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Seed Production and Treatment in a Changing Environment

Chaired by A J Biddle

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Preface

There have been major changes in arable and horticultural production over the past few years, with a greater emphasis on the justification of crop protection management and more effective use of good husbandry techniques, both for seed protection and production.

Since the third Symposium on Seed Health and Treatment in 2001, there has been more information available on the technology of seed testing and treatment, the interpretation of results and improvements in seed production to lessen the risks of seed-borne pathogens. There have also been developments with new pesticides, a very desirable aspect in view of the current changes in pesticide registration criteria in the EU.

Production of high-quality seed continues to be the vital foundation for successful cropping. Seed testing remains an essential tool in the selection of high-quality seed. The results of these tests enable decisions to be made on the use of seed and the necessity of seed treatments for reliability of seedling establishment and control of seed-borne pathogens or seedling pests.

New pesticide actives are also in demand as older materials become less effective or environmental pressures or user safety become even more scrutinised. Without the regular developments and introduction of new products, we will be unable to adapt to the changing environment of new pest or disease pressures or national strategies in crop protection and food supply.

Delivery of pesticides to crop or seed has also changed. Formulations and seed treatments are continually being improved to ensure accurate targeting of the pest or disease and to maximise operator safety from seed processing to seed drilling.

The efficacy of new pesticides or treatments is being tested for a wider range of targets and crops, and successful trialling leads to more opportunities for protection, particularly of minor crops. The justification for the use of seed treatments will continue to be an issue, and seed testing and interpretation of results will play an even more important role in the future.

This Symposium Proceedings brings together current knowledge of seed production and protection, and the contents provide an important discussion forum both for current technologies and for those that will still be required in this changing environment.

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Chairman, Symposium Programme Committee
February 2009

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Requirements and demands on seed for peas and beans in the UK

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Summary

Seed for peas and beans is a major cost of crop production, and seed quality is an important issue in reliable plant establishment. The upward trend in farm saving of pulse seed in the UK increases the risk of pests and diseases and the production of high-quality vigorous seed. This paper outlines the main issues pertaining to pea and bean cropping and the requirement for seed of high provenance.

Introduction

Pulse crops in the UK comprise peas for vining or fresh market, peas for combining, field beans (*Vicia faba*), and lupins. In total around 200,000 ha are cropped annually. The main crops are field beans with both autumn-sown (winter beans) and spring-sown beans occupying around 70,000 ha each, and peas for combining at around 25,000 ha (Anon., 2008).

Seed for most of the vining peas for freezing or fresh market is imported from seed-producing areas in Eastern Europe or the USA, although a proportion is produced in the UK. Field bean and combining pea seed is almost all produced in the UK. The area had shown a decline over recent years due to low prices and competition from other break crops, but with the very recent increase in nitrogen fertiliser costs, and an increase in the demand for high quality peas and beans for premium markets, the area of combinable pulses is set to increase for 2009 and beyond.

Seed quality

A specific requirement for vining pea seed is its reliability in establishing a satisfactory population when sown early in the spring, when soil is cold and the likelihood of rain is high. The ability of a seed to survive these conditions is related to the characteristic known as seed vigour. In vining peas, seed vigour is assessed in the laboratory using the electrical conductivity test. This measures leachates from seed that has been immersed in water for 24 h (Anon., 2009a). The vigour is related inversely to the conductivity of the water. In the field, such 'leaky' seeds attract soil-borne pathogens, particularly *Pythium* spp., which infect the damaged areas of the cotyledon associated with the leakage and result in pre-emergence seedling mortality. Damage can be caused to the testa during harvesting and handling of dry seed, and such damage is associated with high conductivity levels in the testa (Biddle, 1981).

Seed health

Seed-borne diseases include the fungal pathogens *Ascochyta* spp. and *Mycosphaerella pinodes*. In peas, both pathogens result in seedling failure or leaf and pod spot disease, which can result in yield or quality loss. Seed testing is still based on the agar plate method of detection (Anon., 2009b) and there are recommended limits of seed-borne infection for seed use. In peas, seed-borne infection can effectively be reduced by the use of fungicidal treatments, which include thiabendazole and fludioxonil. However, control of *Ascochyta fabae* in field bean seed is less reliable than in peas.

Peas are also susceptible to infection by pea seed-borne mosaic virus, which is primarily seed-borne and aphid-transmitted. Infection causes severe stunting of the plants, poor pod set, and blemished or undersized seeds. There is little effective control of the virus during crop growth, so it has become important to use only healthy seed stocks in the multiplication process. Vining peas have been the most commonly infected pea crop in the UK over recent years, and a seed test based on ELISA was developed for use on soaked seed by PGRO and Rothamsted Research. This test has been in use for several years, and enables a rapid method of screening seed with potentially damaging levels of virus. An international method for pea seed-borne mosaic virus, also based on ELISA, has recently been published in the ISTA *International Rules for Seed Testing* (Anon., 2009c).

Pea bacterial blight (*Pseudomonas syringae* pv. *pisi*) has been a problem for peas over some years. In the UK, all peas are spring-sown and the risk of losses by this disease is generally of no significance (Roberts *et al*., 1995). However, in countries where autumn sowing is practised the disease can result in widespread yield loss, particularly where frosts occur in late spring when the crops are at the early flowering stage. A seed test has been available for some years to detect the presence or absence of blight in a seed sample.

Vicia beans are very susceptible to infestation by stem nematode (*Ditylenchus dipsaci*). Of the two races observed in the UK, the giant race seems to be the one that is most frequently found in field beans and causes the most damage. Typical symptoms of infestation are seen after emergence when the plants are stunted, stems twisted and swollen and foliage is discoloured and distorted. Nematodes are free-living in soil and in wet conditions move to plants, where they enter the stem tissue and begin to multiply. After moving within the tissues, the nematodes congregate under the testa of developing seed, where they can then dehydrate during seed maturation. When infested seed is planted, the nematodes rehydrate and move to surrounding plants. Residues of nematodes then remain in the soil for up to 10 years in the absence of a host crop.

Farm-saved seed of beans is commonly used in the UK, and this has further increased the risk of damaging nematode populations on farm. Seed testing has now become an essential part of bean growing in the UK. Although the test is not part of the Certification Standards, voluntary testing is the norm and seed laboratories have established a standardised procedure for nematode detection. In the UK, a high proportion of seeds of both winter and spring bean varieties can carry nematodes. Growers are recommended not to plant seed with any nematodes detected in the sample, but despite this the pest remains a major problem for seed production Data from the PGRO seed laboratory for the past 2 years show the proportion of infested seed to be high (Table 1).

Table 1 Proportion of bean samples tested at PGRO infested by stem nematode

Harvest year	Winter beans		Spring beans	
	Total tested	**% infested**	**Total tested**	**% infested**
2007	123	17.3	98	16.3
2008	203	22.2	128	22.7

Seed treatments

Although not seed-borne, downy mildew caused by *Peronospora viciae* is a problem in peas, and in some years also with field beans. There are robust differences in susceptibility of peas and beans to infection, but where susceptible varieties are grown in fields with a history of downy mildew, seedlings are infected from a soil-borne source of inoculum. Oospores of *P. viciae* can survive in soil for many years. The principal means of protection of peas is with fungicidal seed treatments. In the UK, the mixture of cymoxanil, metalaxyl-M and fludioxonil is used extensively, although some seed may be treated with fosetyl aluminium as an alternative. Most vining peas are susceptible to mildew, and seed is treated as a routine. Most combining peas are more tolerant, and only susceptible varieties are treated. Information on varietal susceptibility is published annually in the PGRO *Recommended List of Varieties of Field Peas* (Anon., 2009d).

Choice of seed treatment therefore relies on a number of factors. Firstly, because downy mildew is a difficult disease to control and in peas there is no foliar treatment available, the decision to use the more expensive multipurpose treatment is the primary consideration. Secondly, the level of seed-borne *Ascochyta* is the next consideration, and whether thiabendazole is required. Finally, most peas are treated with a standard protectant such as thiram, but this is only to control *Pythium* infection.

For Vicia beans a similar decision is made, although downy mildew can be controlled effectively by foliar sprays, and seed-borne *A. fabae* is not common. Beans rarely need protection from *Pythium* and therefore most are sown untreated.

Conclusions

Pulse seed is the most expensive input into growing costs, and in order to achieve the optimum plant population for each type, making the most effective use of seed is important. Increasing pressure on growing costs has meant that a large proportion of seed is farm-saved, so it is important for growers to recognise the risks involved if seed is not adequately tested for pests or pathogens and the correct choice of seed treatment made. For seed producers, pests and diseases are important, but so too are the harvesting, handling and processing of seed to ensure the highest seed quality.

Seed treatments remain an important part of successful cropping, and changes in the availability of active ingredients will require continuing development of suitable products for peas and beans.

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Reducing risks in a changing environment for UK potato production

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Introduction

Since the last BCPC seed treatment conference in 2001, pressures on seed potato producers to improve quality and health have continued to increase. Although certification standards for seed tubers have changed little in the intervening period, demands by purchasers for tolerances higher than certification have meant that greater attention to detail is required. However, despite rising input costs, the price of seed potatoes has not risen sufficiently, especially for free market varieties, and profitability of seed production has often been marginal. In consequence, the numbers of seed producers has continued to fall and the area grown reduced (Table 1).

The spectrum of diseases challenging seed production in the UK has not changed, although *Phoma foveata* (gangrene) and *Helminthosporium solani* (silver scurf) appear to have reduced in significance. Conversely, *Colletotrichum coccodes* (black dot) and *Pythium* spp. (watery wound rot) have increased in significance.

Another changing factor has been the range of seed treatment options. Whilst seed tuber treatments for control of *Rhizoctonia solani* (black scurf) have increased, those available for other tuber pathogens have decreased to just two active ingredients, imazalil and thiabendazole. Approval for the use of 2-aminobutane (2AB) ceased in December 2007. As the most effective treatment for the control of *Polyscytalum pustulans* (skin spot) and *P. foveata*, there is potential for a substantial increase in the first of these two diseases. The impact of the loss of 2-aminobutane has yet to be realized. There has been a dearth of new seed tuber treatments for control of tuber diseases and, currently, there are no effective seed treatments for *C. coccodes* or *Pythium* spp.

The only other tuber diseases that remain major threats are dry rot caused by a range of Fusarium spp. (most notably *F. caeruleum*, *F. sambucinum, F. culmorum* and *F. avenaceum;* Peters *et al.*, 2008) and bacterial soft rots (*Pectobacterium* spp.), the latter of which cannot be controlled by tuber seed treatment.

Table 1 Numbers of registered producers (seed and ware) and area of seed production in Scotland in 2001 and 2008 (Source: Potato Council Ltd)

	2001	**2008**
No. registered seed producers	673	492
Area of seed production (ha)	12,485	11,145

Table 2 Fungicide use on seed potatoes in Scotland, from Pesticide Usage in Scotland Surveys (tonnes potatoes treated) (Snowdon, 2003; Struthers, 2005, 2007)

Fungicide	2002	2004	2006
imazalil	169,808	119,917	145,886
thiabendazole	–	9,581	800
2-aminobutane*	12,372	3,655	2,353

*Use of 2-aminobutane ceased at the end of 2007.

Whilst seed tuber treatments continue to remain a major plank in seed tuber disease control (Table 2), an increased focus on non-chemical control measures has helped to improve seed tuber health. These measures include earlier harvesting, rapid drying after harvest using positive ventilation and improved store hygiene.

Seed tuber treatment

Apart from dust treatments applied at planting, primarily for the control of *Rhizoctonia solani*, treatment for seed diseases has relied on either hydraulic nozzles or spinning discs to deliver a spray to tubers for more than two decades. Thus, technology for seed tuber treatment has changed little over a period when quality and health demands have increased. Whilst some seed producers treat tubers on the harvester or at loading into store, this early timing of application has not been widely adopted because pickers on a harvester may receive exposure to fungicide treatment, especially in windy weather and most seed is harvested direct into boxes and not subsequently available for treatment when loading into store. Early seed tuber treatment is effective at limiting disease spread in store and to the daughter crop.

Most seed tuber treatment occurs at grading and is aimed primarily at reducing disease spread to the daughter crop. However, because treatment is made just prior to bagging or boxing tubers, there is a desire to limit wetting of tubers and thus the risk of bacterial soft rot or blackleg development. This is particularly important when seed tubers are bagged into 1 or 1.25 tonne polypropylene bags in which air movement is limited. A spray application dose of no more than 1.5 l fungicide solution/tonne and preferably two thirds or half this amount is favoured by producers. In addition to the difficulties of spraying tubers evenly, this low water volume can lead to low tuber residues (Figure 1).

In the series of trials shown in Fig. 1, carried out between Agricultural Scientific Services (now SASA) and SAC in the early 1980's, residues were frequently only 25% of target. Although the data is over 20 years old, it remains relevant today as the application systems have not changed.

Spray application of fungicides to seed tubers is made at a time when seed potato growers are at their busiest grading potatoes. There can be frequent changes of seed stock as orders are often made for relatively small quantities of seed. With frequently changing seed stocks, requests for different seed fractions and different speeds of grading (depending on the condition of the

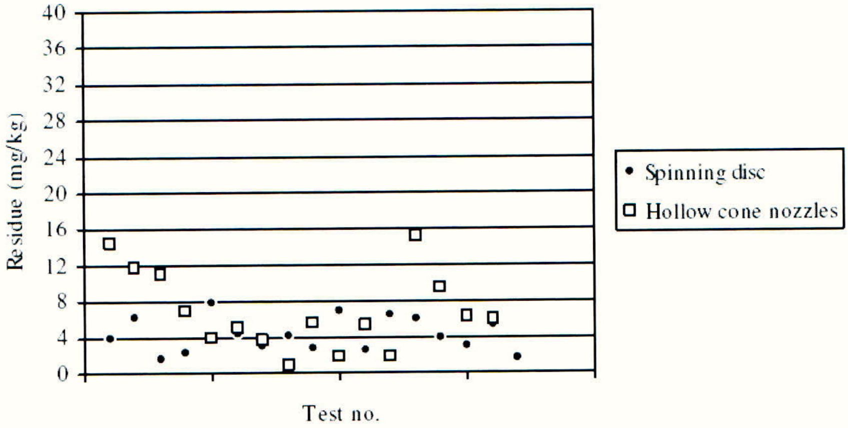

Figure 1 Residues of thiabendazole on seed tubers after application using a spinning disc or hydraulic applicator onto 17 separate tuber lots. Target residue is 40 mg thiabendazole /kg tuber.

stock and the need for more or less picking off), there is a constant requirement to re-calibrate fungicide applications. It is unsurprising that frequent re-calibration does not occur.

In order to achieve optimum control of seed tuber diseases, complete coverage of the tuber surface with fungicide is required. However, even when a water volume of 2 l spray solution per tonne seed is used under good experimental conditions, complete coverage is rarely achieved (Table 3).

Tubers require to be rotating when passing under the spray mist but tubers align themselves along their longest axis on a roller table and, as the data in Table 3 shows, it can be difficult to effectively cover the rose or stolon ends. Tuber dipping would effectively treat all parts of the tuber but the risks of bacterial soft rotting and blackleg are considered so great that this option is not practiced. However, with improved drying methods dipping should be re-examined as an option.

There is an urgent need to identify more consistent ways to apply fungicide spray solutions to tubers.

Table 3 Tuber surface (%) treated with fungicide using hydraulic spray equipment applying 2 l/t spray solution on different parts of potato tubers (SAC data)

	% deposit	**% without deposit**
Middle section	62	38
Rose end	22	78
Average	42	58

Reducing potato disease risks in the changing environment

The conflicting demands of improving tuber health whilst achieving profitability along with the difficulty of applying seed tuber treatments has meant that reliance on seed tuber treatments has lessened (Table 2). Greater attention has been placed by seed companies and seed producers on non-chemical control methods.

In contrast to pre-pack or processing growers, pressure has not been placed on seed producers to limit pesticide use during multiplication. However, a general public pressure to reduce pesticide use has applied further leverage to persuade growers to reduce application of seed treatments.

Maintaining seed in as healthy a condition as possible during multiplication by utilising non-chemical methods will limit the need for seed treatment use. However, even where every effort is made to limit disease development using non-chemical methods, there are constant threats of disease ingress from soil and from cross contamination in store. The strategic use of seed treatments is an important element of disease control. Thus the way to cope with potato disease risks in a changing environment is to provide attention to detail and apply seed treatments strategically within a programme of non-chemical control

In targeting seed tuber treatments, seed growers and those who plant seed require to check seed health during multiplication. Even low levels of some pathogens can be important in some circumstances, where they have a potential to increase from low to high levels.

In the future, diagnostic tuber tests using DNA technology may become available to aid detection and pre-symptom development of pathogens. It is potentially possible to quantitatively determine the level of infection by pathogens on a sample of tubers from a stock at low levels and before symptom expression. Such a test is already under development for early detection of *P. pustulans*, a pathogen with a long latent period. Such technology for accurate detection is likely to be adopted for pathogens which are difficult to identify or detect.

The factors that influence decision making on seed treatment are many, and not always based on objectivity. The factors are listed in Table 4.

Normally, justifications for seed tuber treatment are based on variety disease susceptibility and the level of disease present. However, various other factors can influence risk of disease development such as date of harvest, presence of disease on seed from which the crop was grown, an historic problem of disease on the farm, a late harvest, the level of soil contamination, whether previous seed tuber treatments had been applied to either the mother seed or at an earlier stage to the daughter crop and extent of mechanical damage. In addition, there are marketing factors which can influence a decision to apply a seed treatment such as cost, the ultimate market for the crop and the value of the crop.

Apart from these key factors, the decision making process may also take into account other field factors and storage factors (Table 4). Less rational or less objective arguments for using a seed treatment include a desire to guarantee consistency of seed production, a requirement to treat routinely either because of a market or protocol requirement or because of pride or the desire to have reassurance or insurance that losses will not occur.

Integrating these factors into a decision tree is difficult but two sets of guidelines have been published (Wale, 1997; Wale, undated) in which a logical process is attempted.