

Possible Effects of Cultivated Plants in the Development of Allergy in Population of Sindh, Pakistan

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Summary: Among the various biological particles, pollen grains and fungal spores stand as the two major factors that can cause asthma and allergic rhinitis. Pollen grains can be released by the domestic plants cultivated in and around as ornamentals, on road verges and parklands etc. However, those plants are considered allergenic which are wind pollinated, called anemophilous, and very less attention is paid pollen sensitivity of cultivated plants. The purpose of this publication is to explain the types of flowering plants cultivated in Sindh, their flowering periods and the possibility of their pollen grains to induce IgE mediated hypersensitive reaction in people living in the selected geographical region. In this survey, we have taken into consideration 60 species of plants that are being cultivated in the province of Sindh. These species are divided into two major groups: the first group includes allergenic pollen producing species, while the second group included 38 species that are known to be non-allergenic. Our results show that most of the abundantly cultivated plants may be considered as secondary potential allergens and/or occupational or cross-reacting allergens.

Introduction

In the last few decades, the prevalence of pollen-related allergies, asthma and allergic rhinitis, has increased worldwide. Many reasons have been suggested for this phenomenon such as air pollution, infections and other environmental factors [1]. Without any doubt, an increase in pollution and the amount of allergens in the air are important factors that can cause respiratory allergies. When we talk about the pollen-allergens, we also have to consider the timings of the pollen grains availability and distribution in the area which requires close monitoring of seasonal frequencies [2]. Biochemical composition of these pollen generally remains the same in both anemophilous and cultivated plants but because of their exposure possibility, the former is given priority in research and disease management.

The allergenic content of the atmosphere, along with the physical environment, climate and vegetation varies considerably from region to region. Changes in the climate have a great impact on the flowering of regional flora. Environmental conditions are expected to modify the load and distribution pattern of pollen grains [3]. It is even possible to make an allergy calendar by using the details about the approximate flowering periods. In this manner,

even though the yearly pollen production and dispersal depends on the weather conditions prevailing at the time of anthesis, it is usually possible to forecast the chances of encountering high atmospheric allergenic pollen concentrations in different areas. It is also a well established fact that all the dominant airborne pollen types do not contribute equally to the aeroallergen burden. In fact, some pollen grains, which are found in lower concentrations, may be significant from an allergy point of view [4]. In this regard, aerobiological and allergological studies undertaken in the province of Sindh by using Burkard's 7-Day Volumetric Spore Trap, are being summarized as a separate communication. There is a lack of published data regarding the evaluation of plants that are widely distributed in the areas of Sindh, Pakistan. Cultivated plants are not considered to be a potent source of allergenic pollen producers, because most of them have beautifully colored flowers and are insect pollinated. An important point to be stressed over here is that, along with the exposure to normal airborne biological particles, human beings also come in contact with the pollen grains of urban cultivated plants. There are numerous reports of cross reactivity of different pollen grains [5], since those people who

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have a hypersensitive immune system can be sensitive to a number of pollens belonging to various plants (poly-sensitization). Another important fact is that the pollen grains of numerous plants growing in public places may sensitize or elicit a hypersensitive reaction by a short term rise in the pollen concentration. To understand the pollen grains airborne activities, an allergens calendar may become helpful in predicting the upcoming pollens types, as well as their concentrations. Hence the main purpose of the present work was to emphasize the potential role of cultivated plants and to generate awareness among general public on the issue regarding allergies to cultivated plants. It is hoped that the findings of

this study will help individuals in selecting less harmful and low allergenic plants for their houses, lawns, or gardens, since avoidance stands as the vital key to getting relief from the effects of allergies.

Results and Discussion

The list of plants along with their families, common names, flowering period and references of those papers that have published hypersensitivity to these particular types of pollen grain has been summarized in Table-1. Tables-2a and 2b present those plants that are not known as yet to be allergenic species, but have been observed to release pollens in the air.

Table-1: Plant pollen types found in air with known sensitivity.

Family	Genus	Species	Common name	Flowering Period	References
Aceraceae	<i>Acer</i>	<i>campestre</i>	Field Maple	Apr-May	[1,5,18,32]
Arecaceae	<i>Areca</i>	<i>catechu</i>	Betel palm	Oct, Dec-Jan	[8,17,26,34]
	<i>Cocos</i>	<i>nucifera</i>	Coconut palm	All year	[2,4,8,17,24,26,29,33]
	<i>Phoenix</i>	<i>dactylifera</i>	Date palm	Mar-May	[6,8,11,13,18,34-36]
Apocynaceae	<i>Catharanthus</i>	<i>roseus</i>	Periwinkle plant	All year	[37,38]
Casuarinaceae	<i>Casuarina</i>	<i>equisetifolia</i>	Australian pine	Dec-Mar	[1,2,8,16-18,26,33,38-40]
Cariaceae	<i>Carica</i>	<i>papaya</i>	Papaya	All year	[14,26,40-42]
Cupraceae	<i>Thuja</i>	<i>orientalis</i>	Thuja	Mar-Apr	[1,27]
Euphorbiaceae	<i>Croton</i>	<i>bonplandianum</i>	Ban Tulsī	Jan.-Dec.	[19,26]
	<i>Ricinus</i>	<i>communis</i>	castor oil plant,	Oct-June	[2,8,11,17-19,26,29,43-45]
Leguminosae	<i>Acacia</i>	Spp.	Gum Arabic	Aug-Dec	[14,18]
	<i>Albizia</i>	<i>julibrissin</i>	Persian Silk Tree	May-Jun	[18]
	<i>Albizia</i>	<i>lebeck</i>	Siris Tree	Apr-May	[8,18,37]
	<i>Delonix</i>	<i>regia</i>	Gul Mohar	Apr-Sep	[14,19,37,46,47]
	<i>Robinia</i>	<i>pseudo-acacia</i>	False acacia	Mar-Apr	[1,28,48,49]
	<i>Tamarix</i>	spp.	Cedar, Tamarisk	Apr-Jun	[1,18]
Meliaceae	<i>Azadirachta</i>	<i>indica</i>	Neem tree	Apr-May	[2,4,8,17-19,26,36]
Myrtaceae	<i>Eucalyptus</i>	<i>globulus</i>	Safaida	Dec-May	[1,14,29,46]
Moraceae	<i>Ficus</i>	<i>benjamina</i>	Banyan tree	Oct-Jan	[39,50,51]
	<i>Morus</i>	<i>alba</i>	White mulberry	Mar-May	[1,15,18]
Plantaginaceae	<i>Plantago</i>	<i>major</i>	Common Plantain	Aug.-Sept	[14,18]
Poaceae	<i>Cynodon</i>	<i>dactylon</i>	Bermuda grass	Feb-Apr	[8-19]
	<i>Hordeum</i>	<i>vulgare</i>	Barley	Jun-Aug	[7,18]
	<i>Pennisetum</i>	<i>glaucum</i>	Pearl millet	Sep-Oct	[52]
	<i>Saccharum</i>	<i>officinarum</i>	Sugar cane	Jan-Mar	[18,26]
	<i>Sorghum</i>	<i>vulgare</i>	Jowar	Aug-Nov	[18,53]
	<i>Triticum</i>	<i>aestivum</i>	Wheat	Jun-Aug	[7,18]
	<i>Zea</i>	<i>mays</i>	Corn	Jun-Sep	[7,18,54]

Table-2(a): plants with no reports of pollen grains.

Family	Genus	Species	Common name	Flowering period
Annonaceae	<i>Polyalthia</i>	<i>longifolia</i>	Indian fir, Mast Tree	Mar-Apr
Apocynaceae	<i>Thevetia</i>	<i>peruviana</i>	Yellow Oleander	All year
Araucariaceae	<i>Araucaria</i>	<i>cunninghamii</i>	Hoop pine	Nov-Feb
Arecaceae	<i>Oreodoxa</i>	<i>regia</i>	Royal Palm	Spring
Bignoniaceae	<i>Kigelia</i>	<i>africana</i>	Sausage tree	May-Aug
Leguminosae	<i>Adenanthera</i>	<i>pavonina</i>	Red sandalwood	Mar-May
	<i>Bauhinia</i>	<i>purpurea</i>	Purple Orchid Tree	Sep-Nov
		<i>variegata</i>	Kachnar	Feb.-Apr
	<i>Caesalpinia</i>	<i>pulcherrima</i>	Peacock Flower	Apr-Sep
	<i>Leucaena</i>	<i>leucocephala</i>	Lead tree	June-Nov
	<i>Tamarindus</i>	<i>indica</i>	Imli	May-Jun
Malvaceae	<i>Thespesia</i>	<i>populnea</i>	Indian Tulip Tree	All year
Meliaceae	<i>Cedrela</i>	<i>toona</i>	Indian Mahagony	Mar-Apr
Rhamnaceae	<i>Ziziphus</i>	<i>jujuba</i>	Chinese date	Jun-Jul
Sapotaceae	<i>Madhuca</i>	<i>longifolia</i>	Mohwa	Jul-Aug
Tiliaceae	<i>Corchorus</i>	<i>capsularis</i>	Jute	Sep-Oct
Zygophyllaceae	<i>Guaicum</i>	<i>officinale</i>	Gum guaicum	Mar-Oct

Table-2(b): Plants with no reports of pollen grains sensitivity but pollen types found in air.

Family	Genus	Species	Common name	Flowering period	References
Bombacaceae	<i>Bombax</i>	<i>ceiba</i>	Red silk cottontree	Feb-Mar	[14,19,46]
Combretaceae	<i>Quisqualis</i>	<i>sp.</i>	Ragoon creeper	All year	[55]
Euphorbiaceae	<i>Euphorbia</i>	<i>sp.</i>	Poinsettia	Late winter	[28,55]
Leguminaceae	<i>Butea</i>	<i>monosperma</i>	Parrot tree	Feb-Apr	[46]
	<i>Cassia</i>	<i>fistula</i>	Amaltas	Apr- Jun	[8,14,46]
	<i>Mimosa</i>	<i>pudica</i>	Chhui-Mui, Lajwanti	Sep-Oct	[11,15,27,29]
	<i>Parkinsonia</i>	<i>aculeata</i>	Jerusalem Thorn	Mar-May	[11,15]
	<i>Peltophorum</i>	<i>pterocarpum</i>	Sogabark peltophorum	Mar- Jun	[2,14,29]
Lythraceae	<i>Lagerstroemia</i>	<i>speciosa</i>	Queen's Flower	Apr-Sep	[14,55]
	<i>Lawsonia</i>	<i>inermis</i>	Mehndi	Mar-Aug	[14,19]
	<i>Melia</i>	<i>azedarach</i>	Persian Lilac	Mar-Apr	[27]
Moringaceae	<i>Moringa</i>	<i>oleifera</i>	Drumstick Tree	Jan.-Apr	[14,46]
Myrtaceae	<i>Callistemon</i>	<i>citranus</i>	Bottle brush	Feb-Jun	[27]
	<i>Syzygium</i>	<i>cumini</i>	Jamun	Mar-May	[2,14,19,46]
Rotaceae	<i>Aegle</i>	<i>Marmelos</i>	Bael fruit, Elephant apple	May-Jul	[46]

In total, we have collected the data on 60 species of plants, which are cultivated in Sindh. Out of these, 28 species (Table-1) are known as allergenic pollen producers and their sensitivity has been reported by scientists throughout the world. First group consisted of the following plant species: *Acacia* spp., *Acer campestre*, *Areca catechu*, *Albizia lebbek*, *Azadirachta indica*, *Cocos nucifera*, *Catharanthus roseus*, *Carica papaya*, *Casuarina equisetifolia*, *Croton bonplandianum*, *Delonix regia*, *Eucalyptus globulus*, *Ficus benjamina*, *Hordeum vulgare*, *Morus alba*, *Pennisetum glaucum*, *Phoenix dactylifera*, *Plantago major*, *Ricinus communis*, *Saccharum officinarum*, *Sorghum vulgare*, *Thuja orientalis*, *Triticum aestivum* and *Zea mays*. The purpose of cultivation varies from plant to plant. *Areca catechu*, *Carica papaya* and *Cocos nucifera* are cultivated to obtain fruits and are also used as a food source. Date palm (*Phoenix dactylifera*) is primarily a commercial crop plant, but is also grown in family compounds, gardens, and streets along the road sides for beautification purposes [6]. Taxonomically cereal crops, belong to family poaceae, are cultivated for human and animal consumption. *Triticum aestivum* (Wheat) and *Zea mays* are the major food crops in the entire world. Their pollen grains have certain common proteins which attribute to cause respiratory allergies in the adjacent areas [7]. *Acacia*, *Albizia lebbek*, *Azadirachta indica*, *Catharanthus roseus*, *Casuarina equisetifolia*, *Croton bonplandianum*, *Cynodon dactylon*, *Delonix regia*, *Eucalyptus globules*, *Ficus benjamina*, *Ricinus communis*, *Robinia pseudoacacia* and *Thuja orientalis* are grown as ornamental plants in the gardens, as well as along the road sides. *Ricinus communis* is usually grown in India for its oil, and is generally present at waste places [8]. *Cynodon dactylon* (Lawn grass) and *Morus alba*

(Mulberry tree) are creating major health problems in almost all the countries in which they are grown [1, 8-19]. Studies have shown that the proteins and glycoproteins of the pollens are responsible for triggering of allergic rhinitis and asthma fever [20]. These proteins are present at different areas of the pollen grains like on surface, sporopollenin is present from which exine is made up of and the inner wall made by polysaccharides. A very small number of these proteins can trigger allergic reaction usually ranging from molecular weight of 10-70 kDa [20]. So it is necessary to analyze effect of each pollen type with reference to its protein part. This can be done by purification and characterization of the proteins present in the pollen grains of suspected allergenic species. Purified proteins are identified by means of SDS-PAGE. Some of the allergens present in plants which are mentioned in Table-1 are Cyn d 1, Cyn d 7, Cyn d 12, Cyn d 24 from *Cynodon dactylon* [20-22], Zea m 1, Zea m 11 from *Zea mays* [20, 23], Cocos II, Cocos VI, and Cocos VII from *Cocos nucifera* [24], Tri a 2 from *Triticum aestivum* [22], Hor v 9 of *Hordeum vulgare* [22] and Pho D 1, Pho D 6, Pho d 2 were identified from *Phoenix dactylifera* [6, 25].

Second group jointly comprised of 32 species, with subgroup 2a consisting of 17 flowering trees and shrubs and 2b have 15 plant species. *Adenanthera pavonina*, *Araucaria cunninghamii*, *Bauhinia* spp., *Caesalpinia pulcherrima*, *Cedrela toona*, *Corchorus capsularis*, *Guaicum officinale*, *Kigelia Africana*, *Madhuca longifolia*, *Oreodoxa regia*, *Polyalthia longifolia*, *Tamarindus indica*, *Thevetia peruviana*, *Thespesia populnea* and *Ziziphus jujuba* are presented in Table-2a, which are safe for health. Meanwhile, Table-2b represents 15 plant members belonging to different families i.e. *Bombax ceiba*, *Butea monosperma*, *Cassia fistula*, *Callistimon*

citranus, *Euphorbia sp.*, *Melia azedarach*, *Mimosa pudica*, *Moringa oleifera*, *Parkinsonia aculeate*, *Peltophorum pterocarpum*, *Lagerstroemia speciosa*, *Lawsonia inermis*, *Quisqualis indica* and *Syzygium cumini* that can be a harmful to human health as their pollen grains are airborne and captured by the air samplers. However, no detailed reports of antipathy to their pollen grains have been suggested as yet. Therefore, as a precautionary measure, these plants should be avoided for further plantation in large numbers among urban and rural areas. Interestingly, it is still not apparent as to why so many species that are supposed to be low allergenic can actually become significant in terms of airborne pollen sensitivity [1].

Tables-3 and 4 point out the flowering periods of all the plant species. Table-3 represents the seasons in which hypersensitive individuals to pollen should be more careful about their outdoor exposure. The flowering periods presented in this paper show that the months of March, April, and May are the ones in which both allergenic and non-allergenic species blossom to a great extent. This is the reason why most individuals suffer from high levels of allergic reactions during these months. However, the

months from June to October should not be overlooked, because most of the species continue flowering during these months. Low level of flowering is observed in the winter season i.e. from November to February as well. The above stated results are further confirmed by numerous surveys conducted by scientists in various geographical areas [2, 25-29].

Pollen and fungal spores released by various plant species are considered as the major factors that can cause respiratory allergies. This study sheds light on the possibility of urban cultivated plants as a source of allergenic pollen producers, thereby dismissing the myth that only wild plant species release such pollen grains that can cause allergic reactions among humans. Specifically, the study expands the scope of allergological studies concerning the province of Sindh, and demonstrates the benefit of devising an allergy calendar for each geographical area, in order to better predict the pollen concentrations on season basis. Moreover, the comparatively less harmful and low allergenic plant species that have been identified in this study will enable individuals to select the appropriate species for plantation purposes, thereby providing them relief from the effects of allergic symptoms.

Table-3: Months in which plants bloom (Allergenic reported plants from Table-1 only).

Months	Plant Species
Jan	<i>Areca, Carica, Casuarina, Cocos, Croton, Catharanthus, Eucalyptus, Ficus, Ricinus, Saccharum</i>
Feb	<i>Carica, Casuarina, Cocos, Croton, Catharanthus, Cynodon, Eucalyptus, Ricinus, Saccharum</i>
Mar	<i>Carica, Casuarina, Cocos, Croton, Catharanthus, Cynodon, Eucalyptus, Morus, Phoenix, Ricinus, Robinia, Saccharum, Thuja</i>
Apr	<i>Albizia, Acer, Azadirachta, Carica, Cocos, Croton, Catharanthus, Cynodon, Delonix, Eucalyptus, Phoenix, Morus, Ricinus, Robinia, Tamarix, Thuja</i>
May	<i>Albizia, Acer, Azadirachta, Carica, Cocos, Croton, Catharanthus, Delonix, Eucalyptus, Phoenix, Morus, Ricinu, Tamarix</i>
Jun	<i>Albizia, Carica, Cocos, Croton, Catharanthus, Delonix, Hordeum, Ricinus, Tamarix, Triticum, Zea</i>
Jul	<i>Carica, Cocos, Croton, Catharanthus, Delonix, Hordeum, Triticum, Zea</i>
Aug	<i>Acacia, Carica, Cocos, Croton, Catharanthus, Delonix, Hordeum, Plantago, Sorghum, Triticum, Zea</i>
Sep	<i>Acacia, Carica, Cocos, Croton, Catharanthus, Delonix, Pennisetum, Plantago, Sorghum, Zea</i>
Oct	<i>Acacia, Carica, Casuarina, Cocos, Croton, Catharanthus, Ficus, Pennisetum, Ricinus, Sorghum</i>
Nov	<i>Acacia, Carica, Casuarina, Cocos, Croton, Catharanthus, Ficus, Ricinus, Sorghum</i>
Dec	<i>Acacia, Areca, Carica, Casuarina, Cocos, Croton, Catharanthus, Ficus, Ricinus</i>

Table-4: Months in which plants bloom (Non allergenic plants from Tables-2a and 2b).

Months	Plant Species
Jan	<i>Araucaria, Casia, Euphorbia, Moringa, Quisqualis, Thevetia</i>
Feb	<i>Araucaria, Bombax, Butea, Casia, Callistemon, Euphorbia, Moringa, Oreodoxa, Quisqualis, Thespetia, Thevetia</i>
Mar	<i>Adenantha, Bauhinia, Bombax, Butea, Callistemon, Cassia, Cedrela, Cinnammum, Guaicum, Melia, Moringa, Oreodoxa, Parkinsonia, Peltophorum, Polyalthia, Quisqualis, Syzygium, Thespetia, Thevetia</i>
Apr	<i>Adenantha, Bauhinia, Butea, Callistemon, Cassia, Ceasalpinia, Cedrela, Cinnammum, Guaicum, Lawsonia, Legestromia, Melia, Moringa, Oreodoxa, Parkinsonia, Peltophorum, Polyalthia, Quisqualis, Syzygium, Thespetia, Thevetia</i>
May	<i>Aegle, Adenantha, Callistemon, Cassia, Ceasalpinia, Guaicum, Kigelia, Lawsonia, Legestromia, Parkinsonia, Peltophorum, Quisqualis, Syzygium, Tmarindus, Thespetia, Thevetia</i>
Jun	<i>Aegle, Cassia, Ceasalpinia, Guaicum, Kigelia, Leucaena, Lawsonia, Legestromia, Peltophorum, Quisqualis, Tamarindus, Thespetia, Thevetia, Ziziphus</i>
Jul	<i>Aegle, Ceasalpinia, Guaicum, Kigelia, Leucaena, Lawsonia, Legestromia, Madhuca, Quisqualis, Thespetia, Thevetia, Ziziphus</i>
Aug	<i>Ceasalpinia, Guaicum, Kigelia, Leucaena, Lawsonia, Legestromia, Madhuca, Quisqualis, Thespetia, Thevetia</i>
Sep	<i>Bauhinia, Corcorus, Ceasalpinia, Guaicum, Madhuca, Mimosa, Leucaena, Legestromia, Quisqualis, Thespetia, Thevetia</i>
Oct	<i>Bauhinia, Corcorus, Cassia, Guaicum, Mimosa, Leucaena, Thespetia, Thevetia</i>
Nov	<i>Araucaria, Bauhinia, Casia, Leucaena, Quisqualis, Thespetia, Thevetia</i>
Dec	<i>Araucaria, Casia, Euphorbia, Quisqualis, Thespetia, Thevetia</i>

Experimental

Field surveys were performed to investigate the local flora of Sindh. Abundantly growing species were recorded and identified through the help of Flora of Pakistan [30] and flowering trees and shrubs of India [31]. The species have been classified into the 'allergenic' and 'non-allergenic' categories based upon the literature surveyed and papers published. The non-allergenic plants were further classified based upon the reports of the presence or absence of pollen grains in the air. The insect pollinated entomophilous plants have been included in the study, which produces a large number of flowers in either a catkin type inflorescence, e.g. *Casuarina equisetifoli*, *Acacia spp.*, and *Albizia spp.etc.*, or with fully exposed anthers, e.g. *Caesalpinia spp.*, *Parkinsonia spp.*, *Peltophorum spp.*, and *Delonix spp.*. The pollen of these flowers are frequently distributed among densely populated areas and may be considered a local allergen, as the pollen released by them are most likely to provoke hypersensitivity reactions.

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