

Is rapeseed really an allergenic plant? Popular myths versus scientific realities

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Brassica oilseed crops, such as turnip rape and Indian mustard, have been grown extensively by human societies for at least 4000 years¹. Following a vastly increased demand for edible vegetable oils since the 1960s, the cultivation of rapeseed (*Brassica napus*) has increased dramatically and it now ranks as the most commonly grown oilseed crop in Europe. Within the UK, the area of rapeseed cultivation has been extended more than 60-fold since the early 1970s to reach a current total of about 500 000 ha (Ref. 2). This represents almost 10% of the total crop area and, in view of climatic and rotational requirements, it is unlikely that rapeseed acreages will expand dramatically beyond this value. Rapeseed is a particularly conspicuous part of the rural landscape during its flowering season in May. The crop produces bright yellow flowers and has a characteristic *Brassica* odour due to the release of volatile organic compounds (VOCs).

Coincidental with the expansion of rapeseed cultivation, there have been increases in the number of reported cases of asthma and other conditions related to allergenicity and irritancy. This has led to the creation of a powerful popular perception that rapeseed cultivation is linked to increasing allergic symptoms, particularly among populations in the vicinity of the crop³. Although this perception is supported by little scientific evidence, it continues to be received wisdom in both the popular and scientific press. The purpose of this article is to examine the results of the latest scientific studies showing that there is no clear evidence that rapeseed has adverse effects on human health.

Increased incidence of asthma

The past 30 years have witnessed dramatic increases worldwide in the incidence of symptoms of hayfever and allergic asthma – from 10% to ~25% of adults and to even higher levels in children^{4–6}. Over the past 20 years, the incidence of asthma reported in the UK by general practitioners has increased more than fivefold⁷. Asthma and atopic allergies are highly complex conditions that involve interactive genetic networks plus a plethora of triggers that can be biotic, abiotic or even psychological. Recent genetic studies have shown that four regions on four different human chromosomes contain genes implicated in asthma and atopic allergy⁸. The diversity of the agents that trigger allergenic and asthmatic attacks and their probable

*Rapeseed (*Brassica napus*) is widely blamed for the increased incidence of allergic symptoms since its cultivation has been expanded considerably in recent years. Here, Denis Murphy examines the evidence for the allergenicity of rapeseed, and particularly its pollen, and concludes that it has only a minimal impact on public health.*

multifactorial origins are underlined by the fact that similar symptoms are found to the same extent both in rural and urban populations^{9,10}. The widespread nature of these conditions argues strongly against a single predominant cause, such as industrial air pollution or high pollen levels¹⁰. In assessing the possible contribution of rapeseed crops to human allergies, it is important to determine whether rapeseed pollen does in fact contain specific allergens and if so whether the pollen can become airborne in sufficient

quantities to have a significant effect on adjacent human populations. It is also important to consider other possible contributory factors that may originate from rapeseed crops, including VOCs, which could possibly act as irritants and might potentiate the action of more-specific allergens.

Rapeseed pollen is not widely dispersed in the environment

Rapeseed and its close relatives within the Brassicaceae produce pollen that is primarily broadcast by insects, such as honeybees, syrphids and bumblebees, to maximize chances of insect pollination. Mature rapeseed pollen grains released at anthesis are shaped like elongated rugby balls and are approximately 45 µm long and 20 µm in diameter (Fig. 1). The pollen grains are covered by a sticky lipoidal substance, termed pollenkitt, tryphine or pollen coat^{7,11}. The pollen coat enables pollen grains to stick together in large clumps and then to become attached to insect pollinators as a mass of pollen grains, rather than individual grains. It is most unlikely that these large pollen clumps could become airborne for any significant period, and the successful cross-pollination of rapeseed fields several kilometres apart demonstrates the efficiency of insect pollinators in effecting pollen dispersal^{12,13}.

The potential for wind-borne dispersal of rapeseed pollen has been examined in several studies. However, in most cases, interpretation of the data has been hampered by relatively poor experimental design and a lack of replicates or controls. Nevertheless, the consensus from these data is that rapeseed pollen forms only a minute fraction of the total atmospheric pollen load, but that it is more abundant during the flowering season and in the vicinity of rapeseed crops^{14–19}. It is likely that the vast majority of the exceptionally sticky rapeseed pollen grains either becomes attached to adjacent parts of the same plant or is carried to other plants by insect vectors. All

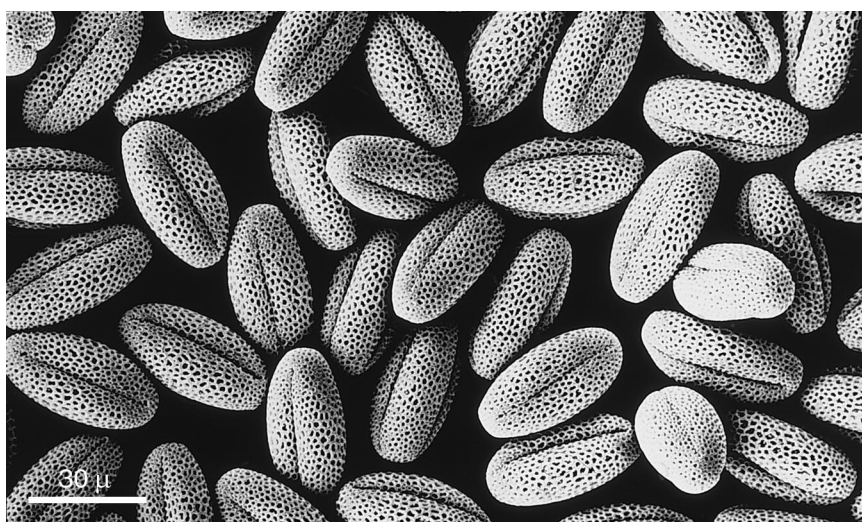


Fig. 1. Scanning electron micrograph of mature pollen grains released from flowers of rapeseed, *Brassica napus*. The pollen grains are coated with a sticky lipoidal substance that causes them to aggregate in clumps and to stick to insect pollinators, hence assisting their dispersal for the purpose of cross-pollination. The micrograph was kindly provided by Kim Findlay, John Innes Centre, Norwich, UK.

commercial cultivars of rapeseed are self-fertile, and the low incidence of outbreeding in the absence of insect pollinators attests to the relative rarity of wind-borne pollen transfer.

Pollen fragments may become dispersed

Although it is unlikely that large amounts of intact, viable rapeseed pollen grains are widely dispersed by the wind, it is quite possible that dead grains or fragments lacking the sticky coating could become airborne. To date, no studies of this possibility in rapeseed have been carried out, although it is a far more likely mechanism for dispersal of allergens than via intact grains. Indeed, it has been shown that grass pollen grains remain viable for only about 1 h after release, and the vast majority of grains in the atmosphere are dead²⁰. In this state, the dead grains will release small, possibly allergenic, molecules from their surfaces; such grains will readily rupture into fine particles upon contact with atmospheric water²¹. Both the free molecules and the fine particles would then disperse efficiently into the atmospheric aerosol. This mechanism is believed to contribute to the greatly increased incidence of asthma immediately after thunderstorms, particularly in the grass pollen season^{22–24}. A recent study²⁵ on daily hospital admissions in England has confirmed moderate rises in asthma cases following thunderstorms, particularly after successive days of high pollen counts, but not on the spectacular scale of some of the previous reports (cited in Ref. 25).

Many grass pollens contain numerous tiny starch granules of 0.5–2.5 μm and these present an ideal vehicle for the dispersal of allergens that adhere to the hydrophobic surface of the granules upon rupturing of the pollen²². However, rapeseed pollen contains very few starch granules¹¹. An alternative hypothetical mechanism for the dispersal of allergen molecules released from ruptured rapeseed pollen grains is via adhesion to other particles, such as other pollen grains or fragments, fungal spores, or even non-biotic particulates such as 'PM10s' (fine particles, less than 10 μm in diameter), which

can arise from vehicle or industrial emissions²⁰. It would be interesting to assess the fate of airborne rapeseed pollen components, their interactions with other atmospheric particulates, and their possible contribution to both atopic and specific allergies.

Sensitization to rapeseed pollen

It is perhaps not surprising that rapeseed pollen, like almost every other biological substance tested, can be allergenic. However, studies on the incidence of sensitization within the general population have given rise to highly conflicting results. One problem undoubtedly lies with the highly sensitive techniques used, such as radioallergoabsorbant tests (RAST) and IgE measurements, which can give rise to both false-positives and false-negatives^{26,27}. In some cases, the

results are difficult to interpret owing to a lack of clarity in reporting. Early studies indicating a high incidence of rapeseed allergenicity^{28–30} have been challenged by more-recent studies showing that such allergies are uncommon, even in areas of intense rapeseed cultivation^{3,16–18,26,31}. Sensitized individuals tend to be atopic and react to a multiplicity of allergens in addition to rapeseed. There is relatively little evidence that individuals become sensitized by rapeseed pollen *per se*, with the possible exception of those individuals who are chronically exposed to flowering plants over an extended period. Examples of the latter include research workers in institutes where rapeseed is grown in glasshouses on a year-round basis¹⁷. Interestingly, there is little evidence that agricultural workers become specifically sensitized by rapeseed pollen during its brief, but visually spectacular, flowering period of three to four weeks³. Moreover, nearly a third of people in country districts report seasonal symptoms, this proportion being the same whether or not they live in a district where rapeseed is being cultivated^{3,18}.

Although rapeseed pollen is by no means a potent allergen, rare individuals have been found who exhibit monosensitization to this pollen¹⁶. Although this study demonstrates that a tiny number of subjects were allergic to specific rapeseed pollen proteins, this is not surprising. Equally rare allergies have been found for many other *Brassica* products that are part of our everyday diet. Examples include an individual who exhibited anaphylaxis upon exposure to cabbage leaves³². Other rare individuals react strongly to mustard paste due to a specific allergy to small proteins of 5–6 kDa and 10 kDa from mustard and rape seeds^{33,34}. These proteins are part of the large family of 2S albumins, which are among the most abundant proteins found in many edible seeds. There are several reports of occupational asthma in workers in animal feedstores resulting from allergies against rapeseed dust³⁵ or flour^{34,36}. One of the most frequently reported *Brassica* pollen allergens is a family of calcium-binding proteins that show considerable sequence similarity to some of the major pollen allergens^{37–41}. These proteins probably constitute

a new class of panallergens in plant pollens in view of their widespread distribution and sequence conservation. In addition, recently it has been reported from Japan that IgE from a single sensitive patient reacted with a *B. rapa* pollen-coat protein of 7.5 kDa, which is part of a large class of lipid-binding proteins found in many plant species⁴².

It can be concluded that rapeseed pollen, in common with some of our most frequently used foodstuffs, such as coleslaw and mustard, can on rare occasions sensitize specific individuals. It is possible that this may occur in a small number of those subject to extensive occupational exposure to the plant¹⁷. However, recent findings demonstrate that the IgEs which react with most rapeseed pollen allergens also crossreact with birch and grass pollen allergens, which are far more prevalent in the atmosphere than rapeseed allergens^{16,26,37,39}. Because patients experiencing allergic symptoms with rapeseed are generally atopic, it is possible that most of the rapeseed allergic pool is a subset of the more extensive pool of patients with grass pollen allergies, who also recognize crossreacting epitopes in rapeseed pollen^{16,37,39,43}.

Role of VOCs

All plants release a range of VOCs, the composition of which can change at different stages of their life cycle. In addition to its prominent colour display, flowering oilseed rape evolves a spectrum of organic volatiles that can serve both to attract beneficial insects and to deter unwanted herbivores⁴⁴⁻⁴⁷. The VOCs are perceived by humans as having a characteristic *Brassica* 'odour'. Because some of the components of the rapeseed volatiles, such as terpenes, aldehydes and organic disulphides can potentially act as irritants, they have been suggested as possible causes or contributory factors in some of the respiratory conditions reported in communities living in the vicinity of cultivated rapeseed. However, it is extremely unlikely that these compounds ever achieve concentrations high enough to cause physiological effects in humans. The concentrations required for this are at least several orders of magnitude greater than those needed for olfactory detection^{48,49}. It should also be noted that the most abundant VOCs produced by flowering rapeseed (i.e. terpenes and aldehydes) are the same as those produced by many other plants. Even the VOCs unique to rapeseed and other *Brassic*as that give the crop its characteristic odour are not restricted to the flowering season⁴⁶. Their odour can be readily detected well after flowering and continues until the crop is harvested. On the basis of the relatively limited clinical studies on the possible effect of VOCs from rapeseed, it can be concluded that there is no direct evidence to suggest that VOCs are responsible for adverse health effects⁵⁰.

Is there a rapeseed hysteria in the UK?

A recent report into the allergenicity and irritancy of rapeseed (Institute for Environmental Health, University of Leicester, UK) concluded that 'currently available data suggests that allergic responses to oilseed rape make very little contribution to the overall burden of allergy in the UK and diagnoses of pollen allergy should be considered in the context of an increasing prevalence of allergy in

developed and developing countries'⁵⁰. The authors of the report further concluded that rapeseed pollen does not contribute greatly to the total pollen load in the environment at the time of rapeseed flowering and that there was no direct evidence suggesting that rapeseed VOCs are implicated in adverse health effects. Despite these conclusions, which were reached after extensive review of research literature, together with a workshop that brought together medical and agricultural experts, there remains a strong perception in the population at large that rapeseed crops contribute directly to allergic conditions and in particular to respiratory problems⁵¹. It is interesting that this extremely negative perception of rapeseed appears to be overwhelmingly concentrated in the UK. For example, in a study of 4468 patients with suspected inhalant allergy in Austria, only four individuals blamed rapeseed for their condition¹⁶. By contrast, a relatively large proportion of individuals with similar symptoms in the UK were inclined to attribute these to rapeseed²⁷. This was particularly true if they lived or worked in the vicinity of rapeseed crops. No similar concerns have been expressed in countries such as France or Germany, despite the fact that each of these countries produces well over twice as much rapeseed as the UK.

Rapeseed has been branded in the UK press as 'the yellow peril'⁵² and has been blamed for disturbing the aesthetic balance of the countryside with its bright yellow flowers. The dramatic expansion in rapeseed acreage in the 1970s and 1980s was largely due to subsidies provided by the European Union and it has been proposed that the anti-rapeseed bias in the UK is linked to prejudice against Brussels' bureaucrats²⁶. In most other European countries, and also in North America and Australia, rapeseed is regarded as a beneficial crop that produces an edible oil with a particularly good nutritional value, second only to that of olive oil⁵³. It will be interesting to carry out rigorous epidemiological studies of matched populations in different rapeseed-producing countries in order to assess the role of psychological factors versus clinically provable factors relating to sensitivity to rapeseed. In the meantime, the admittedly incomplete scientific evidence gives little cause for concern about any possible adverse role of rapeseed in the health of human populations. Although it is important to continue to investigate potential health hazards, we should not unnecessarily stigmatize an important and versatile crop that can provide, not only a nutritious edible oil⁵³, but also a huge spectrum of environmentally friendly, renewable industrial products ranging from lubricants and cosmetics to biodegradable plastics^{54,55}.

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