NONREPRODUCTIVE ROLES OF POLLEN GRAINS

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Pollen grains are the male partners in sexual reproduction of seed plants; their main biological function is to transport male gametes to the vicinity of the female gametes for fertilization; this is familiar to all botanists. Less familiar are their non-reproductive roles which affect humans either directly or indirectly in a number of ways. We cannot avoid pollen grains as they are present in the air we breathe, the water we drink, the food we eat, and the soil on which we walk. Pollen grains represent one of the simplest independent functional units among multicellular organisms and provide an ideal ultra-rapid model system for screening the effects of any chemical or physical agents on a wide range of developmental processes of plants at cellular or organism level. Pollen grains aid in solving legal cases (forensic palynology), in oil exploration and in archeology. They are used in cosmetic industry and are consumed as health food supplements with its world market value of over US $ 520 million in 2019. Recent studies have shown that exine shells of pollen, after removing other components, form an ideal vehicle to deliver vaccines and drugs through oral route. More importantly pollen grains induce great sufferings in humans by causing allergy in over 10 % of the population around the world. Global warming in recent years seems to increase the incidence of pollen allergy. In this article an attempt is made to bring together scattered literature to highlight nonreproductive roles of these tiny microscopic particles.

Pollen grains are the microscopic particles representing male gametophytes of seed plants (Gymnosperms and Angiosperms). They greatly vary in size, shape and surface ornamentation (Fig. 1). Pollen grains are one of the most beautiful objects under the microscope. Although pollen of most of the plants range in size from 15 to 50 µm, some of them may be as small as 5µm, or as large as 200 µm,. Pollen grains are omnipresent -- in the air we breathe, in the food we eat, in the water we drink and in the soil on which we walk; there is no way of avoiding them. Pollen grains of gymnosperms are made up of varying number of cells whereas those of flowering plants are made up of either two or three cells; the former contain a vegetative cell and a generative cell, while the latter contain a vegetative cell and the two male gametes formed by the division of the generative cell. They represent one of the simplest independent functional units amongst multicellular organisms. Being much simpler, the angiosperm pollen grains are more amenable for experimental studies when compared to those of gymnosperms.

Being the male partners of seed plants, their main biological function is limited to the transport the male gametes to the vicinity of female gametes for fertilization. In gymnosperms pollen grains land at the tip of the ovule (pollen chamber) and produce a short pollen tube which grows through a few layers of the nucellar tissue and liberate the male gametes near the archegonia where the female gametes are located. In flowering plants, pollen grains land on the stigma, far away from the site of the female gametes; following their germination, pollen tubes grow through the tissues of the stigma and style, which may often exceed 10 cm, reach the embryo sac (the female gametophyte) and discharge the male gametes for fertilization. Enormous information is available on the structural and functional details of the pollen, particularly of flowering plants, in performing their reproductive function. (Stanley and Linskens 1974, Faegri and van der Pijl 1979, Shivanna and Johri 1985, Shivanna and Sawhney 1997, Shivanna 2003, Willmer 2011, Patiny 2012, Shivanna and Tandon 2014, Pacini and Franchi 2020). Apart from their role in reproduction, pollen grains play important roles in many other areas, which affect humans directly or indirectly. This article briefly brings together widely scattered information on non-reproductive roles of pollen grains.

Use of pollen as a model system to assess the

effects of physical and chemical agents on plant growth and development: Pollen grains provide an ideal ultra-rapid screening system for preliminary screening the effects of any chemical or physical agents on the growth and development of plants at the cellular or organism level. As pollen tubes represent one of the fastest growing cells, they provide ideal system to study biological and biophysical processes associated with cell growth (Michard *et al.* (2009). At cellular level they can be used to study organization and function of cell components such as cytoskeletal elements and associated proteins, and polarity. At the organism level, they form a convenient system to study the effects of pesticides, herbicides and pollutants and any other physical or chemical agents on plant growth and development. Some of the advantages of using pollen grains in these studies are:

- An ample supply of uniform pollen grains can be easily collected.
- Pollen grains can be germinated *in vitro* on a simple nutrient medium. In recent years, pollen of a number of species which were considered to be refractory have been germinated on a medium containing a combination of polyethylene glycol and sucrose in addition to boric acid and calcium (see Shivanna and Rangaswamy 1992, Shivanna and Tandon 2014 for details).
- Pollen germination and pollen tube growth are rapid, and the experiments can be completed within a few hours. Pollen of some species such as *Impatiens balsamina* can germinate within 10 min and scorable tube length is realized in 30 min (Shivanna *et al.* 1974). Pollen of many other species take a few hours at the most to germinate.
- Because the time required for experimentation is limited to a few hours, the experiments can be performed under non-sterile conditions.
- About 70 % of all genes of the plant are transcribed in the pollen (Mascarenhas 1993). Thus pollen can respond for the processes associated with a majority of genes involved in growth and development. Thus any treatment found to inhibit or stimulate pollen germination and tube growth is likely to have

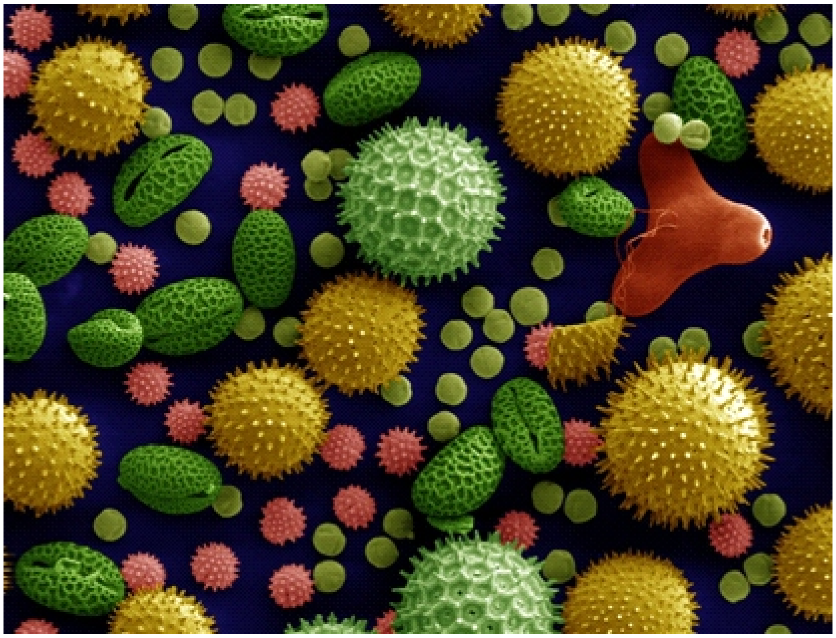

Figure 1: Scanning electron micrograph of pollen grains of a few plants showing variations in size, shape and surface ornamentation (Wikipedia Commons)

similar effect on other processes involved in plant growth and development.

- Pollen grains can be stored for years and thus experiments can be performed throughout the year using the pollen of the same species and of the same batch. Depending on the need, the storage conditions can be manipulated for varying periods. If the storage period needed is limited to a few weeks or months, they can be stored in an air tight vial containing a desiccant such as silica gel (to reduce humidity) and keeping the vial in a refrigerator or a deep freeze. Freeze dried pollen and pollen stored in liquid nitrogen can remain viable for years (for details see Barnabas and Kovacs 1997, Shivanna 2003).

Pollen culture is also an excellent model system to assess toxicity (Kristen 1997). Rapid development of nanotechnology in recent years has resulted in the accumulation of nanoparticles in the environment. Pollen grains are being used to screen the effects of nanoparticles on plants (Speranza *et al.* 2010, Bombin *et al*. 2015). It takes a long time and efforts to study their effects using whole plant system. Recently, pollen grains have been used as ultra-rapid screening tools to screen as many as 1040 bioactive chemical libraries to identify plant growth inhibitors or promotors in *Arabidopsis* and *Nicotiana* (Chuprov-Netochin *et al.* 2016). Based on the preliminary studies on pollen, 65 compounds were selected to compare their responses on seedling root growth. These studies showed that inhibitory or stimulatory effects of the compounds on pollen germination and tube growth reflected similar effects on the growth of seedlings also.

Forensic palynology

Forensic palynology is the science of analyzing pollen and spores as an aid to solve legal cases, both civil and criminal. Most of the literature on forensic palynology is published in forensic journals. It has considerable potential to fight crime (Bryant and Jones 2006, Bryant 2014). Each locality is associated with a pattern of pollen distribution. By carrying out detailed studies, experts can construct 'pollen fingerprints' of specific areas. Because of their small size and static electricity, pollen grains adhere to the surface of objects such as hairs and clothes. They cannot be washed off or removed from the clothes, hairs, foot ware of the criminals or from tools and vehicles used in the crime. Further, even after the vehicles were subjected to post crime arson such as fire, pollen grains can withstand such treatments with intact morphology so that they can be identified (Morgan *et al.* 2014). Such samples can be collected from the forensic materials and match with the pollen pattern of the known locality. Thus forensic palynology helps in confirming/eliminating the presence of the suspect at the scene of the crime. Forensic palynology has been in practice in some countries particularly in New Zealand since 1980s and much later in the United Kingdom and Canada, and to some extent the United States and Australia. It is not being used in many countries because of lack of forensic pollen specialists who have expertise in collection and analyses of pollen samples. There are a number of examples in which forensic palynology has helped to solve crimes of various types (Brown 2006, Mildenhall 2006, Bryant and Jones 2006, Lippi and Mercuri 2009, Green 2015, Ochando *et al.* 2018, Wiltshire 2019), only a few representative cases are presented here.

Solving the case of murder: A man in Brisbane, Australia, killed his wife, took her body in her car to a remote coastal park 50 km away and hid her body under some *Acacia* bushes that were planted to stabilize coastal dunes. One of the *Acacia* was a common native Australian species and the other was imported and planted only in the coastal area to stabilize coastal dunes. He drove back and parked the car at home and washed his clothes thoroughly to remove all traces of evidences of his visit to the coast. After he was identified as a suspect, the police collected his clothing and a forensic palynologist analyzed the pollen. Pollen grains of both the species of *Acacia* were found in the victim's car and the suspect's clothes, in spite of washing. Although the pollen evidence on its own did not prove the suspect was the murderer, it did prove his presence at the site of the crime and helped to convict him of the crime (Milne 2005). There are several other examples in which pollen analysis has been used to identify the murderer (Bryant 2004, Bryant and Jones 2006).

Solving the case of rape: In Christchurch, New Zealand, a young women was forcibly dragged to an alley and raped. Although the suspect was arrested based on the victim's description, he pleaded not guilty. Investigations showed that some shrubs of wormwood (*Artemisia* sp.) were growing in the alley where the crime was committed. The search of the locations near the suspect's home and the places he normally visited did not have this shrub. The dirt-stained cloths of the suspect clearly showed the presence of this pollen thus establishing that the pollen from the dirt of his cloths came from the crime scene. Based on these evidences, the court convicted the suspect (Horrocks *et al.* 1998).

Identifying stolen animals: Animal hairs also form an excellent pollen traps. In New Zealand, 300 sheep were stolen from a ranch located on the South Island. The thief tried to sell them in a livestock auction in the North Island. The auctioneer became suspicious as he knew the seller who had a small ranch in the North Island that could not support so many sheep he was trying to sell and brought it to the notice of the police. The police impounded the sheep and small patches of wool from several sheep were sent to forensic palynologist. The pollen samples from the impounded wool closely matched the pollen print from the original owner's ranch and not of the seller's ranch. The sheep were returned to the original owner and the thief was convicted (Bryant and Mildenhall 1998).

Identifying the location of theft of exported machinery: Some machinery packed in wooden crates were exported from Europe to an Asian country. During the voyage the ship called on many ports where the cargoes were loaded and unloaded. When the wooden crates reached their final destination, the company found that the machinery was stolen from the crates and replaced with sacks of soil. Replacement of machinery with soil could have taken place at any of the ports. Investigations covering all the ports the ship stopped would have been very difficult. Analyses of pollen recovered from the soil showed a geographical association with plants normally found in South Africa. One of the ports the ship stopped was Cape Town in South Africa. Thus pollen analysis enabled the investigators to narrow their search to one port. The missing machinery was later found in a South African warehouse (Bryant and Mildenhall 1998).

Checking the origin of honey: Analysis of pollen grains in honey samples help in distinguishing honey produced locally from those coming from other areas. The US Government used to subsidize the honey produced in the country to protect bee keepers from low-priced imported honey. To tap this subsidy money, many suppliers started selling imported honey as domestically produced honey and claimed the subsidy. The authorities eventually used pollen analysis in honey samples to check the origin of honey and found that 60% of the honey samples used to claim subsidy contained tropical pollen indicating their origin in some Latin American countries and not in USA.

Identifying the country of origin of illegal drugs*:* Samples of drugs are routinely seized in different cities of USA. It becomes important to know the countries from where the drug originated for effective control. Analyses of pollen grains is used regularly to check the origin of the drug samples (Stanley 1992).

Identifying the robber: A man escaped on a motorcycle after robbing a store in New Zealand. He abandoned the motorcycle after he was chased by the police and ran up a muddy hill and escaped. Subsequently a man claimed the abandoned motorcycle as his but declared that it was stolen the previous day. The police recovered a pair of muddy shoes at his place and the suspect claimed that the mud came from a farm he has worked but denied ever visiting the area where the motorcycle was abandoned. Detailed analysis of pollen grains of the soil from the farm where he had worked and from the muddy hill where the vehicle was abandoned revealed that pollen print of the muddy hill matched that of the mud collected from his shoes but not from the farm where he claimed to have worked (Mildenhall D 1990) thus confirming his involvement in the crime.

Fixing the war crimes in Bosnia: Forensic pollen analysis has also made a significant contribution to the investigations of war crimes in Bosnia (Wood 2004). War criminals tried to disguise their act of genocide by exhuming mass graves and reburying the bodies in smaller graves and claiming they were the result of minor battles. Soil samples taken from skeletal cavities, inside the graves and from around the suspected primary and secondary sites were analysed for their pollen samples. The samples of the primary and secondary sites turned out to be similar providing strong proof for the massacre. Pollen evidences strongly supported other evidences and led to the conviction of the persons responsible for the massacre.

Role of pollen analysis in paleobotany and archaeology: Analysis of pollen grains has several advantages in paleobotanical and archaeological studies. Pollen grains are much better preserved as fossils when compared to other plant parts and thus pollen analyses helps in identifying seed plants present through geologic strata and their dates. Studies on pollen of extinct as well as extant taxa have refined our knowledge on the evolution of plant species and their relationships. They have also helped to reconstruct local plant communities in the historical past and their response to changes in the environmental conditions (Faegri and Iversen 1989). It has also been possible to identify the period and the type of cultivation of crop plants in different regions through pollen analysis.

Pollen can also be collected and analysed from pots, tools and clothes used by people of early civilization, and from their faecal matter and other archaeological artefacts. Information obtained from such studies has been used to determine the diets of people, their crops, and the materials they used to build their homes. Pollen analysis has often provided a wealth of data not readily available through other means. Analysis of fossil pollen from the Maya site has revealed widespread cultivation of *Manihot esculentum* and probably *Zea mays* by 2500 BC (Jones 1994). Pollen analysis has also helped in rapid decline of particular plant species and possible reasons for such a decline (Kris 2017). For example, using pollen data it was possible to determine sudden decline of eastern hemlock (*Tsuga canadensis*) in North America over 50-year-period about 5000 years ago. This decline appears to be due to the attack by species-specific pest or by a disease rather than due to climate change.

Analysis of fossil pollen as an aid to oil exploration: Fossil fuels refer to buried organic materials, formed from decayed plant and animal deposits, that have been converted to crude oil, coal or natural gas by exposure to heat and pressure in the earth's crust over millions of years. Pollen grains and spores are well-preserved as intact fossils and analyses of fossil pollen and spores in the geologic past forms an important aid in fossil fuel exploration and exploitation. Apart from precise dating of sediments, palynological studies support basin analysis leading to stratigraphic evolution and prospect for hydrocarbons. Fossilized pollen grains and spores get darker with increased heat and this change in colour can be used to assess the temperature to which a rock sequence was heated after burial. This information can be used to predict whether oil or gas may have formed from the original organic rich deposits in the area of exploration (Hopping 1967, Aswal 2012, Mehrotra 2012). Almost all oil companies have well-established palynology laboratory to aid oil exploration. K.D. Malviya Institute of Petroleum Exploration of Oil and Natural Gas Ltd (under ONGC) at Dehra dun and its regional palynological laboratories have been working on petroleum exploration in India since many decades.

Pollen-based health-food supplements: Commercially available pollen products in health food stores and through on line shopping are generally referred to as bee pollen as they come largely from the pollen brought back by the bees in the form of pollen pellets packed on their hind legs from the flowers they visited. Just 1 g of bee pollen may contain >2 million pollen grains. Apart from basic nutrients, they are rich in lipids, vitamins, amino acids, minerals, enzymes and antioxidants, and low in fat and sodium. It is a powerpack of 18 vitamins including those of B complex and all essential amino acids, Its moisture level is generally <10%. Nutritional quality of pollen surpasses that of any food routinely used by humans (Herbert and Shimamuki 1978).

Bee pollen has gained prominence as a health food supplement (Linskens and Jorde 1997) and its consumption is steadily increasing over the years. Analysis of coprolites recovered from 1400-200 BC indicates that American Indians were consuming pollen grains from prehistoric times (Reinhard *et al.* 1991). Pollen is believed to act as a health restorative and pollen preparations are used as a general tonic. Russians claim that those who live long to reach up to 125 years happen to be bee keepers who consume pollen regularly. Bee pollen is reported to be taken routinely by athletes and also used to feed race horses to enhance their performance (Schmidt and Buchmann 1992). Bee pollen is consumed in the form of tablets or pellets and candy bars (Fig. 2) and enjoys huge market. Bee pollen is recommended as a

Figure 2: Some commercial bee pollen products.

valuable dietary supplement. The world market of bee pollen in 2019 was estimated to be over US $ 520 million and is expected to grow over the next five years to US $ 730 million. The global bee market is largely shared by Asia Pacific 30.14%, Europe 18.43% and North America 17.27% (Anonymous 2019). Major countries producing pollen products are China, USSR, Sweden and USA. Although pollen grains are generally safe for most of the people, it is recommended to avoid bee pollen by those who suffer from pollen allergies, take blood thinners, and also by pregnant and lactating women. It is always better to check with the doctor before taking pollen diet.

Apart from health food supplements, bee pollen has been reported to have a number of therapeutic properties. High amount of antioxidants, which include flavonoids, carotenoids, quercetin, kaempferol and glutathione present in bee pollen have been claimed to give protection from free radicals and chronic diseases. Bee pollen has also been claimed to be effective as anti-inflammatory, anti-carcinogenic, anti-bacterial, fungicidal, hepatoprotective, and anti-atherosclerotic activities capable of modifying or regulating immune functions (Denisow and Denisow-Pietrzyk 2016). Bee pollen plays an important role in ancient Chinese medicine in the treatment of diseases (Xi *et al*. 2018). Although bee pollen components have potential bioactive and therapeutic properties most of these claims are based on animal studies; extensive research using human trials are needed before it can be confirmed for use in human therapies. One of the difficulties in using bee pollen as a phytomedicine is the wide species-specific variation in their composition.

Use of pollen in cosmetic industry: Pollen preparations such as face creams and pollen-mask facials are common. Pollen proteins, carbohydrates, lipids, vitamins and a number of other components are known to promote skin care against a range of skin damaging effects (Xi *et al.* 2018). Bee pollen components are regularly used in preparations aimed to remedy skin aging, skin dryness, ultraviolet B radiation effects, oxidative damage, inflammatory and melanogenesis, which are involved in a wide range of negative effects on human skin. Chinese have been using bee pollen for skin care since ancient times (Xi *et al.* 2018).

Pollen exine shells as vehicles for drug delivery and oral vaccine: In recent years pollen grains and spores have been shown to have potential for use as vehicles to deliver vaccines and drugs through oral route (Gill 2019). Most of the vaccines are presently administered through intramuscular route. Oral vaccination is painless, convenient to administer and child-friendly. Protocols have been standardized to prepare large scale production of hollow shells of exine, free from cytoplasmic components such as proteins and intine from pollen grains and spores retaining only their exine shells (Diego-Taboda 2013, 2014, Fan *et al.* 2018, Gill 2019). Homogeneity of exine shells, their physical and chemical stability to biological degradation and eco-friendly nature make them ideal vehicles to encapsulate and release the desired drugs or vaccines or even nutraceuticals through oral drops. Exine shells are non-toxic and free of allergenic proteins and have been shown to mask the taste of encapsulated material (Diego-Taboda 2013). Their adhesion to the intestinal mucosa may result in extended contact of the shells leading to the delivery with increased efficiency. Oral vaccine delivered through ragweed (*Ambrosia*) pollen shells sustained its immune response for at least 3 months after oral vaccination (Uddin and Gill 2013). So far the studies have been confined to mice and have laid the foundation for developing pollen shell-based oral vaccine to humans. Hopefully they may appear in the market in a few years.

Collection of pollen for commercial purpose: The amount of pollen needed to satisfy the market, particularly as health food supplements and cosmetic industry is considerable. Collection of pollen from individual flowers is not feasible in such a large scale. The manufacturers of pollen products use bees themselves to collect the required amount of pollen (Waller 1980, Benson 1984). The bees after harvesting pollen from thousands of flowers pack them in the form of pellets on their hind legs and return to the hives to store them for their larvae and young ones. The bee keepers place traps at the entrance of the hives which readily allow the bees to get into the hives but the pollen pellets drop into the collection treys placed below the entrance. Collected pollen grains are cleaned and maintained under dry conditions until use.

Pollen Allergy: Allergy is an altered and accelerated reaction of a sensitive person to a second and subsequent exposures to a substrate to which he/she has been sensitized during the first exposure. Pollen allergies have been a major health problem for humans. Allergy is induced when the immune system mistakenly identifies a substance released from pollen and spores of some species, some food items and even some drugs as harmful to the body. Over 10% of human population is allergic to pollen of one or the other species and the number of people affected by pollen allergy is on the increase, particularly in urban and polluted areas. Allergenic proteins are usually located in the pollen wall and pollen cytoplasm, and readily released during rehydration (Knox and Suphioglu 1996). Most of the allergy inducing pollen grains come from wind pollinated species which produce enormous amount pollen to ensure at least a small proportion of them would reach the stigma. Although some insect-pollinated pollen may also cause allergy, chances of them reaching the nose of humans are slim as they are sticky and do not get air borne. Most of the allergenic pollen belong to trees, grasses and weeds.

Allergic pollen grains reach human noses through air currents and induce a chain of reactions in allergic patients. The first exposure results in the releases of species-specific antigens which induce the production of Y shaped immunoglobulin (IgE) antibodies in B cells in sensitive individuals. IgE antibodies circulate in the serum and bind to high-affinity IgE receptors such as mast cells present throughout the body and prominently around blood vessels and nerves, and in the skin, lungs, digestive tract, mouth and nose. The first exposure does not induce any allergic symptoms to the person. Upon subsequent exposure to the same allergen, freshly released antigens cross-link to IgE antibodies bind to the surface of the mast cells; this triggers degranulation of mast cells resulting in the release of histamine, inducing immediate allergic response. Apart from sneezing, wheezing, running or stuffy nose, watery eyes, other common manifestations of allergic responses include cutaneous (acute urticaria, angioedema), respiratory (acute bronchospasm), cardiovascular (tachycardia, hypotension), gastrointestinal (vomiting, diarrhoea), or generalized (anaphylactic shock) reactions. Anaphylaxis is a life-threatening reaction and involves acute respiratory distress, cardiovascular failure, or involvement of two or more organ systems (Siles and Hsieh 2011). Many studies have indicated that a higher proportion of children with allergic rhinitis may eventually develop asthma. Global warming has now become a reality under uncertain mitigation measures. Many studies have shown that it may result in species migration and prolongation of flowering period (see Bellard *et al.* 2012, Pacifici *et al.* 2015, Shivanna 2019 and references there in) extending the period and location of allergenic pollen in the atmosphere. There is hardly any research on aeroallergens in relation to global warming (Bloomberg and Aggarwala 2008, Reid and Gamble 2009). Limited studies available indicate that urbanization, increased vehicle emissions and westernized lifestyle are correlated with an increase in the frequency of pollen-induced respiratory allergy, prevalent in urban population compared to those living in rural areas (D'Amato and Cecchi 2008).

In temperate countries, all tree species flower in the spring. They release massive amount of pollen to the atmosphere. Often the amount of pollen is so large that it results in a yellow haze in the sky. There is escalation of allergic symptoms in the population during this period. More than 150 allergens originating from pollen of grasses, trees and weeds have been identified. Most of the allergens present in the pollen are also essential for performing normal reproductive function of pollen grains (Chen *et al.* 2016). For example profilins, which are the important source of allergy, are needed for assemblage of microfilaments needed for pollen tube growth. Expansins, another source of allergens, are required for loosening the cell wall for pollen tube growth through the tissues of the pistil. Many of the pollen allergens are also involved in stress responses and metabolic processes such as cell wall metabolism during pollen development (Chen *et al.* 2016). Thus, it is not feasible to supress the genes involved in the synthesis of allergens through biotechnological approaches, as such a step would affect reproductive function of pollen grains.

Tests for allergy: Allergy is routinely tested through skin tests. In prick test a drop of potential allergen is placed on the skin and gently scratched. In intradermal test a small amount of allergen is injected just below the skin. In patch test potential allergen is put on a patch and stuck to the skin. Skin tests are generally performed on the inner side of the forearm or the back. In all the skin tests, the skin becomes red and often show swelling in sensitive persons. Apart from clinical history of the patient, skin tests are performed in routine allergy diagnosis. Rapid advances have been made in recent years in developing more refined and rapid tests (Peblos *et al.* 2016). IgE detection test involves measurement of specific IgE in the serum is now available. This is the most commonly used in vitro test for diagnosis. In IgE detection test using crude pollen extract, there is a possibility of other minor or non-allergenic cross-reacting components of the extract impeding proper diagnosis. More than 150 well-characterized and purified allergens from natural sources are now commercially available for diagnosis. Some of the allergens are being produced through recombinant DNA technology also. Allergen micro-assays with purified allergen molecules enable IgE measurement using very small amounts of blood serum. Molecular-based approaches using purified allergens enable distinction between genuine from cross reacting sensitization. This also enables selection of the authentic allergen for immunotherapy. Specific IgE antibodies can be measured by using enzyme-linked immunosorbent assay (ELISA), radioallergosorbent test (RAST) and fluorescent enzyme immunoassay (FEIA).

Treatment of pollen allergy

Avoidance: Avoidance is the best way to prevent allergic attacks. Use of masks, staying in air-conditioned rooms when allergic pollen count in the atmosphere is prevalent or temporarily moving to a place where allergic pollen is absent are some of the methods to avoid allergic pollen. Avoidance is facilitated by the availability of dependable pollen calendars and daily pollen counts. Pollen calendars (Fig. 3), available in most of the cities give information on diurnal, seasonal and annual variations in the pollen types and their counts (concentration in the air) in the cities. Pollen counts are expressed as the number of pollen grains present per m^3 of air sampled, averaged over 24 h. Daily pollen forecasts and current pollen levels are also available on local TV, radio, newspapers and weather websites.

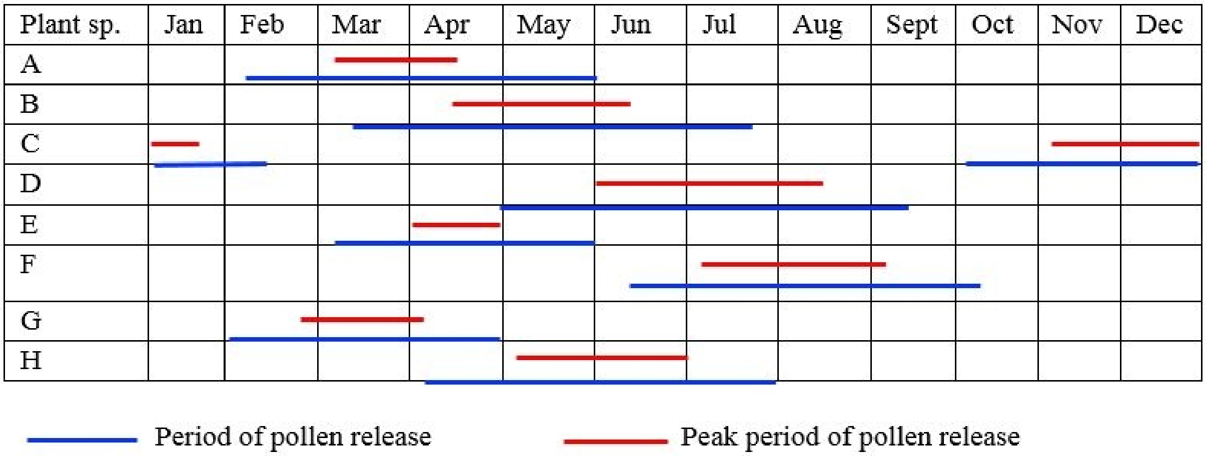

Figure 3. Graphic representation of a pollen calendar. The period of pollen prevalence in the atmosphere shown is arbitrary. Accurate pollen calendars help allergic patients to move, during pollen release period, to a place where allergic pollen is absent.

Apart from helping diagnosis and treatment of patients, these forecasts are very helpful in knowing the prevalence of specific allergic pollen for the patients, and in finding suitable places and periods that are comparatively safer. These days pollen allergy apps, many of them compatible with iPhones and iPads, are also available. They give pollen counts of the day and the forecasts for up to five days. They also provide a diary to record day to day symptoms and relevant notes which may help the physician for better treatment.

Antihistamines: Over the counter antihistamine tablets such as Cetirizine and Claritin can be used to get relief from the attacks. Many of them induce side effects particularly drowsiness. In recent years several antihistamines, which are reported to be free from drowsiness, are available. Allergy tablets that are administered under the tongue (sublingual immunotherapy) and allergy drops are also available.

Immunotherapy (allergy shots): In this treatment, the allergen is injected periodically at increasingly larger doses until the body builds up the production of excessive amounts of antibodies (Wu 2012). Excessive amount of antibodies produced in the serum as the result of immunotherapy probably block the antigens released from allergic pollen before they cross-link to the antibodies bind to the surface of the mast cells, thus preventing the release of histamine and resulting allergic reaction. The immunotherapy generally extends for 2-3 years and its benefits persist long after the discontinuation of the treatment and it can also prevent the development of new sensitivities and asthma. Availability of authentic allergens is of vital importance for immunotherapy.

Concluding remarks

Pollen grains, though microscopic made up of only a few cells representing male partners in sexual reproduction of seed plants, have much wider ramifications for humans. The market for use of bee pollen as health food supplement is growing steadily. The potential of forensic palynology is underutilized largely because of the limitation of expertise needed for pollen analyses. The application of non-reproductive role of pollen grains no doubt would grow steadily in the coming years. Although there is ample scope for commercial exploitation of pollen products in India, there is hardly any progress being made in this direction. The most important negative effect of pollen on humans is their role in causing allergy in considerable proportion of the population. The details of allergenicity in relation to climate change is yet to be explored. Pollen allergy is one of the active areas of research and a number of additional avenues are being opened up for effective diagnosis and treatment of those unfortunate persons who are allergic to pollen of one or the other species.

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