



SFI Options that Include Non-Crop Legume Species in Legume Rotations

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There are several options available to growers with SFI agreements that offer good payments. PGRO has conducted a review of information available from multiple sources to evaluate potential impacts of some of those options in pulse and vegetable legume rotations. The options most likely to contain legume species are NUM3 (legume fallow – 1-to-3-year option) and AHL1 (pollen and nectar mixture – 1-to-3-year option). Many AHL1 mixtures on the market contain vetches, clovers and other legumes, up to 99% of the mixture in some cases. Where peas and beans are used in mixtures, risk is likely to be high.

SFI or CS options that must or are likely to include legumes in seed mixtures are as follows:

NUM2 – legumes on improved grassland.

Num3 – legume fallow

IPM3 – Companion crop on arable and horticultural land.

SAM2 – Multi-species winter cover.

AHL1 – Pollen and nectar flower mixture

AHL2 – Winter bird food on arable and horticultural land.

AB15 – Two-year sown legume fallow (CS).

1. Potential risks

There are multiple pathogens, insect pests and nematodes that are hosted by several legume plant species, some of which are likely to be contained in legume fallow and pollen and nectar mixtures. We have described below some of the key areas that may impact on pea and field bean rotations and what to consider when including SFI options in legume rotations.

The SFI options offer benefits for biodiversity and soil health if established well, but may lead to build up of pathogens, insect populations, nematode populations and provide reservoirs for virus infections. Little practical work has been conducted to date to evaluate the on-farm effects of the new SFI options in legume cropping rotations, although PGRO is pursuing this through farm-scale trials across the country. Options that are situated in margins or areas where crop production is not planned, such as flower-rich mixtures, will present little risk, and are intended to provide benefits to integrated pest management.

Diseases

Soil-borne diseases

Soil-borne diseases, especially foot rot diseases in legumes, build up over time, and can lead to significant crop failures in peas and field beans if not managed. There are several diseases in the foot rot complex, including *Fusarium* spp., *Aphanomyces euteiches*, and *Didymella pinodella*. *Pythium* spp. and *Rhizoctonia solani* are also diseases that can cause seedling blight and damping-off at establishment. Some *Fusarium* spp. are specific to plant species and do not become pathogenic in other species, and others have multiple crop and plant hosts. The genus generally poses significant risk to peas and beans and more detail about each species that affects legumes is given below.

Fusarium spp.

Fusarium avenaceum has several other legume hosts including clover, faba bean, lucerne, lupins, berseem clover, crimson clover, Italian ryegrass, black oat, perennial ryegrass, reversed clover, red clover, vetch, and white clover. Damage caused by the disease may be seen in lupins, red clover and white clover.

Fusarium solani is hosted by faba bean, pea, lucerne, Phaseolus bean, and chickpea. In peas and Phaseolus beans the disease can cause serious damage to roots, leading to plant failure. Little is known about host or multiplication for other mixture species, although it is generally considered to be of low risk in vetches and clovers.

Fusarium culmorum is responsible for ear disease in wheat and crown rot in sugar beet. Field beans should not be planted directly following these crops, where disease has caused noticeable infection. Hosts are oats, barley, brassica, sugar beet, lentil, perennial and Italian ryegrass, wheat, and faba beans.

Aphanomyces euteiches hosts include peas, clover, faba bean, lucerne, Phaseolus beans, berseem clover, red clover, vetch, white clover. Severe damage can be seen in peas, Phaseolus beans and berseem clover.

Didymella pinodella (*Phoma medicaginis* var. *pinodella*) is seed and soil-borne, hosted by clover, faba bean, lucerne, lupins, Phaseolus beans, peas, berseem clover, crimson clover, reversed clover, red clover, and white clover. Phaseolus beans, peas, lupins and red clover may show significant damage from *Didymella* and can lead to strong multiplication of the pathogen in soils.

Thielaviopsis basicola is hosted by clover, faba bean, lucerne, Phaseolus beans, peas, crimson clover, red clover, and white clover. Root rot can be observed in peas and Phaseolus beans.

All of the diseases above have potential to carry over from SFI options to pea and bean crops, and diseases with highest potential risk of carry-over to peas and beans are likely to be *Didymella pinodella*, *Aphanomyces euteiches* and *Thielaviopsis basicola*. The *Fusarium* species cause most damage in slightly warmer conditions (20-30°C), on wet soils with neutral pH, or when plants are under drought stress. *D. pinodella* and *T. basicola* are more prevalent in cooler conditions (12-20°C), in wet conditions on neutral pH soils. Infection with *A. euteiches* is most prevalent when host plants are in the seedling stage, on neutral pH soils, and when temperatures are between 22 and 28 °C, preferring warmer, wetter conditions. All of the diseases form persistent soil-borne spores that survive for several years in the absence of a host and are multiplied in soils by their main hosts.

Pythium spp. are hosted by clover, faba bean, lucerne, Phaseolus beans, peas, Italian ryegrass, perennial ryegrass, reversed clover, berseem clover, crimson clover, red clover, sorghum, and white clover. *Pythium* spp. can cause significant damage in peas, Phaseolus beans and sometimes in faba beans. It is likely that *Pythium ultimum* causes most damage in peas and beans, although other species may be implicated in damping-off, and these diseases are encouraged by cool wet conditions at establishment.

Rhizoctonia solani is hosted by clover, faba bean, lucerne, lupins, Phaseolus beans, peas, Italian ryegrass, marigold, mustards, perennial ryegrass, Phacelia, radish, niger, turnip, white clover, and white mustard. Phaseolus beans, peas and phacelia are known to suffer high levels of damage from Rhizoctonia. Faba beans, Phaseolus beans, peas, marigolds, perennial ryegrass phacelia, white clover and white mustard are known to multiply *R. solani* in soils. Root rot occurs during warmer periods when temperature is between 15 and 18°C and is encouraged by poor soil conditions and consolidation. Losses from this disease tend to be less in peas and beans and maintaining good soil conditions will reduce likelihood of infection.

There are currently no chemical options to assist management of the soil-borne diseases listed above. As such, good use of rotational disease breaks and soil health management are critical to reduce the risk of build-up of these diseases.

Ascochyta pisi is seed-borne, hosted mainly by peas, although faba bean, lucerne, red clover, and vetch may also host the disease. In general, the disease causes less damage than it has done historically, and fungicides may be used to control *A. pisi* leaf and pod spot in peas.

Mycosphaerella pinodes is soil and seed-borne, hosted mainly by peas, although clover, faba bean, lucerne, lupins, red clover and vetch may also host the disease. Leaf and pod spot in peas caused by *M. pinodes* may be controlled using fungicides.

These diseases are thought to be less likely to be carried over from SFI options into peas. Pea seed can be tested for the presence of the Ascochyta complex diseases. It is not known whether seeds within SFI mixtures are tested. Both *A. pisi* and *M. pinodes* leaf and pod spot may be controlled in pea crops using appropriate fungicides.

Sclerotinia sclerotiorum is hosted by spring-sown faba bean, lucerne, lupin, Phaseolus beans, peas, buckwheat, chickpea, fodder rape, marigold, mustard, Phacelia, radish, niger, red clover, turnip, white clover, white mustard and oilseed rape. In faba beans, peas, lupins, Phaseolus beans, peas, and brassicas, *S. sclerotiorum* can cause significant damage, and overwinters as sclerotia in soils for several years, which germinate when temperature is between 20 and 25°C and canopy humidity or wetness is high for a period.

Sclerotinia trifoliorum is hosted by winter faba bean, clover, lucerne, Phaseolus beans, berseem clover, crimson clover, reversed clover, red clover, vetch, and white clover. All of these species display moderate to high levels of damage when infected, and multiplication of the disease is by formation of sclerotia which survive in soils for several years.

Sclerotinia spp. in peas and beans leads to stem and pod rot and may be controlled by effective use of appropriate fungicides.

Viruses

Viruses in peas and beans can lead to significant yield and quality losses. The main viruses considered risks in terms of other legumes in the rotation are listed below:

Bean leaf roll virus (BLRV, persistent, potentially 50-90% yield loss recorded), also known as Pea leaf roll virus, causes stunting, chlorosis of upper leaves and leaf roll. The virus causes a disease known as 'Pea top yellows virus'. BLRV is persistently transmitted by *Acyrtosiphon pisum* (pea aphid), and *Myzus persicae* (peach-potato aphid) but is not transmitted by seed. BLRV is hosted by many legumes including faba beans, peas, lucerne, red clover, sainfoin, and white clover. Lucerne is probably the main overwintering source of

BLRV in areas where lucerne is common, but elsewhere red and white clovers are probably as important.

Bean yellow mosaic virus (BYMV, non-persistent, (seed-borne)) also known as Pea common mosaic virus and Pea mosaic causes a mild mottle and vein chlorosis in peas and can cause necrosis in the stem. BYMV is non-persistently transmitted by many aphids including *A. pisum*, *M. persicae* and *Aphis fabae* (black bean aphid). BYMV can be transmitted by seed, but this is uncommon. The host range of BYMV is wide and not limited to Fabaceae. Legume crop hosts include chickpeas, faba beans, peas, lentils, and lupins. Other legume hosts include lathyrus, lucerne, vetch, medic and clover species.

Broad bean true mosaic virus (BBTMV, up to 40% yield loss) causes chlorosis, leaf distortion, vein clearing and necrosis of the stem leading to stunting. BBTMV is transmitted by weevils *Sitona lineatus* (pea and bean weevil) and *Apion vorax* (clover seed weevil). BBTMV is seed-borne in field bean.

Pea enation mosaic virus (PEMV, persistent, potentially 30-50% yield loss) causes distortion of leaves, pods and stem, vein clearing, mottling and stunting of the plant. PEMV also causes proliferations on the underside of leaves, called enations. PEMV is transmitted by aphids in a circulative, persistent manner by *A. pisum*, *Macrosiphum euphorbiae* (potato aphid) and *M. persicae*. Hosts include peas, lucerne, faba beans and vetches.

Pea early-browning virus (PEBV, persistent) causes necrosis and staining of leaves, stem and pods and causes the seed coat to be wrinkled and green or grey in colour. PEBV is transmitted by seed and nematodes *Trichodorus anemones*, *T. primitivus* and *T. viruliferous* (stubby root nematodes). Hosts include peas, lupins, black medic, lucerne, Phaseolus beans and faba beans.

Pea seed-borne mosaic virus (PSbMV, non-persistent, high yield loss) can cause mosaic, distortion of leaves and pods and stunting of the plant but these symptoms are often subtle and hard to spot in the field. PSbMV can also cause discolouration and necrotic rings on pea seed. PSbMV is primarily spread by seed, and plants grown from infected seed act as a primary source of inoculum. Virus from these infected plants is spread to neighbouring plants by aphid transmission. PSbMV is known to be non-persistently transmitted by many aphids, including *M. euphorbiae*, *M. persicae*, *A. pisum*, and *A. fabae*. Hosts include peas, chickpeas, lentils, shepherds purse and faba beans.

Turnip yellows virus (TuYV, persistent, up to 40% yield loss) is known to be present in the UK and causes high yield loss in oil seed rape. This is the most prevalent virus found in peas at present. Status in field beans in the UK is not known. TuYV has a wide host range, including brassicas (all), radish and legumes (pea, clovers, chickpea, lupin, vetch, faba bean). Shepherds purse, common fumitory, henbit deadnettle, purple deadnettle, wild radish, white mustard, wild mustard, chickweed, dandelion, pennycress, crimson clover (and other clovers), and nettle are wild hosts. Stunting and yellowing have been previously associated with TuYV infection but often there are no symptoms in peas. Despite lack of symptoms, up to 40% yield losses may occur. TuYV is persistently transmitted by aphids (*M. persicae*, *A. pisum*) but is not known to be transmitted by seeds or mechanically.

Some persistent viruses may be managed by careful use of aphicides at the earliest growth stage approved. In pulses (combining peas and field beans), there are no completely effective products available for use before the enclosed bud stage, and therefore virus risk may be greater in years when aphids are invading crops at earlier growth stages. Pyrethroids, while approved at earlier growth stages, may not give complete control of aphids in peas and beans. In some vegetable legumes, it is possible to apply an effective aphicide from the six leaf-pair stage, and therefore virus management may be more effective in these crops. For more information about virus management, please contact PGRO in 01780 782585.

Pests

Bean seed fly larvae damage large seeded species including legumes and are hosted by more than 40 plant species. The flies overwinter as pupae in soils. There is potential for carryover from one legume to the next if there is only a short period between destruction of SFI option and following legume crop in spring and summer. The main damage to pea crops occurs when they are established in late spring from mid-April onwards. Adults invade crops at drilling, laying eggs around the area where seed is planted. Larvae feed on seeds and seedlings shortly after planting, leading to seed and stem tunnelling. In peas, this leads to the development of multiple shoots or plant death, and in green beans plants are not able to compensate for the damage and high levels of plant death may occur. Establishment losses due to this pest may be high, as the adults aggregate in large numbers. Higher levels of damage occur when green weed material or crop debris persists in soils, in soils high in organic matter and when soils are freshly disturbed.

Pea and bean weevil hosts are peas, faba beans, chickpeas, vetch, trefoil, birds foot trefoil, lupins, black medic, lucerne, yellow clover, honey clover, sainfoin, Phaseolus beans, clovers, alsike clover, crimson clover, red clover, white clover, common vetch, and hairy vetch. Pea and bean weevils may transmit broad bean true mosaic virus (BBTMV), as well as causing direct damage by larval feeding in root nodules and adult leaf feeding.

Key aphid species affecting peas and beans and considered a potential risk when SFI options are included in rotations are listed below. Main damage may be caused by direct feeding of large colonies of aphids, transmission of viruses and encouragement of disease infection where honeydew residues remain on plant tissue.

Pea aphid (*Acyrtosiphon pisum*) plant hosts are peas, faba beans, milk vetch, Shepherds purse, chickpea, vetchling, lentil, trefoils, birds foot trefoil, lupins, medic, lucerne, yellow clover, sainfoin, nightshade, clovers, vetch, and faba beans. Peas, beans, clovers and lucerne are major hosts. Main damage is caused by virus transmission prior to flowering, as well as direct feeding and disease infection. Pea aphids overwinter as adults or eggs in wild legume hosts such as clovers, vetches and lucerne, and there is potential for survival in cover crops and long-term legume leys. Some of these other hosts may also host the viruses that are transmitted to peas and beans.

Black bean aphid (*Aphis fabae*) hosts are faba bean, sugarbeet, beetroot, fat hen, thistle, hawthorn and cotoneaster (winter hosts), spindle (winter host), and vetch. The main damage is caused by direct feeding during flowering, as well as increased likelihood of disease infections by chocolate spot in beans due to honeydew residues deposited by large colonies of black bean aphids. Black bean aphids transmit fewer viruses than pea aphids.

Peach potato aphids (*Myzus persicae*) have many wild and crop hosts, including brassicas (all species), lupins, lucerne, Phaseolus beans, peas, meadow grass, wild radish, radish, *Prunus* spp., white clover, vetch, and faba beans. They transmit many viruses including TuYV to host crops, including peas.

Overwintering aphid populations may transmit viruses from known wild and cultivated legume hosts into legume crops.

Nematodes

Nematodes may cause root or stem damage in peas and beans, leading to significant yield losses in some circumstances. The key species of concern are listed below:

Root knot nematodes (*Meloidogyne* spp.) are free-living nematodes, hosted by several crop and wild or cultivated plant species, including oats, carrots, barley, lettuce, Italian ryegrass, lucerne, phacelia, tomato, wheat, and vetch. Moderate to high levels of damage may be seen in peas or beans depending on conditions during the growing season. Damage from root knot nematodes leads to stunting and poor vigour. Root systems become swollen and form galls. The nematodes are found on light, free draining soils and may lead to increased infection with *Pythium* spp. Species include the following and are listed with their crop hosts:

False Columbia root knot nematode (*Meloidogyne fallax*) hosts include peas, berseem clover, Italian and perennial ryegrass, black oat, reverse clover, Phacelia, sorghum, vetch, white clover, and white mustard. High levels of nematode multiplication can be seen from all species apart from peas, sorghum and phacelia. Damage to peas can be significant.

Northern root knot nematode (*Meloidogyne hapla*) hosts include faba beans, Phaseolus beans, peas, berseem clover, reversed clover, phacelia, radish, vetch, white clover, and white mustard. High levels of damage are seen in Phaseolus beans and peas, and moderate to high levels of nematode multiplication are seen from most of the species listed above.

Northern root lesion nematode (*Pratylenchus penetrans*) hosts include faba beans, Phaseolus beans, peas, fodder rape, Italian ryegrass, perennial ryegrass, phacelia, radish, sorghum, vetch, white clover, and white mustard. Peas and beans can be damaged by the nematodes and all species listed lead to high levels of nematode multiplication in soils.

Stem nematodes (*Ditylenchus* spp.)

Ditylenchus gigas is hosted by faba beans as the major host, as well as lentils, vetch, peas, onions, and sterile oats as minor hosts. Severe damage can be caused in faba beans, resulting in stem swelling and discolouration, plant stunting and death, and reduced yields.

Ditylenchus dipsaci hosts include faba bean, Phaseolus beans, peas, Italian ryegrass, perennial ryegrass, red

clover, white clover, oats, lucerne, alliums and brassicas. *D. dipsaci* was previously known as the 'oat-onion' race, and has a wide plant host range, including peas and beans. Damage caused by this pest is often less serious than that caused by *D. gigas*, and the pest is reported to be less common than *D. gigas*.

D. gigas and *D. dipsaci* are free-living nematodes, seed-borne as well as soil-borne, and remain in soils for up to ten years. Management to reduce the risk of infestation in fields includes seed testing to ensure that seed does not contain nematodes, good sanitation of machinery and prevention of soil movement between fields, and destruction of bean straw where nematodes are known to be present. Damage tends to be greater when wet weather occurs during late spring and early summer in the UK, leading to higher numbers of nematodes in topsoil and more movement through soil water. When present, a period of ten years between host crops is required to reduce populations to an acceptable level.

Stubby root nematodes (*Paratrichodorus pachydermus/ similis/ Trichodorus primitivus/ similis*) are free-living nematodes, hosted by faba beans, Phaseolus beans, peas, Italian ryegrass, perennial ryegrass, phacelia, and radish. Effects in peas and beans may be clearer during the summer when crops begin flowering. Damage from stubby root nematodes leads to bushy root systems and proliferation of secondary roots, especially on sandy soils following a wet spring, and this can cause significant yield loss in areas of the field.

2. Choices for pulse rotations

Choice of SFI options and plant species selection, when accounting for legume cropping options, should be carefully considered. The risk of any of the pests and diseases described here will depend on weather during the season, timing of movement of pest species into crops, soil health (particularly in relation to soil-borne disease) and management of the crop. In addition, options such as flowering field margins that provide conditions that encourage natural pest predators, can help to reduce the incidence of pests in legume crops. Risks are likely to be greater when whole-field or part-field options are situated in areas intended for cropping legumes, and especially when peas and beans are included in non-crop legume mixtures. For further information contact PGRO on 01780 782585 or go to the Pulse Agronomy Guide at www.pgro.org.

Sources of information include the following:

AHDB: <https://ahdb.org.uk/>

Best4Soil Database: A network of practitioners for sharing knowledge on prevention and control of soil borne diseases and pests. <https://www.best4soil.eu/database>

Biddle and Cattlin (2007). Pests, diseases and disorders of peas and beans. Manson Publishing.

CABI/ Plantwise. <https://www.cabi.org/plantwiseplus/impact/plantwise/>

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Details of the SFI actions in the SFI 2023 offer <https://www.gov.uk/government/collections/sustainable-farming-incentive-guidance>

Fox *et al.* (2022). Surveillance of virus diseases in UK Pea Crops. Project Final Report FV459. <https://horticulture.ahdb.org.uk/fv-459-surveillance-of-virus-diseases-in-uk-pea-crops>

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