
fenitrothion	spray	?	>75%	?	?	>75%	?	?	?	?
fenthion	spray	?	?	?	?	>75%	?	?	?	?
garlic	spray	?	?	?	?	?	?	?	?	?
garlic + pyrethrins	spray	?	?	?	?	?	?	?	?	?
hexythiazox	spray	<25%	<25%	0w	<25%	<25%	0w	<25%	<25%	0w
imidacloprid	spray	?	>75%	?	>75%	>75%	?	?	?	?
imidacloprid	drip	?	<25%	0w	<25%	<25%	0w	?	?	?
indoxcarb	spray	?	?	?	?	?	?	?	?	?
lambda-cyhalothrin	spray	?	>75%	>8w	>75%	>75%	>8w	>75%	>75%	>8w
lindane	spray	?	>75%	>6w	?	?	?	?	>75%	?
malathion	spray	?	>75%	>8w	>75%	>75%	>8w	?	>75%	>8w
methomyl	spray	?	>75%	>8w	>75%	>75%	>8w	?	>75%	>8w
methoxyfenocide	spray	?	?	?	?	?	?	?	?	?
mineral oil	spray	?	?	?	?	?	?	?	?	?
omethoate	spray	?	>75%	?	>75%	>75%	?	?	?	?
oxamyl	spray	50-75%	>75%	>8w	>75%	>75%	>8w	>75%	>75%	>8w
oxamyl	drip	?	<25%	0w	?	<25%	?	?	<25%	?
oxydemeton-methyl	spray	?	>75%	?	?	?	?	?	?	?
parathion-methyl	spray	?	?	?	?	?	?	?	?	?
Phytoseiulus persimilis	bio	<25%	<25%	0w	<25%	<25%	0w	<25%	<25%	0w
pirimicarb	spray	?	>75%	1w	?	<25%	?	?	50-75%	<1w
pirimiphos-methyl	spray	?	<25%	0w	>75%	>75%	?	?	>75%	?
profenofos	spray	?	?	?	?	?	?	?	?	?
propargite	spray	?	50-75%	?	<25%	<25%	?	?	?	?
pymethrozine	spray	?	?		?	?	?	?	?	?
pyrethrine (+ P.B.O)	spray	?	>75%	>2w	?	?	?	?	>75%	1w
spinosad	spray	?	?	?	50-75%	50-75%	?	?	?	?
sulphur	spray	<25%	25-50%	?	25-50%	25-50%	?	?	25-50%	<1w
teflubenzuron	spray	?	25-50%	?	?	<25%	?	?	>75%	0w
tetradifon	spray	?	<25%	?	?	<25%	?	?	<25%	0w
thiocyclam	spray	50-75%	25-50%	?	25-50%	>75%	?	?	>75%	?
trichlorfon	spray	?	>75%	?	?	>75%	?	?	>75%	?

APPENDIX 5 : PESTICIDE SENSIVITY CHARTS –KENYAN APPROUVED FUNGICIDES FOR PEAS-EFFECT ON RELEVANT NATURAL ENEMIES

Fungicides (peas) active ingredients	application method	Spider mite predator						Leafminer parasitic wasp			thrips and general predator		
		Phytoseiulus persimilis			*Amblyseius californicus*			*Diglyphus isaea*			*Orius*		
		egg	adult	persistence (wks)	egg	adult	persistence (wks)	nymph	adult	persistence (wks)	nymph	adult	persistence (wks)
azoxystrobin	spray	<25%	<25%	?	<25%	<25%	?	?	?	?	<25%	<25%	?
benomyl	spray	<25%	50-75%	>2w	?	?	?	?	<25%	0w	?	?	?
bitertanol	spray	<25%	<25%	0w	<25%	<25%	0w	?	<25%	0w	25-50%	<25%	?
buprimate	spray	<25%	25-50%	4d	?	<25%	0w	?	25-50%	0w	50-75%	25-50%	0w
captan	spray	<25%	<25%	0w	<25%	<25%	0w	?	?	?	<25%	<25%	0w
carbendazim	spray	50-75%	>75%	>1w	?	?	?	?	<25%	0w	<25%	?	?
carbendazim	dust	?	>75%	>2w	?	?	?	?	?	?	?	?	?
chlorothalonil	spray	<25%	<25%	0w	<25%	<25%	0w	?	?	0w	<25%	<25%	0w
chlorothalonil	fog	?	<25%	0w	?	?	?	?	?	?	?	?	?
copper oxychloride	spray	<25%	<25%	0w	<25%	<25%	0w	?	?	?	?	<25%	?
cymoxanil (see also famoxadime)	spray	<25%	<25%	?	<25%?	<25%	?	?	?	?	?	?	?
difenoconazole	spray	?	<25%	?	?	?	?	?	?	?	?	?	?
dithianon	spray	?	<25%	?	?	<25%	?	?	?	?	?	<25%	?
fosetyl-aluminium	spray	<25%	<25%	0w	<25%?	<25%	0w	?	<25%	0w	<25%	?	?
garlic	spray	?	?	?	?	?	?	?	?	?	?	?	?
iprodione	spray	<25%	<25%	0w	<25%	<25%	0w	?	<25%	0w	<25%	<25%	0w
mancozeb (see also zoxamide)	spray	<25%	50-75%	0w	<25%	<25%	0w	?	<25%	0w	25-50%	<25%	0w
metalaxyl	spray	?	50-75%	?	?	?	?	?	?	?	?	?	?
metalaxyl + mancozeb	spray	<25%	<25%	0w	<25%	<25%	0w	?	?	?	?	?	?
metiram	spray	?	50-75%	?		?	?	?	?	0w	<25%	<25%	0w
myclobutanil	spray	<25%	<25%	0w	<25%	<25%	0w	?	?	0w	25-50%	?	?
nitrothal-isopropyl	spray	?	<25%	?	?	?	?	?	?	0w	?	?	?
oxycarboxin	spray	<25%	<25%	0w	<25%	<25%	0w	?	<25%	0w	?	?	?
pencycuron	seed t	<25%	<25%	0w	<25%	<25%	0w	<25%	<25%	0w	<25%	<25%	0w
propamocarb	spray	<25%	<25%	0w	<25%	<25%	0w	?	<25%	0w	?	?	?
propamocarb	drench	<25%	<25%	0w	<25%	<25%	0w	?	<25%	0w	?	?	?
propineb	spray	50-75%	>75%	1w	?	?	?	?	?	?	?	<25%	?
pyrazofos	spray	<25%	<25%	0w	?	?	?	?	>75%	?	>75%	50-75%	?
sulphur	spray	<25%	<25%	0w	?	?	?	?	50-75%	<1w	25-50%	<25%	?
sulphur	dust	<25%	25-50%	1w	?	?	?	?	?	?	?	?	?
sulphur	fog	<25%	25-50%	1w	?	?	?	?	?	?	?	?	?

insecticides active ingredients	application method	Spider mite predator						Leafminer parasitic wasp			thrips and general predator		
		ladybrird			***Aphidius***			***Diglyphus & Dacnusa***			***Orius***		
		egg	adult	persistence (wks)	larva	adult	persistence (wks)	larva	adult	persistence (wks)	nymph	adult	persistence (wks)
tebuconazole	spray	?	<25%		?	?	?	?	?	?	?	?	?
thiophanate-methyl	spray	25-50%	>75%	>2w	?	?	?	?	<25%	0w	25-50%	?	?
thiram (see also pencycuron)	spray	?	25-50%		?	?	?	?	<25%	0w	<25%	25-50%	?
thiram	dust	50-75%	<25%	>1w	?	?	?	?	?	?	?	?	?
triadimefon	spray	<25%	<25%	0w	<25%	<25%	0w	?	<25%	0w	?	<25%	?
Trichoderma	spray	<25%	<25%	0	<25%	<25%	0w	<25%	<25%	0w	<25%	<25%	0w
triforine	spray	<25%	25-50%	0	?	?	?	?	<25%	0w	?	<25%	
zoxamide (mixture with mancozeb)	spray	?	?	?	?	?	?	?	?	?	?	?	?

Fungicides (peas) active ingredients	application method	aphid predator			aphid parasitic wasp			caterpillar egg parasitoid			thrips and caterpillar parasite	
		Ladybrids			*Aphidius*			*Trichogramma*			*entomopathogenic nematode*	
		larva	adult	persistence (wks)	larva	adult	persistence (wks)	larva	adult	persistence (wks)	infective juvenile	persistence (wks)
azoxystrobin		?	?	?	<25%	<25%	?	?	?	?	?	?
benomyl	spray	?	>75%	?	<25%	<25%	0w	?	?	?	<25%	0w
bitertanol	spray	<25%	<25%	0w	<25%	<25%	0w	<25%	<25%	0w	<25%	0w
buprimate	spray	?	<25%	0w	<25%	<25%	0w	<25%	<25%	0w	<25%	0w
captan	spray	?	<25%	0w	?	?	?	?	25-50%	?	?	?
carbendazim	spray	?	<25%	0w	<25%	<25%	0w	<25%	25-50%	1w	50-75%	?
carbendazim	dust	?	?	?	?	?	?	?	?	?	?	?
chlorothalonil	spray	?	<25%	0w	<25%	<25%	0w	?	<25%	?	<25%	0w
chlorothalonil	fog	?	?	?	?	?	?	?	?	?	?	?
copper oxychloride	spray	<25%	<25%	0w	?	?	?	<25%	<25%	0w	<25%	0w
cymoxanil (see also famoxadime)		<25%	<25%	?	?	?	?	?	?	?	<25%	0w
difenoconazole	spray	?	?	?	?	<25%	?	?	<25%	?	<25%	?
dithianon	spray	<25%	<25%	?	?	<25%	?	?	<25%	?	<25%	0w
fosetyl-aluminium	spray	?	<25%	0w	?	?	?	?	?	?	<25%	0w
garlic		?	?	?	?	?	?	?	?	?	?	?
iprodione	spray	<25%	<25%	0w	<25%	<25%	0w	<25%	<25%	0w	<25%	0w
mancozeb (see also zoxamide)	spray	?	2	0w	<25%	<25%	0w	<25%	50-75%	2w	<25%	0w
metalaxyl	spray	?	?	?	?	?	?	?	?	?	<25%	
metalaxyl + mancozeb	spray	?	<25%	0w	?	?	?	?	?	?	?	?
metiram	spray	<25%	<25%	?	<25%	<25%	?	<25%	>75%	>4w	?	?
myclobutanil	spray	?	<25%	0w	?	?	?	?	?	?	25-50%	?
nitrothal-isopropyl	spray	?	?	?	?	?	?	?	?	?	?	?
oxycarboxin	spray	?	?	?	?	?	?	<25%	<25%	0w	?	?
pencycuron		<25%	<25%	0w	<25%	<25%	0w	<25%	<25%	0w	<25%	0w
propamocarb	spray		<25%	0w	?	?		?	?	?	<25%	0w
propamocarb	drench		<25%	0w	<25%	<25%	0w	?	?	?	25-50%	?
propineb	spray	50-75%	>75%	0w	?	<25%	?	?	25-50%	?	?	?
pyrazofos	spray	?	>75%		?	>75%	?	<25%	>75%	>4w	<25%	0w
sulphur	spray	25-50%	25-50%		25-50%	50-75%	?	25-50%	>75%	>4w	>75%	0w
sulphur	dust	?	>75%	>6w	?		?	?	?	?	?	?
sulphur	fog	?	?	?	?		?	?	?	?	?	?

insecticides active ingredients	application method	aphid predator			aphid parasitic wasp			caterpillar egg parasitoid			thrips and caterpillar parasite	
		Ladybrids			***Aphidius***			***Trichogramma***			***entomopathogenic nematode***	
		larva	adult	persistence (wks)	larva	adult	persistence (wks)	larva	adult	persistence (wks)	infective juvenile	persistence (wks)
tebuconazole	spray	?	?		?	25-50%	?	?	?	?	<25%	?
thiophanate-methyl	spray	?	<25%	0w	<25%	<25%	?	?	<25%	0w	25-50%	?
thiram (see also pencycuron)	spray	?	25-50%	0w	<25%	<25%	?	?	<25%	0w	<25%	
thiram	dust	?	?	?	?	?	?	?	?	?	?	0w
triadimefon	spray	?	<25%	0w	?	?	?	?	<25%	0w	<25%	?
Trichoderma		<25%	<25%	0w	<25%	<25%	0w	<25%	<25%	0w	<25%	?
triforine	spray	25-50%	<25%	0w	<25%	<25%	0w	?	<25%	0w	25-50%	0w
zoxamide (mixture with mancozeb)		?	?	?	?	?	?	?	?	?	?	?

APPENDIX 6 : CLASSIFICATION OF PEAS

Peas are classified in two classes defined below:

Class 1 Peas

(i) Peas in this class must be of good quality. They must be characteristic of the variety and/or the commercial type. The pods must be:– fresh and turgid,– free from damage caused by hail,– free from damage caused by heating. For shelling peas:– the pods must be:– with peduncle attached,– well filled, containing at least five seeds;

(ii) The seeds must be:– well formed,– tender,– succulent and sufficiently firm, i.e., when squeezed between two fingers they should become flat without disintegrating,– at least half the full-grown size but not full grown,– non-farinaceous,– undamaged, without cracks in the skin of the seeds;– the following slight defects of the pod, however, may be allowed, provided these do not affect the general appearance of the produce, the quality, the keeping quality and presentation in the package:– slight skin defects, injuries and bruises,– slight defects in shape.– slight defects in colouring.

Class 1 mangetout and sugar snap

(i) The seeds if present must be small and underdeveloped,– the following very slight defects of the pod, however, may be allowed, provided these do not affect the general appearance of the produce, the quality, the keeping quality and presentation in the package: very slight skin defects, injuries and bruises,– very slight defects in shape,– very slight defects in colouring.

Class II Peas

(i) This class includes peas which do not qualify for inclusion in class I but satisfy the minimum requirements specified above. For shelling peas:– the pods must contain at least three seeds,– they may be riper than those in class I, but over-mature peas are excluded,– the following defects may be allowed provided the peas retain their essential characteristics as regards the quality, the keeping quality and presentation:– defects of the pods:– skin defects, injuries and bruises provided they are not progressive and there is no risk of the seeds being affected,– defects in shape,– defects in colouring,– some loss of freshness, excluding wilted pods;– defects of the seeds:– a slight defect in shape,– a slight defect in colouring,– be slightly harder,– be slightly damaged.

Class II mangetout peas and sugar snap peas

(i) The seeds if present can be slightly more developed than in class I,– the following defects of the pods may be allowed provided the peas retain their essential characteristics as regards the quality, the keeping quality and presentation:– slight skin defects, injuries and bruises,– slight defects in shape, including those due to the seed formation,– slight defects in colouring,– some loss of freshness, excluding wilted and un-coloured pods.

APPENDIX 7 : MAIN PESTS AND DISEASES OF PEAS

Bacterial Blight

Scientific name: *Pseudomonas syringae* pv. *pisi*

Other host plants: Sweet pea, everlasting pea, cowpea, hyacinth bean, purple vetch, hairy vetch, red clover, soybean and maize. Weed hosts (fat hen, goose foot, Bermuda grass, sunflower, birds foot trefoil, groundsel) can also harbour pea blight.

Symptoms and damage: Seed borne inoculum is the main infection source and seeds can maintain infective propagules for up to three years in storage. During germination the plumule becomes infected. Unless favourable environmental conditions prevail (high rainfall), the developing seedlings may not exhibit symptoms. Infected lower leaves will die off and produce inoculum during seed formation. Plant debris can be an important source of infection in the field. *P. syringae* pv. *pisi* may attack the entire plant, leaves, buds and seeds.

The bacteria multiply at an exponential rate within the intracellular spaces. Symptoms develop within 6-10 days at 24- 28°C, but this can be delayed when temperatures are hot. The blight bacteria cause leaf necrosis or dieback. Leaf tissues first become translucent and water-soaked due to water uptake in the intracellular spaces. The blight spots that subsequently develop on leaves are sometimes angular in appearance. Losses of approximately 0.5 tons/ha are possible for each 10% increase in affected canopy area. Under high moisture conditions complete crop loss may occur.

Conditions conducive to infection: Bacterial blight is particularly severe during the rainy season or if overhead irrigation is used. Cold and humid climatic conditions are conducive to the development of bacterial blight disease.

The pathogen survives in infected seeds and it is important to purchase seeds from a reputable seed merchant with a phytosanitary certificate to confirm the health status of the seeds. Using self-saved seed increases the risk of introducing pea blight to the growing area.

Pea blight will also survive in crop residue on the soil surface and it is important to identify and rogue out badly infected plants as soon as they occur in the field to slow down the spread of the disease within the field. A bag should be brought to the infected plant so that it can be placed inside the bag before it is removed from the field. If infected plant material is left on the soil surface in situ, or dragged through the rest of the crop, it is likely to spread the disease. The pathogen can survive for 12 months on dry leaves at 24° C, which makes it essential that composting or burial destroys roughed plants. Roughed plants could be fed to animals as long as there is no pesticide residue on the crop debris.

The disease can be spread between leaves and plants via splashing rain and irrigation water. It can be disseminated as far as 26 m from the primary focus. Overhead and furrow irrigation can spread the disease through water splash. Drip irrigation is recommended to reduce the spread of the disease by reducing the humidity in the canopy and keeping the leaves dry. Growing the crop under plastic tunnels will keep the leaves dry and greatly reduce the spread of this disease.

Weeds and some non-host species can also serve, as a primary source of inoculum since the bacteria is able to survive on these plants without inducing symptoms.

Laboratory isolation methods: Seven races of *P. syringae* pv. *pisi* have been identified. Colonies which form on agar plates are greyish-white are slightly raised with wavy margins. On King's Medium B colonies fluoresce when observed under ultraviolet light.

Preventive control: It is essential to use clean seed with a full Phytosanitary Certificate to prevent the major source of infection. It is recommended that at least 5,000 seeds from each seed lot be tested for pea blight in order that the seed lot is certified. Use of a 1 % sodium hypochlorite solution can reduce primary infection by 85-90%.

The use of crop covers to keep off the rain will reduce pea blight – see above.

Equipment used in the field should be disinfected after use to prevent mechanical spread of the disease.

Fields should be cleared of plant debris, crop residue and wild host weed plants to reduce primary sources of inoculum. Field workers can spread the disease if they walk through the crop when the crop is still wet (after rain, overhead irrigation or dew).

Non-chemical control: Some varieties show resistance to pea blight and these should be chosen during the rainy season. However, because there are several 'races' of this disease, the local races should be identified before choosing the most effective resistant cultivar. Resistance should be described by the seed merchant in terms of the races to which the cultivar is resistant.

Pesticides applications: See Appendix 1 for products, which are approved for use in Kenya on fine pea by PCPB (Pest Control Products Board) for controlling pea blight.

Fusarium Collar Rot, *Fusarium* Root Rot Of Pea

Scientific name: *Fusarium solani* f. sp. *pisi*

Other host plants: ***Pisum*** spp. (most legumes).

Symptoms and damage: *Fusarium*-infected plants are weak and the seedlings wilt. Longitudinal reddish lesions appear at the base of the stem. The roots become necrotic and the taproot turns reddish. The pea canopy will begin to dehydrate and turn brown when flowering commences and the water requirements of the plants go up. Increased symptoms can also occur if the soil is waterlogged.

Monitoring and diagnostic methods: This fungus can be identified by monitoring plant wilt in the field, sampling infected plants and culturing the sampled tissues. Since there are no real fungicide 'controls' for *Fusarium*, it is important to note the fields, and areas within fields, where *Fusarium* has been detected. Often corrective measures to improve soil conditions may reduce the risk of this disease in subsequent crops. Field 'crop histories' are a useful means of identifying areas or fields which should be 'rested' from peas' in a crop rotation plan. Ideally, sites, which have heavy *Fusarium* infections, should have at least one maize crop or *Brassica* crop before the next peas crop is planted. Avoid replanting peas in a field, which has suffered badly from *Fusarium*.

Conditions conducive to infection: The most common reason for the spread of *Fusarium* in peas is poor rotation following introduction of the disease in a low level from infected seeds. The use of crop cover tunnels and the inconvenience of moving the tunnels, when the land should be rotated with crops that do not need covers, will exaggerate the problem.

However, it is worth moving the crop tunnels to protect the soil health. Temperatures within the 20-25°C range are optimal for *Fusarium* root rot development. *Fusarium* is a seed and soil borne disease. The use of self-saved seed increases the risk of transmitting *Fusarium* into a clean field. In Kenya, seed should be purchased from a KEPHIS-registered seed merchant. Ideally seed should be sorted and examined by the grower before planting and any damaged or poor quality seed rejected. If infected seed is planted and *Fusarium* introduced to a clean site, it can remain in the soil for many years.

Excess nitrogen in the soil can accelerate the development of *Fusarium* in infected plants. Care should be taken in the fertiliser programme to avoid excess fertilisation, which also reduces root nodulation with nitrogen-fixing *Rhizobium* bacteria.

Any soil factor, which prevents effective root function, such as soil compaction, water-logging and drought, will increase the stress on infected plants and increase the development of the disease. Often, infected plants appear symptom-less until flowering, when the plant's water requirements increase to fill pods. At this time, plants can collapse suddenly, as the water vessels are blocked by *Fusarium* development and insufficient water is delivered to the plant.

Susceptible growth stages of crop: From the seedling stage until flower bud formation.

Preventive control: Ideally, crop rotations should be practised, with at least 3 years between each peas crop. On the Equator, where two and a half crops can be grown in each 12- month period, it may not be necessary to have such a long rotation. If pea crops are separated in the rotation with maize and cabbage crops, it may be possible to come back into the same field within 18 months, depending on the severity of any previous infection in that field.

If the organic matter content of soils is actively managed to maintain between 3 –5% organic matter content, by applications of composted manure or crop debris – this will build up beneficial microbes such asTrichoderma in the soil which are antagonistic to *Fusarium.Trichoderma* can grow on organic matter.

In terms of tillage, preliminary cultivation should be carefully carried out to ensure good drainage and aeration of soils. Avoid compaction and uneven field surfaces, where water may accumulate and cause plant stress. Ensure that any equipment used to cultivate the soil is cleaned thoroughly before it is used to plough the land or prepare beds. Otherwise soil infested with *Fusarium* may be brought to a clean site from a field which carries *Fusarium*.

Non-chemical control: *F. solani* has several natural enemies, including some, which are pathogenic to this fungus, i.e. *Trichoderma viridens*, *Gliocladium virens* and *Pseudomonas fluorescens*. Some of these enemies are antagonists, including *Bacillus subtilis*. These beneficial micro-organisms build up in the soil, if the organic matter content is high. They are also available in some countries as formulated 'biopesticides'. All these biopesticides would need to be registered as a crop protection agent before use. *Trichoderma* is registered in Kenya as a crop protection product. Seed treatments with *Trichoderma* are recommended on the Product Labels and may make a contribution to crop protection from *Fusarium*. However, the *Trichoderma* is itself a fungus and advice must be sought to integrate the use of *Trichoderma* with fungicides applied to the soil or seeds. *Trichoderma* can also be applied via drip irrigation (see Label).

Pesticides applications: Control is usually done by seed treatment with captan or thiram.

Damping Off, Black Leg and *Pythium* Root Rot

Scientific name: *Pythium aphanidermatum*

Other host plants: *Lycopersicon esculentum* (tomato), *Arachis hypogaea* (peanut), *Cucumis sativus* (cucumber), *Solanum melongena* (aubergine), *Solanum tuberosum* (potato).

Symptoms and damage: After sowing, emergence is hampered and the seedlings that manage to emerge have black rotting roots. The plants suddenly wilt and soft and wet rot are noted on the roots, collar and sometimes the stems. Once the plant has emerged and begun growing, infections caused by the pathogen are no longer lethal but they can still have a significant impact on plant growth and yield.

Symptoms other than root rot are sometimes also noted, such as nutrient-deficient foliar symptoms due to the root rot. In the post-harvest period, under high humidity conditions, a white fragile mycelium can develop on pods in export packing boxes.

Monitoring and diagnostic methods: Infected tissues have wet rot-like necrosis. The diseased plants are weak and their development is slower than that of healthy plants. Oospores can be observed directly on infected tissues, but this depends on how opaque the tissues are and their extent of degradation. Some other phytopathogenic fungi induce similar types of damage, so diagnosis must be confirmed by isolating and identifying the pathogen. This isolation can be done by placing infected tissues on agar gel. The tissues do not have to be disinfected unless they have been highly colonised by bacteria or fungal contaminants, which would complicate identification. Then the samples should be cleared of soil particles, the tissues dried and transferred to culture medium and, if necessary, the samples could be further disinfected in a mixture of javel water and ethanol.

Identification can also be done on the basis of the morphological features of zoosporangia and oogonia. *Sporangia* generally appear within 2-3 days, oogonia after 3- 5 days and oospores 5-7 days after culturing and colony. There are also more complex diagnostic techniques, including serological tests, molecular techniques based on RFLP analysis of mitochondrial DNA, RFLP analysis of PCRamplified DNA sequences, etc.

Conditions conducive to infection: *P. aphanidermatum* oospores are primary survival structures: they are resistant to drought and can survive in soil for long periods (11 months) when there is no suitable host or organic substrate upon which they can survive as saprophytes. Oospores germinate between 15 and 45°C (peak germination at 35°C) and when the pH is in the 5-8 range. Germination frequency reaches up to 90% when sufficient moisture and light are available. *Sporangia* are induced to produce mobile zoospores—the main disease agents—when certain nutrients are present and under high relative humidity. When free water is present, these zoospores are attracted to and penetrate the crop seeds and roots. When environmental conditions are unsuitable for disease development, the zoospores encyst and can remain in the soil for at least 7 years if the soil moisture and temperature are suitable. High soil moisture and mild to hot temperatures (27°C) promote the disease caused by *P. aphanidermatum*. Pathogen dispersion is favoured by the presence of a film of water and high humidity. Soil pH is also an important factor with respect to field infections because it alters the ecology (oospore germination) and pathogenicity of this phytopathogenic fungus. The saprophytic activity of the fungus in the field is markedly reduced when the pH is between 5 and 6.

Environmental conditions also have a direct and indirect impact on *P. aphanidermatum*. In field soils, the optimal temperature for disease development is around 27°C, but antibacterial treatment of the soil will reduce bacterial populations and this significantly boosts disease development and oospore germination, thus indicating that the temperature modulates bacteria-fungus interactions.

Susceptible growth stages of crop: Emergence, germination, vegetative growth and post-harvest stages.

Preventive control: This pathogenic fungus cannot be completely controlled via crop rotations because of the many different possible hosts, but the inoculum load can be reduced through some rotation practices. Conducting 2-3 year rotations can eliminate post-harvest soilborne *P. aphanidermatum* population densities. Mineral fertilisers such as phosphorous, potassium, potash, gypsum and dolomitebased amendments can also reduce the disease severity and soilborne propagule densities. Indeed, the resulting modifications in the soil pH and ammonia production in the soil atmosphere are toxic to this pathogen. Different mixtures of organic and inorganic compounds are known to reduce the incidence of this disease. The pathogen can thus be controlled for around 25 days after the amendment application and urea seems to be the most effective compound for controlling this pathogen. The mechanism for suppressing the fungus is linked with a direct effect of mineral fertilisers and an indirect effect of the mixture, which reduces the pH and stimulates microbial activity in the soil. Solarisation can also effectively control the fungus, especially in tomato and cucumber crop fields.

Non-chemical control: It is known that it is hard to find hosts that are resistant to *Pythium* spp. fungi. However there are some tolerant plants such as ginger, corn and a few bean species. Some organisms, including many bacteria, have been studied in terms of their potential as *P. aphanidermatum* biological control agents. *Pseudomonas* spp. fluorescent bacteria seem to have a positive effect on reducing root colonisation, but the control mechanism is not yet clearly understood. It is thought that these bacteria alter root exudates, thus reducing zoospore attraction to the plant roots. Fungal biological control agents have also been reported. A *Trichoderma* harzianum-based powder formulation mixed with the soil amendment can enhance control of this disease. Effective formulations can also be made with *Trichoderma* viride and *Streptomyces* spp. fungi. In Kenya, the use of all biological control agents must be registered by PCPB before use in any crop. However, good agricultural practice and addition of organic mater to the soil, will increase natural levels of *Trichoderma* in the soil.

Pesticides applications: Control is usually done by seed treatment with captan, thiram or matalaxyl-M which is a more specific fungicide.

White Mould

Scientific name: *Sclerotinia sclerotiorum*

Other host plants: Various vegetables including - *Solanum tuberosum* (potato), *Brassica* spp., sunflower and other pea and bean crops.

Symptoms and damage: The primary source of infection is sclerotia in the soil, so stems and parts of the plants which are touching the soil will be the first to show signs of infection. Where the plant canopy is dense and leaves remain wet for long periods, especially at the base of the plant, watery lesions will develop on leaves and stems, from infection sites. The familiar white mould quickly develops and becomes a dense mat on the stems and pods. Pods and stems may become slimy. Within the white mat, black sclerotia are formed, nicknamed 'rats droppings'. Monitoring and diagnostic methods: Yellowing and falling of the top leaves is the first sign of this disease. This symptom is often accompanied by soft rot of the stem at the soil line. The most common symptom noted in *Sclerotinia* infections is the development of a whitish mycelium mass at the stem base and on dead leaf litter around the stem. The mycelium develops during hot humid periods and disappears when the conditions become dry. Spherical sclerotia can be seen on mycelium growing on infected plant parts and on the soil surface. They are initially white and then turn brownish-black.

Conditions conducive to infection: During overcast weather or periods of high humidity, infection of plant tissue can occur either from direct germination of sclerotia in the soil or from ascosprores. Ascosprores are dispersed by wind and are released in wet weather – a period of leaf wetness of at least 48 hrs is needed for ascospore germination. Optimum temperatures for this disease are 20- 25 deg C. *Sclerotia* can survive for 5 – 7 years in the soil. Seed crops can also be contaminated with sclerotia and seed cleaning is essential.

Susceptible growth stages of crop: From emergence to flowering stages, through vegetative growth, fruiting and post-harvest stages.

Preventive control: Since the disease needs prolonged wet periods to assist germination cultural practices that increase air circulation will speed up the process of leaf-dying after rain or irrigation. Pea crops, which are left, unsupported and allowed to touch the ground, will be prone to infection, particularly during the rainy season. Prompt attention to providing plant supports and careful 'tucking-in' of shoots into the supports, without causing damage, will reduce the likelihood of infection. Wider plant spacing during seasonal rains will increase air circulation as will the orientation of the rows into the prevailing wind.

Drip irrigation is the preferred method of irrigation since it does not wet the leaves and is less likely to over-water the crop.

Excessive use of nitrogen fertiliser will increase the density of the crop canopy and encourage conditions suitable for infection. However, if there is a lot of crop debris from a previous crop, in the top layer of soil, applications of nitrogen may speed up the decomposition of the source of infection.

Ideally, there should be no crop debris on the soil surface, this should have been buried deeply or fed to animals (providing there are no pesticide residue issues).

Field mapping of areas with high *Sclerotinia* incidence is helpful. Field operations can be planned, so as to avoid dragging infected soil into clean areas of the field. Soil amendments and expensive biological control agents can also be focused in these hotspots.

Since the pathogen has a very wide host range, there is little to benefit from rotations, however if the disease develops, a 5-year rotation with cereals is recommended.

Non-chemical control: *Trichoderma* is registered for use in Kenya and it has some effect on *Sclerotinia*. *Coniothyrium* minitans is another fungal parasite of *Sclerotinia* and it will even attack the sclerotia in the soil, destroying them within two to three months. It is formulated as a biopesticide in the EU (Trade name Contans) but is not registered in Kenya. In Kenya, all use of biological control agents must be approved by PCPB.

Pesticides application: For controlling *Sclerotinia*, dicarboximide fungicides (vinchozoline, procymidone) can provide some protection in fields where *Sclerotinia* is known to be present – if applied preventatively prior to flowering.

Powdery Mildew on Peas

Scientific name: *Erysiphe pisi*

Other host plants: Various other pea crops (alfalfa, vetch, lupine, lentils).

Symptoms and damage: Yield, and growth can be severely reduced to the point of causing plant death if young seedlings are infected from an early stage and the disease is not controlled. The white mycelium, which spreads over the leaf surface, interferes with the photosynthesis of the crop.

Monitoring and diagnostic methods: The symptoms are very characteristic white patches of mould on the upper surface of the leaves. At first these will be confined to the lower leaves and be small pinpoint white dots. Eventually these enlarge and spread over the while leaf surface. Mature patches of mildew will have black dots within the mat. These are cleistothecia (fruiting bodies).

Preventive control: There is some evidence that powdery mildew may sometimes be seed borne. However, the main source of inoculum is spores carried on air currents from infected crops, or on pickers' clothing. Careful quarantine of badly infected crops is helpful – organising field operations to ensure that the spores are not spread from that field to young crops (order of work in the day etc).

Powdery mildew can 'bridge' from one crop to the next on infected plant material, so careful destruction of crop debris is important. Pulling out an infected crop and loading the crop debris onto an open trailer to a tip site will spread the spores all over the farm! Conditions conducive to infection: In warm dry weather if nights are cool enough for dew formation (especially if peas are grown at high altitude) powdery mildew will develop rapidly. Although some humidity encourages powdery mildew spores to germinate, prolonged leaf wetness (rain or overhead irrigation) will wash spores from the leaf surface and reduce the viability of spores. This is why powdery mildew is not often a problem in areas of high rainfall.

A crop which is highly vegetative, either from high soil moisture levels or excessive nitrogen, will encourage the development and spread of powdery mildew.

Susceptible growth stages of crop: From emergence to flowering stages, through vegetative growth, fruiting and post-harvest stages.

Non-chemical control: When applied for other reasons, the botanical products such as neem-based pesticides have an impact on powdery mildew of peas, especially the oil based formulations. This may be due to the fact that powdery mildew if a very delicate fungus which is easily 'squashed' by heavy products such as oil based formulations. The control may be by physical action rather than a chemical process. Starch and oil have been used on other crops for the control of powdery mildew and may work for the same reason.

Pesticides application: See Appendix 1 for products, which are approved for use in Kenya on peas by PCPB (Pest Control Products Board) for controlling powdery mildew in peas.

Leaf and Pod Spot, Blight, Foot Rot

Scientific name: *Ascochyta pisi* (leaf and pod spot); *Mycosphaerella pinodes* (blight), and *Ascochyta pinodella* (foot rot)

Other host plants: other pea crops.

Symptoms and damage: Leaf stem and pod lesions characterise this disease complex. Discolouration of the root area may also indicate *Ascochyta*. The lesions are normally tan brown in colour, sunken with a darker brown border. On the leaves and pods these lesions are round whereas they appear elongate in shape if on the stem. Stem lesions can sometimes develop a blue/black or purplish colour. In the rainy season, the leaf lesions may develop concentric rings, whereas in dry spells symptoms will appear as uniform yellowing of lower leaves. To distinguish between bacterial blight lesions and *Ascochyta* blight lesions on leaves, hold the leaf to the sunlight. *Ascochyta* lesions will be opaque and bacterial blight lesions will be translucent. *Ascochyta* can cause flower abortion, when the flower is infected. The fungus girdles the sepal and the small pod or blossom will distort or fall off.

Ascochyta foot rot is less of a problem nowadays since seed treatment and phytosanitary measures have been developed. However, if seedlings are killed or stunted by early infections, suspect seed infection as the primary source of the problem. In severe infections the whole canopy except for the top few shoots will appear desiccated and brown. The three diseases are very common and crops are rarely free of one or more of the diseases. These diseases suppress yields even if present in low levels. If the presence of the disease is noted and controlled it is possible to increase yields by 15 – 75%.

Monitoring and diagnostic methods: Early signs of the infection will appear as spots on the leaves.

Conditions conducive to infection: Prolonged leaf wetness.

Susceptible growth stages of crop: From emergence to flowering stages, through vegetative growth, fruiting andpost-harvest stages.

Preventive control: *Ascochyta* will colonise pea straw and live saprophytically on this in the absence of a live pea host. Therefore it is important to bury crop debris or feed it to animals, if there is no harmful pesticide residue. Ascospores can be carried on the wind for more than a mile, so planting young crops down wind to old crops will encourage the spread of the disease. Always plant young crops upwind from older crops and if possible plant a wind break in between crops. Growing the pea crop under plastic tunnels will keep leaves dry and will significantly reduce the disease problem.

Since the disease needs prolonged wet periods to assist germination cultural practices that increase air circulation will speed up the process of leaf-dying after rain or irrigation. Pea crops, which are left, unsupported and allowed to touch the ground, will be prone to infection, particularly during the rainy season. Prompt attention to providing plant supports and careful 'tucking-in' of shoots into the supports, without causing damage, will reduce the likelihood of infection. Wider plant spacing during seasonal rains will increase air circulation as will the orientation of the rows into the prevailing wind. Drip irrigation is the preferred method of irrigation since it does not wet the leaves and is less likely to over-water the crop. Excessive use of nitrogen fertiliser will increase the density of the crop canopy and encourage conditions suitable for infection).

Non-chemical control: Cultural controls will be the most effective means of reducing this disease.

Pesticides application: See Appendix 1 for products, which are approved for use in Kenya on fine pea by PCPB (Pest Control Products Board) for controlling *Ascochyta*.

Downy Mildew on Peas

Scientific name: *Peronospora viciæ*

Other host plants: Various other pea crops (pea, broad bean and vetch).

Symptoms and damage: Infections can be systemic (spread throughout the plant) or a local lesion on leaves and stems. Leaf lesions are grey fluffy patches of mould on the lower surface of leaves. These appear as green, yellow or brown patches on the upper surface. Systemic infections are severe and will stunt and distort the plant with sporulation occurring all over the plant. The plant may be killed by systemic infections before flowering commences. If humidity is very high, the pods may become infected and deformed, showing signs of superficial blistering with yellow and brownish areas.

Felt-like growths may occur within the pods as a result of endocarp stimulation. Pod infections can occur, even if there are no leaf symptoms.

Monitoring and diagnostic methods: Grey fluffy mould on the lower surface of leaves is the most common symptom used in monitoring this disease in the field.

Conditions conducive to infection: Moist, cool weather will encourage the spread of downy mildew.

Susceptible growth stages of crop: From emergence to flowering stages, through vegetative growth, fruiting and post-harvest stages.

Preventive control: Downy mildew will bridge from one crop to another either on crop debris or in the soil. Oospores can survive for more than five years in the soil and longer rotations may be necessary if a severe infection occurs in a field. However, deep tillage and crop rotation will have some impact on disease reduction.

Since sporangial production requires at least 12 hrs of 90% relative humidity, cultural practices, which reduce the period of leaf wetness, will also minimise the spread of the disease. (See section on *Ascochytae* controls).

Non-chemical control: See section on powdery mildew controls.

Pestcides application: See Appendix 1 for products, which are approved for use in Kenya on peas by PCPB (Pest Control Products Board) for controlling downy mildew in peas.

Grey Mould

Scientific name: *Botrytis cinerea*

Other host plants: Very wide host range.

Symptoms and damage: The most common *Botrytis* blights are those caused by the fungi grouped together as *Botrytis cinerea*. *Botrytis* fungi attack a very wide range of hosts, both field grown crops and those grown under protection. They are also responsible for considerable post harvest losses of many crops during and after transit or storage. *Botrytis* disease is often called the 'disease of bad management' because there are many cultural factors in the control of the grower which could reduce the risk of infection.

Botrytis blights can range from leaf spots, stem cankers and root rots to damping-off of young seedlings. Commonly, the blighted tissue will produce prolific brown sporulations. *Botrytis* can also be called grey mould.

Monitoring and diagnostic methods: Suspected lesions on plant tissue will develop the characteristic grey mould if it is stored in a plastic bag at room temperature.

Conditions conducive to infection: Epidemics can spread very quickly because the life cycle is fast and the disease infects an extremely wide range of crops. A conidium can be formed on a new lesion within 8 hrs of a new infection! Usually, *Botrytis* epidemics occur in cool, wet and humid weather. Infections are encouraged by surface wetness, which, together with temperature drives the life cycle from a latent infection to a sporulating one.

Either very young or senescing tissue is susceptible to a Botrytis epidemic – Between these stages, epidemics are less common. Spores are airborne and produced in vast numbers. Infection can occur by germination of conidia, with penetration through undamaged tissue, stomata or wounds.

It may also occur from hyphae growing from dead parts of plants or from other dead plant material in contact with the crop plant (eg straw in the alleyways of plantations). Hyphae growing from petals which have fallen onto lower leaves are a common source of infection. There can be a latent or dormant infection which can go undetected for weeks, until environmental conditions are right.

Susceptible growth stages of crop: From emergence to flowering stages, through vegetative growth, fruiting and post-harvest stages.

Preventive control: Crop management and handling practices which prevent plant damage, reduce the easy entry points for *Botrytis* on a plant. Post harvest rots can be reduced by controlled temperature storage or controlled atmosphere storage. Air circulation and the practice of venting at the end of the day is useful in preventing the conditions which encourage *Botrytis*. High levels of sanitation before and during cropping (remove all dead or infected plant material). Do not wet foliage when irrigating. Space plants for good air circulation. Apply a protective fungicide programme, particularly during risky wet weather.

Non-chemical control: *Trichoderma* has both a suppressive and eradicant effect on *Botrytis*. This biopesticide is approved in Kenya and further guidance should be sought from the Label regarding its use in vegetable crops for the control of leaf diseases.

Pesticides application: See Appendix 1 for products, which are approved for use in Kenya on peas by PCPB (Pest Control Products Board) for controlling *Botrytis* in peas.

Green Pea Aphid, Pea Aphid

Scientific name: *Acyrthosiphon pisum*

Other host plants: *Vigna* spp., *Fabaceæ*

Symptoms and damage: Green pea aphid if allowed to establish can completely cover the crop and drastically reduce yields. Pea aphid can transmit various viruses such as pea enation mosaic virus, pea mosaic virus and pea leaf roll virus.

Monitoring methods: Although predictive models have been developed for this pest in the EU, these are not as useful in countries on the Equator, where all year round growing conditions allow all year round pest incidence. Check the outside rows along the edge of the crop carefully for the first signs of aphid attack. Rows adjacent to older crops are particularly vulnerable. Green pea aphid can build up at some times of the year on the lower leaves as well as the youngest leaves within the growing shoot tip. Monitoring will reveal where the spray should be directed. Vigorous shaking of the pea supports will dislodge the aphids on the lower leaves and in severe infestations, the ground can become green with fallen aphids. These could then be drowned by drenches of water or sprayed with an insecticide, since they are easier to contact when the are not on the underside of the lowest leaves.

Conditions conducive to infestation: Green pea aphid easily develops resistance to repeated use of certain active ingredients and a resistance management programme is important to ensure that a wide range of pesticides remains effectively useful to growers. Care should be taken in over-reliance on the active ingredient pirimicarb, as part of the resistance management programme. Commercial products based on the pyrethrum flower extract, registered in Kenya have provided good control of green pea aphids, if applied in high volume as a directed spray into the growing tips of plants. It is less likely that repeated use of pyrethrum will result in resistance as there are several 'active ingredients; in this botanical insecticide (unlike synthetic pyrethroids or other organophosphate or carbamate products. Maize windbreaks between sections of pea crops from different plantings may reduce migration of aphids from crop to crop.

Susceptible growth stages of crop: All stages, especially during flowering and pod set.

Preventive control: Ensure that consecutive plantings of peas are not planted down-wind of older crops, which could be heavily infested with aphids. The pest always migrates from an adjacent infested crop. Outside rows in a block need to be carefully monitored. It is important to direct the sprays directly into the growing points of the peas, where aphids colonise the plants (careful choice of nozzle and volume).

Care should be taken when removing the old pea crop if it is infested with aphids as millions of aphids will transfer to adjacent crops. It may be necessary to apply a post-harvest aphicide before removal of the crop. Alternatively, it should be determined if aphid migration is prevented (as it can be for whitefly in beans) if the crop is removed in cooler periods of day when the aphids may be less active.

Non-chemical control: Aphid predators (ladybirds and hoverfly) are useful predators of the pea aphid. They are encouraged by interplanting with maize plants (hosts to aphids which do not attack peas – but allow ladybirds and hoverfly to build up) and cabbage plants (host to the grey aphid which does not attack peas). When aphids are attacked by predators they give off an alarm pheromone which casues other aphids nearby to fall off the leaf, to get away from the predator. However, other predators such as rove beetles, await them on the soil surface. This is only made possible by eliminating the broad spectrum sprays applied to the crop. *Erynia*, is a naturally occurring fungal disease of green pea and other aphids. The aphid bodies are infected and turn a beige colour with a slightly fluffy appearance. When aphid populations are high and there is high humidity locally (either from rain or overhead irrigation) *Erynia* will build up quickly and can spread to almost 100% of the population, killing the aphids. If the disease is observed, the rate of spread can be increased if the crop is irrigated overhead, or water is applied with the spray equipment. Heavily infested shoots with many infected aphid bodies can also be moved around the crop, to spread the aphid-killing disease. *Erynia* is quite broad spectrum in its effect on aphids and if there are also aphids present in companion plants, they can also become a host to this entomopathogen (insect-killing fungi).

However, it is important to ensure quick control of early aphid infestations, since the longer it takes to eliminate the aphid population, the larger the aphid colony will develop. IPM scouting will determine the relative levels of aphids and aphid predators and parasites in the crop. If the ratio of aphid predators/parasitoids to aphids is less than 1:20 (i.e. for every 20 aphids there is one aphid predator or parasitoid), then it may be advisable to use a pesticide to quickly bring down the level of aphids. This will avoid any damage due to high aphid populations and the honeydew they excrete. If a virus is present, then the tolerance for green pea aphid is zero, as this pest is a vector for many pea viruses.

If the aphids are detected early, then there may be less pressure to resort to chemical controls. The speed of the control achieved can be accelerated if the grower collects aphid predators and parasitoids from older crops and moves them into the new crop. The key to success is to identify aphid colonies as soon as they appear and to introduce beneficial insects to these 'hot-spots' as quickly as possible.

Parasitoid wasps are particularly useful biological control agents since they lay many eggs and can quickly parasitise aphid colonies. Local Kenyan species of *Aphidius* have proved to be very useful in the control of black bean aphid and can make a contribution to green pea aphid control. This wasp lays eggs inside the body of a wide range of aphids. The aphid host does not die immediately and remains attached to the leaf where it is feeding. The *Aphidius* eggs hatch inside the body of the aphid and feeds on the aphid's body fluids. As the *Aphidius* larvae develop within the host's body, it pupates and spins a cocoon inside the aphid body. The aphid is still attached to the leaf and takes on a papery 'mummified' appearance. The *Aphidius* continues to develop into an adult *Aphidius* wasp within the aphid 'mummy'. Eventually it bites a circular hole in the aphid body, which it then pushes open like a trap door and emerges as a fully mature *Aphidius* wasp. Sometimes hyper-parasites attack the developing *Aphidius* within the 'mummified aphid' and lay their eggs in the *Aphidius* larvae. It is possible to distinguish a mummified aphid, which has been 'hyper-parasitised', because the 'exit hole' for the hyper-parasite is usually a torn, split aphid body, instead of a neat circular trap door-like exit hole. The indigenous parasitic wasp, *Aphidius* transcaspinus is registered by PCPB as a biological control agent in Kenya. It has been mass-reared commercially in Kenya. Care is needed in the use of *Aphidius* since it does not integrate with pyrethroid chemicals.

Pesticides application: See Appendix 1 for products, which are approved for use in Kenya on fine pea by PCPB (Pest Control Products Board) for controlling aphids. Early applications of aphid controls are essential to prevent establishment of this pest. This may have to be done prophylactically, before pea plant supports are applied.

Old World Bollworm or Tomato Fruitworm

Scientific name: *Helicoverpa armigera* (Heliothis armigera)

Other host plants: *Gossypium* (cotton), *Lycopersicon esculentum* (tomato), *Solanum tuberosum* (potato), *Sorghum*, *Arachis hypogaea* (peanut), *Brassicaceae* (crucifers), *Cucurbitaceae*, *Allium*, *Citrus*, *Capsicum annuum* (pepper), *Mangifera indica* (mango), *Pennisetum glaucum* (millet), *Phaseolus*, *Pisum sativum* (pea), *Solanum melongena* (aubergine). EU Notifiable Pest: *Heliothis armigera* is a notifiable pest in the EU, which means that it must not be imported on produce to the EU. This is one of the most frequently intercepted pests from Kenya to the EU.

Symptoms and damage: *H. armigera* is an important pest of many crops throughout most of the world. It is especially well adapted to artificial ecosystems such as crop fields because of the following features: highly mobile, polyphagous, rapid reproduction capacity and diapause. As this pest shows a preference for flower-derived plant parts (pods, seeds, etc.) of high added value crops (cotton, tomato, bean, etc.), it has a substantial economic and socio-economic impact, especially in subsistence farming systems.

The bollworm nibbles on the pods and leaves and eats the seeds. Adult females lay their eggs in the pea pods. These eggs and young caterpillars are hard to detect during pea sorting operations, so the pods can subsequently be damaged in the export packing boxes.

Monitoring methods: This caterpillar can reach 40 mm long at full development. Its colour varies markedly, ranging from very dark brown to green or yellow. Black and white sinuous lines run along the entire length of its body. Feeding larvae can be noted on the plant surface but they are often hidden in the flowering and fruiting organs. During pest monitoring, some of these organs should thus be cut off, opened and the internal parts carefully inspected. These caterpillars can also be detected by the presence of organic waste outside of or on the pea pods which is produced by feeding larvae. Exit holes made by mobile larvae, which subsequently pupate into nymphs in the soil, can also be observed.

Conditions conducive to infestation: *A H. armigera* female can lay (mainly at night) up to 3000 eggs during its life cycle. These eggs hatch after 3 days of incubation at temperatures around 25°C. These temperature conditions also promote the development of first and second instar larvae, which pupate in the soil. The adult life span of these caterpillars is about 3 weeks. Their longevity, however, depends on food availability (sucrose, nectar). For this reason, bollworm tends to peak in populations after the rains in Kenya, when the adults emerge from pupae in the soil and there is an increased likelihood that suitable host plants will have emerged after the rains. Its development is favoured by a succession of host crops: tomato, bean, aubergine, cotton, etc.

Susceptible growth stages of crop: From fruit set to harvest, including the vegetative growth, flowering and fruiting stages.

Preventive control: It is not very effective to try to manage populations of this pest in the crop fields because of its high mobility and dispersed habitats. Adapted cultural techniques, such as reducing the cropping period, can be a useful control strategy but there should be no wild host plants in the vicinity, or those that are present should be isolated. Other crop management techniques using bait plants such as chickpea have been set up, but they have some limitations, since they may serve as a breeding ground, unless they are carefully and regularly inspected and the caterpillars present are removed. Even one caterpillar being destroyed may prevent many hundreds of a second generation from developing (since an adult can lay up to 3000 eggs each). Crop rotations without a spatio-temporal succession of crops that host this pest are recommended for preventive control. It is also recommended to carefully choose cultivars that are to be planted, to space and fertilise the crop so as to increase the crop yield, and to specifically target the larval stages in control operations since they are the most susceptible to conventional treatments with pesticides and microbial formulations.

Non-chemical control: *Trichogramma* is a minute parasitic wasp, which lays eggs in the eggs of caterpillars, including bollworm. Kenyan companies have developed mass-rearing systems for *Trichogramma*. *Trichogramma* is the most widely used natural enemy in the world and it is mass released over millions of hectares each year for maize stalk borer control in the US, China, southern Europe and Russia. A virus which infects bollworm is also well researched and being mass-produced in a pilot scheme for small-scale farmers in East Africa. This system has been used in other parts of the world and involves collecting bollworm caterpillars in a bucket from the wild and introducing one or two infected caterpillars. The virus then spreads very quickly throughout the collected caterpillars and when they have died, their bodies are macerated and sprayed onto the crops to kill other bollworm pests. This is called a 'biopesticide' and should be registered in Kenya, even if the home-made formulation is for own use on-farm.

There are also commercial virus based biopesticides registered for this pest elsewhere in the world, based on similar microbes to that described above. In Kenya, PCPB will confirm how these can be legally imported with permission from the Kenyan Standing Technical Committee for Imports and Exports (KSTCIE) for an experimental permit to develop registration data for a Kenyan Label. Formulations of *Bacillus thuringiensis* (Bt) are registered for use in Kenya by PCPB. It is important to use these sprays in the late afternoon or early evening because UV light breaks down the Bt during the daytime. This has to be injected by the caterpillar in order to kill it and it works best on young caterpillars as high doses are needed to kill mature caterpillars. Early applications are essential when the newly laid eggs have just hatched to make the Bt spray effective.

Since it is very difficult to see these small larvae or to find the bollworm eggs on leaves, it is best to begin a weekly spray when the adult moths are seen. Adult moths can be caught in light traps and their numbers recorded to determine when the peak migration has occurred. This will help to time the Bt application to when the first small young (susceptible) larvae are present.

Planting *H. armigera* tolerant or resistant varieties has long been and still is an important focus of research (cotton, pea).

Several plants have a genetic potential that could be tapped to develop varieties at are less susceptible to pests. However, developing one specific trait sometimes weakens the plant's defence against another pest (e.g. glabrous cotton, which reduces egg laying but increases susceptibility to jassid infestation). In recent years, advances in genetic technology have made it possible to introduce genes responsible for the secretion of *Bacillus thuringiensis* toxin in some crop plants (cotton, corn). However, these plants should be mixed with susceptible varieties to avoid placing high selection pressure on the pest populations.

As an IPM strategy, considerable research has been focused on achieving a suitable level of control by introducing natural enemies or increasing predator and parasitoid populations in association with other pest control methods. As it is essential to produce a high quantity of parasitoids or predators, research has also been focused on *Trichogramma spp.* which can be mass propagated easily. There are other natural enemies of *H. armigera* (lacewings, ladybugs, *Bacillus spp*., braconid wasps, etc.), but the results have not always been very promising, especially for systems in which pesticide treatments are necessary. Micro-organism-based pesticides are quite useful for IPM on account of their relatively high specificity, potential activity, environment-friendliness and pesticide immunity. These are *B. thuringiensis*- and virus-based formulations. They are not widely used, however, because of their high light degradability, the fact that larvae do not ingest sufficient quantities, and their virulence is sometimes not very high.

Pesticides application: See Appendix 1 for products, which are approved for use in Kenya on fine pea by PCPB (Pest Control Products Board) for controlling caterpillars. *H. armigera* is mainly managed with pesticides, alone or combined with other control methods. Clearly, to get the best results, these pesticides should only be applied when the economic threshold has been reached, but operators do not always comply with this rule. Most recommended pesticides target larva, but are actually only efficient against first instar larva. Young larvae are hard to find and older instars are often well hidden in the pods, thus reducing their accessibility for treatment and forcing operators to increase the active ingredient dose. Moreover, larvae from resistant populations are only susceptible when they are less than 4 days old, so targeting neonate larvae is the most efficient approach for controlling such pests. As preventive control, it is recommended to conduct treatments weekly after fruit set and throughout the harvest period. As curative control, treatments should be undertaken as soon as 1% of the pods have been attacked. Preventive control is preferred because batches of green pea can be turned away by importing countries if any worms are detected. Resistance phenomena due to selection pressure induced by the use of pesticides such as pyrethroids were already noted in the 1980s in H. armigera populations. The high dispersal potential of this pest could lead to dilution of this resistance, but the same mechanism also facilitates the spread of resistance genes beyond the initial region.

Based on the importance of the dispersal and migratory behaviour of this pest, its movements could be monitored by a trapping system so as to be able to forecast infestations in a given region. This would only be qualitatively useful for indicating the onset of infestations and the location of the migratory front, and preventive treatments should still be conducted during the initial vegetative stages. This monitoring is required to determine exactly when the economic threshold is reached and surpassed so that control measures can be initiated. It is hard to get accurate data on this threshold, some are based on egg numbers (1 egg/2 plants, 2 larvae/18 plants, 2 eggs/1 m row).

South American Leafminer (*L. Huidobrensis*) and American Serpentine Leafminer (*L. Trifolii*)

Scientific name: *Liriomyza huidobriensis* and *L.trifolii* and other *Liryomyza* spp

Other host plants: *Cucurbitaceae* (cucumber), *Gossypium* (cotton), *Lycopersicon esculentum* (tomato), *Solanum tuberosum* (potato), *Solanum melongena* (aubergine), *Arachis hypogeae* (peanut) and various weed species.

EU Notifiable Pest: *Liriomyza* is a notifiable pest in the EU, which means that it must not be imported on produce to the EU. This is one of the most frequently intercepted pests from Kenya to the EU. It can be a significant problem on the pods of mangetout and sugarsnap peas than in garden peas (which have the pod removed before export).

Symptoms and damage: Feeding damage caused by leafminer appears as tunnelling (0.13-0.15 mm diameter) on the upper side of leaves. The shapes of these tunnels vary according to the attacked plant, but they are long, linear, and not very wide when sufficient leaf area is available. They are generally greenish to white. A sac forms for pupation at the end of feeding tunnels on the smallest leaves.

Monitoring methods: Flies of this species are black and yellow, so they can be clearly seen flying around host plants and above the leaves. They feed on the leaves, leaving small round feeding marks which can be distinguished from the eggs which they lay in the leaves, as these are oval shaped white marks. The eggs hatch into leafminer larvae, which feed on the leaf tissue and make tunnels or mine in the leaf blade – hence their name…'leafminer'.

The leafminer larva exits from a tunnel to pupate in the soil. Pupation casings can sometimes be found on the leaf surfaces, but in most cases the satiated larva will quickly find its way to the soil. This behaviour is often noted under dry weather conditions as the larva-pupa must seek shelter to avoid drying out on the leaf surfaces.

Tunnel damaged leaves should be collected in polyethylene bags and transferred to a press as quickly as possible. Leaves containing larvae that are to be kept for rearing should be placed in individual bags that are then filled with air and sealed. Pupae should be transferred into separate tubes where they are kept until emergence of adult flies. These adults are retained in the glass tubes for at least 24 h.

Condensation within the tube should be avoided because the flies could stick to the walls after emergence. Adult flies are collected in the field by net trapping. The use of yellow sticky traps, which are placed around the crop plant, is a very efficient sampling and infestation assessment method. However, it is not advisable to use these routinely or for mass trapping except in severe infestations, since the yellow sticky traps also catch

Diglyphus which is a very efficient parasitoid wasp that controls this pest without the need for any pesticides. Leafminer prefer to sit on horizontal surfaces rather than vertical surfaces and will therefore be more effective if placed horizontally in the crop.

Conditions conducive to infestation: The eggs are laid just under the leaf surface and hatch within 4-7 days at 24°C. The larval development time also depends on the temperature– several generations a year are possible under suitable temperatures and when growing host plants are available. Leafminer pupate in the soil near the plant, although sometimes the pupae can be seen sticking to the outside of the leaf. The adults emerge 1-2 weeks thereafter when temperatures range between 20 and 30°C, with peak emergence occurring at midday but earlier for males. The lifespan of these pests is 15-30 days. When temperatures exceed 40 deg C, leafminer lay fewer eggs.

Susceptible growth stages of crop: From the seedling stage to the first harvest, including the vegetative growth, flowering and fruiting stages.

Preventive control: Cropping should be avoided in or near fields where there have been heavy leafminer infestations. Runnerbean crops can produce millions of leafminer if not properly protected. To avoid *L. trifolii* introductions, international authorities (EPPO) recommend monthly inspection of propagation material (except seed) from other host plants, such as pepper, cucumber, lettuce and tomato from other countries where this pest prevails, over a 3-month period. The plants should be exempt of this pest. A phytosanitary certificate is required for leafy plants.

Destroying host weed plants growing along the edges of the crop fields is recommended, unless biological controls are used, in which case, the natural enemy will migrate into the weedy areas and kill any leafminer larvae present. Since leafminer pupates in the soil, deep ploughing can bury the pupae and prevent them from emerging. However, take care to ensure that there is sufficient topsoil to do this without bringing sub-soil up to the surface. Crop debris should also be quickly destroyed after harvest is completed, if there has been a heavy infestation of leafminer – to prevent more adult leafminer from hatching from the crop debris. However, crop debris is not always a problem…since if biological control has been good, it may be possible that more *Diglyphus* than leafminer will hatch from crop debris! (see below).

Non-chemical control: The indigenous parasitic wasp, *Diglyphus* isaea, is the best method of control for leafminer since it lays eggs prolifically and actively flies in search of leafminer larvae in which to lay its eggs. *Diglyphus* will naturally migrate into crops, if they are not sprayed and it is important for the scouts to be able to identify this parasitoid wasp.

An effective IPM scouting system will determine the ratio between the *Diglyphus* and the leafminer adults. If the ratio is 1:3 or below (ie one *Diglyphus* adult for 3 leafminer adults) then the leafminer is under control and no action needs to be taken.

Diglyphus is registered as a crop protection agent with PCPB in Kenya and it is mass reared locally. The wasp lays eggs inside the leafminer larvae within the leaf. The leafminer larva eventually dies and the *Diglyphus* pupates within the leaf, to emerge later as an adult wasp. Mass rearing courses are available in Kenya and advice about how to harvest the naturally occurring *Diglyphus* from old crop debris.

Pesticides application: See Appendix 1 for products, which are approved for use in Kenya on fine pea by PCPB (Pest Control Products Board) for controlling leafminer. Chemical control is quite problematic because the larva is endophytic (develops within the leaf sheltered from pesticide treatments).

Legume Pod Borer

Scientific name: *Maruca testulalis (Maruca vitrata)*

Other host plants: *Fabaceae*, *Cajanus cajan* (pigeon pea), *Phaseolus lunatus* (lima bean), etc.

Symptoms and damage: *M. vitrat*a belongs to a group of Lepidopteran pod borers. It is broadly distributed in tropical areas, especially in West and East Africa. Other pests such as *H. armigera* or dipterans can occur simultaneously in crop fields. The crop damage caused by *M. Vitrat*a is usually not distinguishable from that caused by other pests of the group present, but this insect is generally considered to be one of the major pests of the group (especially in India, but less in Kenya for instance). Yield losses range from 33 to 83% (Tanzania), but are often around 60%. The larvae bore circular holes in the corolla of flowers; the pods become deformed because of the larger larvae that they contain. The damage caused by this pest includes round bore holes in the corolla, which can turn the flowers into a brownish mass within 24 h. Monitoring methods: The adult is a pyrallid moth measuring around 25 mm that keeps its wings spread when roosting. The moths can be observed on the lowest leaves during the day, but it is more efficient to attract them at night with a light trap. The wings of adults are brown with white markings. They have a brown head. The eggs are yellowish-white, translucent and look like fine separate water droplets. The size of the pupae ranges from 2.5 to 11.5 mm. The flowers should be examined to detect circular holes bored by the larvae and signs of pod deformation.

Conditions conducive to infestation: This nocturnal Lepidopterea insect requires high relative humidity conditions. The egg stage lasts around 3 days at 24-27°C. When flowers are present at the onset of the rainy season, a few first instar larvae, which are initially grouped, are able to disperse later. Young larvae feed on leaves and pods during the 13-14 day larval stage at 24-27°C. The pupa stage lasts around a week. The adults are inactive during the day and can be found roosting on the lower plant leaves. Several generations a year (up to 7) are possible. The alternating flowering patterns of the different host plants along a southnorth gradient induces *M. Vitrata* migration from the coast towards the West African savanna regions. During this migration, the pod borers find suitable reproduction conditions on different crop plants, thus boosting the size of each new generation. Up to 1500 adults can be captured per night in light traps during the growing season, with peak captures of 5000 butterflies a night reported in northern Benin.

Susceptible growth stages of crop: Vegetative growth, flowering and fruiting phases (fruit set to harvest)

Preventive control: Studies carried out for 10 years on crop rotations in Kenya revealed that the sorghum-pea association is the most effective in reducing pod borer populations. This also applies to the corn-sorghum succession, whereas the corn-sorghum succession was found to be the most detrimental combination.

Non-chemical control: The introduction of resistant or tolerant varieties or late flowering cultivars is an alternative strategy for controlling these pests, especially when pea varieties are cropped in alternation with corn varieties (Tanzania). Tests were carried out to assess the impact of introducing natural enemies (Mauritania, 1950) and, on the basis of the results, two species, i.e. *Bracon cajani* and *Eiphosoma dentator*, were subsequently introduced in this geographical area.

Pesticides application: Preventive chemical control treatments should be carried out weekly from fruit set onward and throughout the harvest period. There is currently less dependence on chemical products for controlling this pest, partially because of the development of resistance phenomena, especially in Nigeria where pod borers have shown resistance to cypermethrin, dimethoate and endosulfan. Alternative control methods are thus recommended, and these products should only be used when there are no other options. Pesticide foliar spray treatments with cypermethrin, endosulfan and monocrotophos, beta-cyfluthrin and deltamethrin have, nevertheless, been widely used in the past (1990s). Alternative pesticides such as neem (*Azadiracta indica*) oil extracts are sometimes more efficient for controlling pod borers than some other products such as carbaryl or lambdacyhalothrin, i.e. providing protection against third instar larvae within 2 days post-treatment.

Red Spider Mite or Two-Spotted Spider Mite

Scientific name: *Tetranychus* spp.

Other host plants: *Gossypium* (cotton), *Citrus*, *Abelmoschus esculentus* (okra), *Lycopersicon esculentum* (tomato), *Cucurbitaceae* (cucumber), *Arachis hypogaea* (peanut), *Carica papaya* (papaya), *Citrullus lanatus* (watermelon), *Ipomoea batatas* (sweet potato), *Solanum melongena* (aubergine), *Solanum tuberosum* (potato) commercial flower crops and local weeds.

Symptoms and damage: Spider mites feed on the sap of plants and leave small white/yellow specks on leaves, were the green chlorophyll has been removed. If spider mite a present in very large numbers (several hundred per leaf) the leaf can become so dry and brittle that it falls off. The mites are generally found on the under surface of leaves where they are difficult to kill with pesticides because underleaf cover with sprays is not always very efficient. A very fine web may be noted when these mites occur in high numbers. Plants grow poorly when they are heavily infested. Infestation occurs in concentrated patches, with mites often migrating from heavily attacked neighbouring crops. In pea crops, where supports are used, the spider mites will move up the pea posts and accumulate on the tips, so that the wind can blow them away to new crops.

Monitoring methods: Spider mites can be detected on the basis of leaf symptoms, but it is better to pinpoint them prior to symptom development. Regular sampling of leaves is required and they should be examined under a magnifyingglass or microscope. The eggs are spherical (0.15 mm diameter), initially translucent, and then take on a pearl-like quality, sometimes with a pinkish tint. The larvae are beige in colour and as they feed they develop two black spots in the abdomen (hence their name). These spots are their guts filling up with the plant sap, which is dark green when concentrated and eventually looks black. The two spots can merge into one if the spider mite has been feeding excessively. On the equator, in Kenya, the spider mite does not enter diapause (hibernation) like it does in Europe where the growing season is broken by a long, cold winter. However, it can exhibit symptoms similar to the European 'summer diapause' and it will turn red if it is stressed for some reason. This will happen when the spider mite population on a plant is very high. This causes the plant to suffer and the nutritional quality of the plant sap goes down – this stresses the spider mite because this is its sole food source. It turns red because its slows down its development rate in relation to the quality of the sap. The red pigment is a feeding deterrent to potential predators and it is important to take this into account if the grower is using biological controls for this pest – as *Phytoseiulus* may not be so efficient if there is a preponderance of red spider mite. In this situation the spider mite may also migrate to the top of the plant, form a silken strand to dangle itself in wide currents. This is how it migrates to find other host plants.

Conditions conducive to infestation: This pest can increase dramatically during dry weather whereas high rainfall quickly reduces spider mite outbreaks. Red spider mites develop very rapidly, particularly under high temperature conditions, i.e. around 9-12 days at 30°C.

Susceptible growth stages of crop: Before flowering and especially from flower bud formation until harvest.

Preventive control: If local spider mite control is not good, it is recommended to avoid growing pea in or near fields that have undergone heavy previous spider mite infestations, or where susceptible trees (papaya, etc.) are growing. Since spider mite moves on wind currents, it is useful to ensure that young plantations are planted upwind of older infested crops, to minimise the migration of spider mite in the wind onto new crops. Windbreaks can also be used to slow migration.

Excessive nitrogen fertilisation and enclosed fields without aeration should also be avoided. Crop residue should be collected and burned immediately after harvest if the spider mite infestation has been very high. However, if biological control has been used, the leaves at the end of a crop's life should be checked before they are destroyed, since they may have more *Phytoseiulus* on them than spider mite and the leaves could then be used to transfer the *Phytoseiulus* to other crops. It is important to use a hand lens for this purpose because the leaves may be severely damaged by the spider mite feeding, but this could just be 'historical' damage, since there may not be many spider mite left if the *Phytoseiulus* has developed in this crop. The grower may even decide to leave the crop in the ground and even water the crop, to allow the *Phytoseiulus* population to develop to a stage where there are very few spider mite but a preponderance of *Phytoseiulus*. Good weed control will allow more effective spray penetration to the underside of the crop's leaves. Many weeds are also a host for spider mite. Finally, sprinkler irrigation will limit damage.

Non-chemical control: The predatory, *Phytoseiid* mite *Phytoseiulus* persimilis has been successfully used to control spider mites in both field and greenhouse crops. It is very specific in its host range, feeding almost entirely on spider mites. If the spider mite population is eliminated, the *Phytoseiulus* will either move out of the crop and into the surrounding area in search of spider mite, or it will become cannibalistic and attack other

Phytoseiulus. There is no negative environmental impact from *Phytoseiulus*, which is used in most countries of the world as a commercial means of controlling spider mite. *Phytoseiulus* is a predatory mite, which moves much faster on leaves than spidermite. It has a red, pear-shaped body with a glossy appearance and is slightly larger than spidermite. *Phytoseiulus* is registered in Kenya by PCPB as a biological control agent for spider mite and it is mass reared commercially in Kenya.

At a temperature of about 18 C an adult *Phytoseiulus* female lays 50-60 eggs; these will hatch in five days and the life cycle is completed in 9-11 days. This progress from egg to adult is twice as fast as spider mite which takes about 21 days from egg to adult at 18 C. The predator can live up to 26 days.

Although red spider mite can reproduce very rapidly as temperatures rise, *Phytoseiulus* will complete its life cycle twice as fast as spidermite is able to do so at the same temperature.

The daily multiplication rate of *Phytoseiulus* is 1.25 times. Multiplication per generation is 44 times. At 20 C predator populations will increase 300 times in 30 days. At 26 C predator populations will increase 200,000 times in 30 days. With an introduction rate of 30,000 *Phytoseiulus* per hectare in field crops it is possible to build up phenomenal numbers and the build up of predators can be easily monitored.It is this speed of reproduction and the morphology of *Phytoseiulus*, which enables it to get underneath the webbing that makes this predator more effective at controlling spidermite than pesticides. However, if the introduction rate of *Phytoseiulus* is properly matched to the field spidermite population, the problems caused by excessive temperatures can be minimised.

Advantages of *Phytoseiulus*

Predatory mites have the advantage over pesticides in that they will actively move to the underside of leaves in search of spidermite. It is not possible for spidermite to become resistant to attack from predators.

If the grower has access to sufficient *Phytoseiulus* at a reasonable cost, it is feasible to apply enough predatory mites to 'clean-up' a farm and reduce the 'pest status' of spidermite.

Types of *Phytoseiulus* 'Products'

Phytoseiulus can be supplied to growers either in a bottle of vermiculite (an expanded clay particle used simply as a carrier) or on freshly harvested bean leaves. The *Phytoseiulus* are actually reared on bean plants, so the leaf will have all stages of the *Phytoseiulus* present (adults, juveniles and eggs). There may also be a small amount of spider mite on the leaf as well. This is not a problem and should be considered a 'packed lunch' for the *Phytoseiulus*! If it does not have something to eat --it has less chance of establishing in the crop.

Extreme care must be taken with the *Phytoseiulus* in transport to the farm. They will not establish if they die before they are applied to the crop!. If the bottle with vermiculite in it gets too hot the vermiculite will dry out and even dehydrate the *Phytoseiulus* inside the bottle – killing them. If condensation arises inside the bottle, the *Phytoseiulus* in the bottle will drown.

Phytoseiulus, which is provided on a fresh bean leaf, should remain alive as long as the leaves are stacked carefully on top of each other in thin layers and held between sheets of tissue paper. It is easy to see if the leaves are 'old' because they will be brittle and dehydrated. It is easier to examine the number of *Phytoseiulus* on a bean leaf rather than in a bottle of vermiculite.

Never store *Phytoseiulus*. Always apply it as soon as it arrives on the farm, having already checked that the spray programme is compatible.

Establishing *Phytoseiulus* in a crop

Introduction strategies

Never apply *Phytoseiulus* to a crop, which is heavily infested with spider mite, as it may take too long for the predator to kill the entire pest population and the crop will be severely damaged in the meantime. It is advisable to apply a prophylactic introduction of *Phytoseiulus*, early in the life of the crop - whether scouts see spider mite in the crop or not. One approach is to make a minimum of two applications between two and four weeks apart.

The minimum individual application should be 15,000 *Phytoseiulus* per hectare. If a prophylactic programme is adopted – the *Phytoseiulus* applications should begin before spider mite is observed in the crop. In this case – the introduction rate for *Phytoseiulus* does not need to be calculated, based on the total spider mite population in the crop – as there is not likely to be much present. The grower would just apply a minimum of 15,000

Phytoseiulus **per hectare.**

However, a grower will need to assess spider mite populations before applying *Phytoseiulus* only if:

- the introduction is made LATE to a crop and spider has already become a problem (not ideal – as you will need a lot of *Phytoseiulus*).

OR

- the *Phytoseiulus* do not establish (because of a harmful spray or lack of food) and you want to re-introduce *Phytoseiulus* and need to know how many to apply (see section on remedial action and how to estimate total field populations).

If the risk of spider mite build-up is high (hot weather coming)

– then modify the introduction strategy as follows:

- reduce the time between applications (one to two weeks apart).
- continue making applications until scouting indicates that the ratio is less than 1:5 (*Phytoseiulus* to rsm). If you have plenty of *Phytoseiulus*, try to bring this down to 1:1.

OR

- assess the total spider mite population per hectare by sampling and calculate introduction rate for *Phytoseiulus* which ensure a ratio of at least 1:10 or lower – in one application.

Field guide – application methods

Phytoseiulus may be available either as a freshly harvested product on leaves or in a plastic bottle with vermiculite inside (this is just used to help distribute the Phytoseiulus and it is inert).

Never store *Phytoseiulus*, always use it as soon as it arrives on the farm. If it has to be stored, do so in a domestic fridge at 5 deg. C for no longer than 24 hrs.

Only order the *Phytoseiulus* when you are ready to apply it, having organised the spray programme to ensure that no harmful sprays have been applied recently and there are not plans to apply harmful sprays within 2 weeks after the application of the *Phytoseiulus*. (See Appendix for pesticide sensitivity charts).

It is important to apply predators as evenly as possible. If predators are applied unevenly into a crop, the spider mite on plants between those, which received *Phytoseiulus*, will remain untreated until the predators have eaten the entire spider mite on the plants to which they were originally applied. This may result in hot spots of high spider populations, which` will be more difficult to control biologically.

Biological control of red spidermite may take several weeks to complete. To avoid damage to the crop the manager must make this process as quick as possible by:

- applying *Phytoseiulus* on a prophylactic programme early in the life of the crop (minimum strategy is - 15,000 per hectare in wk 3 and 15,000 again in week 6)
- distributing *Phytoseiulus* as evenly as possible (a piece of transfer leaf at every meter along the planting row – so the distribution can be checked easily by the supervisor)
- applying small amounts of spider with the *Phytoseiulus* (these will come on the transfer leaf).

- if some spider is already present in the field, ensure the *Phytoseiulus* is applied to these areas without fail. (train staff to recognise spider mite damage on the leaf – as well as applying to every meter along the row – these areas should also receive extra Phytoseiulus)
- apply the leaves with the *Phytoseiulus* on them, with the underside of the transfer-leaf, facing the ground – so the *Phytoseiulus* eggs do not dry out in the sun.
- wedge the transfer-leaves between leaf stalk and the stems, lower down in the canopy – so they do not blow away before the *Phytoseiulus* have walked off the transfer-leaf on to the crop.

Measuring biological control

It is possible to measure biological control by weekly monitoring of leaf samples to determine the ratio of predator to pest – just as advised with leafminer and *Diglyphus*.

In this way, if historical weekly records are kept, the progress of the ratio (*Phytoseiulus* to spider mite) over a period of time can be measured and the success of the biological control programme is determined.

The ratio of *Phytoseiulus* to red spider mite at the time of introduction and the average temperature at that time will influence the time it takes for the *Phytoseiulus* to eliminate the red spider mite.

If the ratio of *Phytoseiulus*: rsm is 1:500, it will take longer to get control, than if the ratio was 1:50 or even 1:5. This is logical.

Assuming a prophylactic introduction of *Phytoseiulus* has taken place early in the crop, before spider mite is present – the following scouting method should be used.

After introduction, the *Phytoseiulus* will actively search for spidermite – therefore when monitoring check only the leaves with spidermite damage – this is where the mites are – so this is where any Phytoseiulus will be.

Compatible spray programmes

If an IPM programme is adopted for spider mite – all prophylactic sprays for spider mite must be removed from the programme immediately. *Acaricides* will kill *Phytoseiulus*.

Other sprays, including fungicides will also kill some *Phytoseiulus*. However, scouting will indicate if further introductions are required to compensate for any negative affect of the fungicide/pesticide programme. (See Appendix for pesticide sensitivity of *Phytoseiulus*)

A successful IPM programme needs:

The absence of harmful pesticide residues on the leaves from the previous spray programme. NB: This is NOT the same as the Pre-Harvest Interval
A compatible spray programme after introduction of *Phytoseiulus*. Bear in mind that even a 'safe' pesticide is likely to kill 25% of *Phytoseiulus*.

Always organise the introduction of *Phytoseiulus* to take place AFTER a spray application (including fungicides) – as these will kill some *Phytoseiulus*. Never apply *Phytoseiulus* just before a spray application – give them a chance. In a successful IPM programme, the crop itself is a good breeding ground for beneficial insects, It has been possible to produce about 100 million in half a hectare over seven weeks – by putting *Phytoseiulus* into a badly infested crop in about week 8. These can then be moved around the farm, to introduce *Phytoseiulus* into young blocks *Amblyseius californicus*

Another predatory mite is regsitered in Kenya by PCPB as a biological control agent for spiderr mite. *Amblyseius* is indigenous to Kenya and it has the advantage that it is generally more resistant to pesticides than *Phytoseiulus* . It can also survive for longer without spider mite being present since it can also feed on pollen. If spider mite is not present it will prey on the very young stages of thrips.

Pesticides application: See Appendix 1 for PCPB Approved chemicals for the control of spider mite in Kenya. Preventive or curative treatments should be conducted during the vegetative phase to ensure that infestation levels are very low at the beginning of harvest. *Acaricide* resistance phenomena have also been documented in spider mites. Resistance can quickly develop within a relatively small number of generations along with cross-resistance to other acaricides. These products should therefore be carefully chosen and only used when absolutely necessary. A resistance management strategy drawn up by IRAC (Insecticide Resistance Action Committee) involves changing active ingredients belonging to different groups with the aim of extending their efficacy time.

Armyworm

Scientific name: *Spodoptera exigua*

Other host plants: *Zea mays* (corn), *Gossypium* (cotton), *Lycopersicon esculentum* (tomato), *Oryza sativa* (rice), *Pisum sativum* (pea), *Solanum tuberosum* (potato), *Solanum melongena* (aubergine), etc.

Symptoms and damage: Young larvae feed on the superficial layer of leaves, often leaving the epidermis and large veins intact. Later instar larvae pierce irregular holes in the leaves and fully developed larvae can consume all of the leaves, leaving only the main leaf ribs.

Monitoring methods: Looking for signs for feeding damage caused by the larva facilitates detection of this pest.

Pheromone and light traps can also be used.

Conditions conducive to infestation: The eggs are deposited at night on host plants on the under sides of the lowest leaves. The 6-stage larval development process is determined by a combination of diet and temperature conditions, with temperatures required to go from the egg to the larva and then pupa stages being 13, 15 and 15°C, respectively. This development period lasts from 10 to 12 days at 28°C, but can last for 35 days at 16°C. The larvae vary in colour but are often green and range from 20 to 30 mm in size. The adults emerge at night and live for 8-11 days. This is a tropical and subtropical butterfly species that is adapted to hot regions, with an optimal temperature of 28°C for larvae. There can be 4-6 generations annually in these regions. Activity and development are stalled at lower temperatures, and all stages are killed during cold periods. *S. exigua* winters in hot regions of the Mediterranean Basin and Africa.

Susceptible growth stages of crop: All stages, from sowing to harvest, but the worm shows a preference for the flowering, fruiting and vegetative development stages.

Preventive control: One control technique involves exposing larvae and pupae on the soil surface so that they will dry out and die. Weeding is also recommended in order to destroy all potential shelters for this pest.

Non-chemical control: The importance of natural enemies has been demonstrated, with a wide range of arthropod predators (ground beetles), parasitoids (*braconid wasps*, *Ichneumonidae*,*Trichogramma*, etc.) and pathogens (*Bacillus* spp., *viruses*, etc.). A molecule called volicitine is secreted by *S. exigua* larvae and can be applied on damaged leaves (corn) to trigger the release of volatile compounds that attract the female pests along with the parasitoid *Cotesia marginiventris*. Improvement programmes have been set up to boost resistance to *S. exigua* in corn–leaf hardness was thus enhanced and the leaves were induced to secrete *B. thuringiensis* toxins that are harmful to armyworm larvae.

Pesticides application: See Appendix 1 for pesticides approved for use by PCPB for the control of caterpillars in Kenya.

Thrips and Western Flower Thrips

Scientific name: *Thrips palmi*, *Frankliniella occidentalis*

Other host plants: *Zea mays* (corn), *Oryza sativa* (rice), *Arachis hypogeae* (peanut), *Gossypium hirsutum* (cotton). EU Notifiable Pest Note that Thrips palmi is a notifiable pest in the EU and scouts should be trained to distinguish this species. Symptoms and damage: Punctures caused by thrips induce tissue discoloration and metabolic disorders in the plant, which thus weakens and wilts.

Monitoring methods: Thrips are very small and therefore hard to detect, and this is also problematic with respect to taking quarantine measures. The larvae and adults are gregarious feeders that first attack the leaves along the veins. On stems, they especially attack the terminal buds but they are also sometimes detected on the petals. Feeding stains also indicate the presence of this pest. There are also some predatory thrips species.

Conditions conducive to infestation: These pests are well adapted to the hot climate (25-30°C) of tropical and Sahelian countries. Their development is also favoured by the presence of weeds and secondary host plants.

Preventive control: It is often virtually impossible to eradicate secondary host plants that could be virus reservoirs or harbour thrips. It could, however, be useful to plough and harrow the fields after harvest in order to kill larvae remaining in the ground and adults on the vegetation. Sowing could also be done at an earlier date and sowing rates could also be modified.

Non-chemical control: Thrips are mostly of commercial significance during the dry seasons, which constitute almost six months of the year – and may cause down grading losses of up to 20%. Thrips control strategies may benefit from the following additions. In many crops, there is a pattern in the activity of thrips on crops. In some areas, it has been observed that thrips emerge onto the outside of flowers and the upper surface of leaves from about 7.30 to 8.30 am and from 4.30 to 5.30 p.m. It is possible to confirm this locally if scouting is undertaken every half hour from 6.30 am onwards. Thrips do this for social reasons, and are otherwise either flying or tucked very tightly inside flowers or on the underside of leaves. They are difficult to kill when they are hiding, so it is best to spray when they are exposed, on the upper surface of leaves and on the outside of flowers. Contact insecticides could then be used instead of the systemic organophosphates which tend to be more harmful to operators and the environment.

After very hot dry spells, thrips become very thirsty and feeding damage will increase on the plant as they scrape moisture from leaves and petals. If during the dry spell, there is a heavy downpour of rain in the late afternoon, this often brings thrips out onto the outside surface of leaves and flowers during the evening. If this happens, this would be a good time to spray, as more would be killed.

Providing the top-soil depth is adequate, deep ploughing of heavily infested thrips blocks will bury the thrips which pupate in the soil. Do not deep plough, if sub-soil is brought to the surface, as this will reduce subsequent yields. Varieties could be used that are tolerant or less susceptible to thrips, but this is often a difficult practice to apply on account of the high price of the seed. Thrips parasitoids and predators, including some *Hymenoptera*, can also be used. *Amblyseius californicus* is registered in Kenya as a biological control for spider mite but it will also eat the younger stages of thrips. Other predators such as *Orius* are very common in Kenya and can have a significant impact on thrips numbers. Scouts should be trained to recognise this natural enemy. Mass production systems for this natural enemy have been developed and training is available in mass rearing systems. Planting sunflowers and maize in windbreaks will increase the number of Orius in the locality.

Pesticides application: See Appendix 1 for pesticides approved for use by PCPB for the control of thrips in Kenya.

Root-Knot Nematodes

Scientific name: *Meloidogyne* spp.

Other host plants: *Arachis hypogaea* (peanut), *Musa* (banana), *Oryza sativa* (rice), *Solanum tuberosum* (potato), *Lycopersicon esculentum* (tomato); almost all market-garden crops except onion, mint, strawberry, garlic and leek.

Symptoms and damage: The larvae penetrate the roots and settle in the vascular area, inducing swellings or galls. The shape, size and appearance of the galls varies with their age, number, the host plant, extent of attack, *Meloidogyne* species involved, and environmental conditions. Under heavy infestations, the roots can become swelled and stunted. The decreased branching of the root system and metabolic problems resulting from the presence of root-knot nematodes lead to poor plant development and gradual reductions in yield. The root injury caused by *Meloidogyne* nematodes also facilitates attacks by other phyto-pathogenicmicro-organisms (*Pythium*, *Fusarium*, *Rhizoctonia*).

Root knot nematode is often confused with the normal nodulation of legumes by the nitrogen-fixing *Rhizobium* bacteria. *Rhizobium* nodules are round and attached to the outside of the root, whereas root knot nematode is a swelling within the body of the root. *Rhizobium* nodules are often pink inside if they are actively fixing nitrogen.

Monitoring methods: The root galls that form are easy to observe. Infected plants may also wilt. Root samples can be collected and then sections prepared (1-2 mm) and stained with fuchsin. Microscopic examination of these sections can reveal the presence of juvenile endoparasitic stages. The size of the stylets in females, of the tips of the stylets in males and second instar juveniles are useful features for identifying different *Meloidogyne* species. Species identifications can also be confirmed through tests on host plants.

Conditions conducive to infestation: The lifespan of one generation of *Meloidogyne spp*. nematodes is highly dependent on the temperature conditions. At very high temperatures (above 29°C), the cycle lasts around 3 weeks but it can last as long as 3 months at low temperatures. Crops are at risk of nematode attack throughout the year but especially during hot periods, with cardinal temperatures of 14°C-28°C-32°C. Excessive irrigation promotes the dissemination of root-knot nematodes.

Susceptible growth stages of crop: From emergence to flowering.

Effective treatment period: See pesticide product Labels for the effective treatment periods, pre-harvest intervals and the recommended frequency of applications.

Preventive control: The soil should be tilled and it is especially important to carefully eliminate infected crop residue from the previous season. Successions of peas crops, or of peas crops with other crops that also host root-knot nematodes, should be avoided.

Non-chemical control: There are some biological control agents under development in Kenya (*Pasteuria*, *Pochonia*) as well as registration in progress of imported biopesticides for nematode control. PCPB should be contacted for further information as the Registrations are approved. Root knot nematode (*Meloidogyne incognita*) can become a problem if the crops grown on that ground which are a host to root knot nematode (okra, pea, chillies etc) and the nonhost crops (brassicas and babycorn) are not in balance with these in the planting programme. Dwarf Mexican marigold as a trap crop for root knot nematode (rkn) is a useful break crop if there are many rknsusceptible crops grown on the land. Root knot nematode will enter the roots of the marigold but does not complete its life cycle effectively. Therefore the marigold acts like a sponge – mopping up levels of root knot nematode in the soil. However they will only attract nematodes which have hatched from egg masses and do not kill the egg masses which may have been dislodged when the previous infested crop was removed. The relative levels of rkn per block should be ascertained so that the blocks with high rkn levels are identified and appropriate management can be implemented in a timely fashion. Nonhost crops could be planted or other cultural operations, described below, could be prioritised in these blocks. Scouts may need training to ensure correct sampling procedures are used for collecting soil samples to assess rkn levels in fields. If the soil samples are too dry or stored incorrectly prior to dispatch to the lab for assessment of rkn levels – misleading information may be provided regarding the levels of rkn in the soil. This is because the extraction of nematodes from the soil sample relies on them being alive to swim out of the soil into water. The nematodes in the water are then counted and identified. If the pea are grown in a hot climate and are a long distance from soil labs, it may be useful to train staff in simple extraction methods, so that water containing nematodes can be sent for analysis, instead of soil samples. This will give more accurate data and it may be cheaper, as the lab does not have to undertake the extraction process. Blocks identified with high rkn levels could be planted (full field) with dwarf Mexican marigold at a rate of 8 – 10 kilos/ha of seed. If water is a limiting factor on the farms, it could be organised for these high-risk fields to be removed prior to expected rainy

periods, so that rainfall can help establish the marigold 'trap crop'. It is important to recognise that weeds, particularly 'MacDonald's Eye or Gallant Soldier (Galinsoga parviflora) are hosts for root knot nematode. To optimise the benefit of marigold, the marigold-planting should be weed-free for at least six weeks, which is the period required to maintain maximum benefit of nematode trapping from the marigold. There is no additional benefit from the marigold after six weeks growth. This six week period is a 'growth period' – from germination onwards (not from planting). Root knot nematode can be killed by desiccation of soil from disking operations after the removal of the infested crop. A proportion of the rkn egg masses, which remained in the soil after the removal of the crop, will be killed by desiccation.

The remaining egg masses, that survive the desiccation process, will hatch if the ground is irrigated. Since rkn is an obligate parasite (cannot live in the absence of the host) – it is possible to further reduce the field rkn levels by ensuring a weed-free period of two weeks after the eggs hatch. Any eggs, which hatched as a result of irrigation (or rain) after the desiccation process, will produce nematodes that search for a host. If they do not find a host within about two weeks – they die.

Scouts would benefit from being able to distinguish the difference between root knot nematode and healthy *Rhizobium* nodules on legume roots. *Rhizobium* nodules are external swellings of the root (sometimes pinkish). Root knot nematode egg masses are internal swellings of the root.

Pesticides application: See Appendix 1 for pesticides approved for use by PCPB for the control of root knot nematodes in Kenya.

ILLUSTRATED SHEET OF MAIN DISEASES AND PESTS OF PEAS

BACTERIAL BLIGHT

Pseudomonas syringae pv. *pisi*

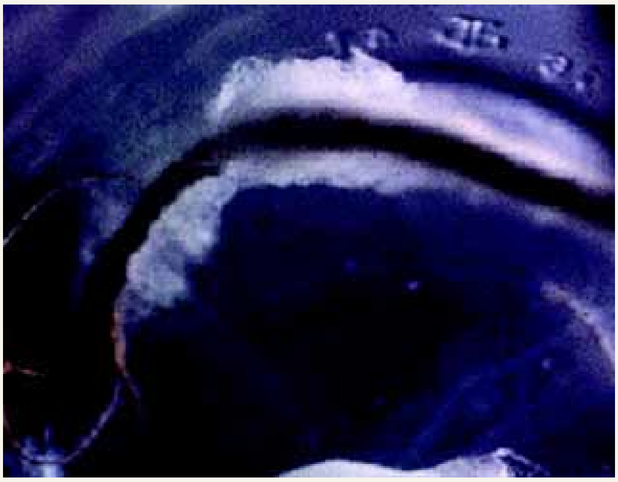
P. syringae, infection on leaf

P. syringae, infection on pods

FUSARIUM COLLAR ROT, FUSARIUM ROOT ROT OF PEA

Fusarium solani f. sp. *pisi*

DAMPING OFF, BLACK LEG AND PYTHIUM ROOT ROT



Pythium, growth on root

WHITE MOULD

Sclerotinia sclerotiorum

Sclerotinia, 'rats droppings'

White mould growing on bean stem caused by *Sclerotinia*

POWDERY MILDEW

Powdery mildew on peas

LEAF AND POD SPOT, BLIGHT, FOOT ROT

Ascochyta pisi (leaf and pod spot); *Mycosphaerella pinode*s (blight), and *Ascochyta pinodella* (foot rot)

DOWNY MILDEW ON PEAS

Peronospora viciae

GREY MOULD

Botrytis cineria

GREEN PEA APHID, PEA APHID

Acyrthosiphon pisum

OLD WORLD BOLLWORM OR TOMATO FRUITWORM

Helicoverpa armigera (Heliothis armigera)

H. armigera on pods

Adult *H. armigera*

SOUTH AMERICAN LEAFMINER (*L. HUIDOBRENSIS*) AND AMERICAN SERPENTINE LEAFMINER (*L. TRIFOLII*)

Liriomyza huidobriensis and *L.trifolii* and other *Liryomyza* spp.

Miner

Larva

Pupa

Adult

LEGUME POD BORER

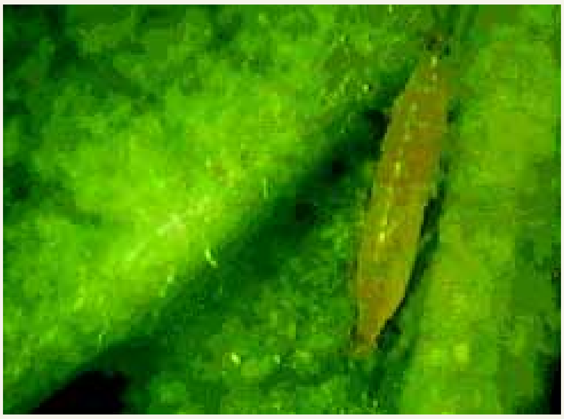
Maruca testulalis (*Maruca vitrata*)

RED SPIDER MITE OR TWO-SPOTTED SPIDER MITE
Tetranychus spp.

ARMYWORM
Spodoptera exigua

THRIPS OR WESTERN FLOWER THRIPS

Frankliniella occidentalis



Larva

Damage on a leaf

Damage on a pod

ROOT-KNOT NEMATODES

Meloidogyne spp.

Root knots caused by *Meloidogyne* spp.

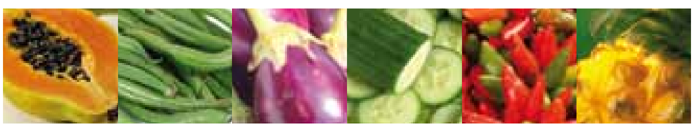
Rhizobium nodules ***(not a pest !)***

CROP PRODUCTION PROTOCOLS

Avocado (*Persea americana*)
French bean (*Phaseolus vulgaris*)
Okra (*Abelmoschus esculentus*)
Passion fruit (*Passiflora edulis*)
Pineapple Cayenne (*Ananas comosus*)
Pineapple MD2 (*Ananas comosus*)
Mango (*Mangifera indica*)
Papaya (*Carica papaya*)
Pea (*Pisum sativum*)
Cherry tomato (*Lycopersicon esculentum*)

GUIDES TO GOOD PLANT PROTECTION PRACTICES

Amaranth (*Amaranthus* spp.)
Baby carrot (*Daucus carota*)
Baby and sweet corn (*Zea mayis*)
Baby Leek (*Allium porrum*)
Baby pak choy (*Brassica campestris* var. *chinensis*), baby cauliflower (*Brassica oleracea* var. *botrytis*), baby broccoli and sprouting broccoli (*Brassica oleracea* var. *italica*) *and head cabbages* (*Brassica oleracea var. capitata* and *var. sabauda*)
Banana (*Musa* spp. – plantain (*matoke*), apple banana, red banana, baby banana and other ethnics bananas)
Cassava (*Manihot esculenta*)
Chillies (*Capsicum frutescens, Capsicum annuum, Capsicum chinense*) and sweet peppers (*Capsicum annuum*)
Citrus (*Citrus* sp.)
Coconut (*Cocus nucifera*)
Cucumber (*Cucumis sativus*), zucchini and pattypan (*Cucurbita pepo*) and other cucurbitaceae with edible peel of the genus *Momordica, Benincasa, Luffa, Lagenaria, Trichosanthes, Sechium* and *Coccinia*
Dasheen (*Colocasia esculenta*) and macabo (*Xanthosoma sagittifolium*)
Eggplants (*Solanum melongena*, *Solanum aethiopicum*, *Solanum macrocarpon)*
Garlic, onions, shallots (*Allium sativum, Allium cepa, Allium ascalonicum*)
Ginger (*Zingiber officinale*)
Guava (*Psidium catteyanum*)
Lettuce *(Lactuca sativa*), spinach (*Spinacia oleracea* and *Basella alba*), leafy brassica (*Brassica* spp.)
Lychee (*Litchi chinensis*)
Melon (*Cucumis melo*)
Organic Avocado (*Persea americana*)
Organic Mango (*Mangifera indica*)
Organic Papaya (*Carica papaya*)
Organic Pineapple (*Ananas comosus*)
Potato (*Solanum tuberosum*)
Sweet potato (*Ipomea batatas*)
Tamarillo (*Solanum betaceum*)
Water melon (*Citrullus lanatus*) and butternut (*Cucurbita moschata*)
Yam (*Dioscorea* spp.)



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